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June 2022
Office of Chemical Safety and
Pollution Prevention

United States
Environmental Protection Agency

# Final Scope of the Risk Evaluation for Asbestos
# Part 2: Supplemental Evaluation Including Legacy Uses and Associated Disposals of Asbestos

*June 2022*

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**Docket**
Supporting information can be found in public docket, Docket ID: EPA-HQ-OPPT-2021-0254.

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# ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| A/C | Asbestos-cement (products) |
| ACGIH | American Conference of Governmental Industrial Hygienists |
| ACM | Asbestos-containing material |
| ADME | Absorption, distribution, metabolism, and excretion |
| ADAF | Age-dependent adjustment factors |
| AHERA | Asbestos Hazard Emergency Response Act |
| ASHAA | Asbestos School Hazard Abatement Act |
| ASHARA | Asbestos School Hazard Abatement Reauthorization Act |
| BAF | Bioaccumulation factor |
| BBP | Butylbenzyl phthalate |
| BCF | Bioconcentration factor |
| BMF | Biomagnification factor |
| BOD | Biochemical oxygen demand |
| $BW^{3/4}$ | Body weight scaling to the 3/4 power |
| CASRN | Chemical Abstracts Service Registry Number |
| CBI | Confidential business information |
| CDR | Chemical Data Reporting |
| CEHD | Chemical Exposure Health Data |
| CERCLA | Comprehensive Environmental Response, Compensation and Liability Act |
| CEM | Consumer Exposure Model |
| CFR | Code of Federal Regulations |
| ChemSTEER | Chemical Screening Tool for Exposure and Environmental Releases |
| COC | Concentration of concern |
| COU | Condition of Use |
| CPSA | Consumer Product Safety Act |
| CPSC | Consumer Product Safety Commission |
| CPSIA | Consumer Product Safety Improvement Act |
| CSF | Cancer slope factor |
| CWA | Clean Water Act |
| ECHA | European Chemicals Agency |
| EC | European Commission |
| $EC_x$ | Effective Concentration that causes a response that is x% of the maximum |
| ECHA | European Chemicals Agency |
| EPA | Environmental Protection Agency |
| EPCRA | Emergency Planning and Community Right-to-Know Act |
| ERG | Eastern Research Group |
| ESD | Emission Scenario Document |
| EU | European Union |
| FDA | Food and Drug Administration |
| FFDCA | Federal Food, Drug and Cosmetic Act |
| FHSA | Federal Hazardous Substances Act |
| FR | Federal Register |
| FYI | For your information (TSCA submissions) |
| GDIT | General Dynamics Information Technology |
| GS | Generic Scenario |
| HAWC | Health Assessment Workplace Collaborative |
| HHE | Health Hazard Evaluation |
| HMTA | Hazardous Materials Transportation Act |

| | |
|---|---|
| HQ | Headquarters |
| HSDB | Hazardous Substances Data Bank |
| IARC | International Agency for Research on Cancer |
| ICF | ICF (a global consulting company) |
| IECCU | Indoor Environmental Concentrations in Buildings with Conditioned and Unconditioned Zones (model) |
| IUR | Inhalation unit risk |
| $K_{OC}$ | Organic carbon: water partition coefficient |
| $K_{OW}$ | Octanol: water partition coefficient |
| $LC_{50}$ | Lethal concentration of 50% test organisms |
| LAA | Libby Amphibole Asbestos |
| LOAEL | Lowest-observed-adverse-effect level |
| LOEC | Lowest-observed-effect concentration |
| MAP | (Asbestos) Model Accreditation Plan |
| MOA | Mode of action |
| MOE | Margin of exposure |
| NESHAP | National Emission Standard for Hazardous Air Pollutants |
| NHANES | National Health and Nutrition Examination Survey |
| NICNAS | National Industrial Chemicals Notification and Assessment Scheme (Australia) |
| NIOSH | National Institute for Occupational Safety and Health |
| NLM | National Library of Medicine |
| NOAEL | No-observed-adverse-effect level |
| NOEC | No-observed-effect concentration |
| NPDES | National Pollutant Discharge Elimination System |
| NPL | National Priorities List |
| OCSPP | Office of Chemical Safety and Pollution Prevention |
| OECD | Organisation for Economic Co-operation and Development |
| OEL | Occupational Exposure Limit |
| ONU | Occupational non-user |
| OPPT | Office of Pollution Prevention and Toxics |
| OSF | Oral slope factor |
| OSHA | Occupational Safety and Health Administration |
| PBPK | Physiologically based pharmacokinetic |
| PBT | Persistent, bioaccumulative, toxic |
| PECO | Population, exposure, comparator, and outcome |
| PEL | Permissible exposure limit |
| PESO | Pathways and processes, exposure, setting or scenario, and outcomes |
| PESS | Potentially exposed or susceptible subpopulation |
| POD | Point of departure |
| POTW | Publicly owned treatment works |
| PPE | Personal protective equipment |
| RCRA | Resource Conservation and Recovery Act |
| REACH | Registration, Evaluation, Authorisation and Restriction of Chemicals (European Union) |
| RESO | Receptors, exposure, setting or scenario, and outcomes |
| RQ | Risk quotient |
| SDS | Safety Data Sheet |
| SDWA | Safe Drinking Water Act |
| SNUR | Significant New Use Rule |
| SRC | SRC, Inc., formerly Syracuse Research Corporation |

| | |
|---|---|
| $T_{1/2}$ | Half-life |
| TCCR | Transparent, clear, consistent, and reasonable |
| TIAB | Title and abstract |
| TMF | Trophic magnification factor(s) |
| TRI | Toxics Release Inventory |
| TSCA | Toxic Substances Control Act |
| UNEP | United Nations Environment Programme |
| U.S.C. | United States Code |
| WHO | World Health Organization |
| WWTP | Wastewater treatment plant |

# EXECUTIVE SUMMARY

On December 19, 2016, EPA published a list of 10 chemical substances, including asbestos, which have been the subject of the Agency's initial chemical risk evaluations (81 FR 91927), as required by section 6(b)(2)(A) of the Toxic Substances Control Act (TSCA) (Docket ID: EPA-HQ-OPPT-2016-0718).

Following the designation of asbestos as one the first 10 chemicals to undergo risk evaluation under TSCA, as amended by Frank R. Lautenberg Chemical Safety for the 21st Century Act in June 2016, EPA initially focused the risk evaluation for asbestos on chrysotile asbestos as this is the only asbestos fiber type that is currently imported, processed, or distributed in the United States. EPA informed the public of this decision to focus on ongoing uses of asbestos and exclude legacy uses and disposals in the Scope of the Risk Evaluation for Asbestos document, published in June 2017 (U.S. EPA, 2017). However, in late 2019, the court in *Safer Chemicals, Healthy Families v. EPA*, 943 F.3d 397 (9th Cir. 2019) held that EPA's Risk Evaluation Rule, 82 FR 33726 (July 20, 2017) should not have excluded "legacy uses" (*i.e.,* uses without ongoing or prospective manufacturing, processing, or distribution for use) or "associated disposals" (*i.e.,* future disposal of legacy uses) from the definition of conditions of use—although the court did uphold EPA's exclusion of "legacy disposals" (*i.e.,* past disposal). Following this court ruling, EPA continued development of the risk evaluation for chrysotile asbestos and determined that the complete Risk Evaluation for Asbestos would be issued in two parts. The Risk Evaluation for Asbestos Part 1: Chrysotile Asbestos was released in December 2020, allowing the Agency to expeditiously move into risk management for the unreasonable risk identified in Part 1. The Risk Evaluation for Asbestos Part 2: Supplemental Evaluation Including Legacy Uses and Associated Disposals of Asbestos is the subject of the current efforts for this final scope document, described herein.

The first step of the risk evaluation process is the development of the scope, which generally includes issuing a draft scope document as described in 40 CFR 702.41(c)(7). EPA published the *Draft Scope of the Risk Evaluation for Asbestos Part 2: Supplemental Evaluation Including Legacy Uses and Associated Disposals of Asbestos* (EPA Document No. EPA-740-D-21-002 (U.S. EPA 2021) and provided a 45-day comment period, including a 15-day extension, on the draft scope per 40 CFR 702.41(c)(7). EPA has considered comments received (Docket ID: EPA-HQ-OPPT-2021-0254) during the public comment period to inform the development of this final scope document, and public comments received will continue to inform the development of the risk evaluation for Asbestos Part 2. This document fulfills the statutory and regulatory requirements under TSCA to issue a final scope document per TSCA section 6(b)(4)(D) and as described in 40 CFR 702.41(c)(8). The scope is specific to Part 2 of the Risk Evaluation for Asbestos and includes the following information: the conditions of use (primarily legacy uses and associated disposals); potentially exposed or susceptible subpopulations (PESS); hazards; and exposures that EPA plans to consider in Part 2 of the Risk Evaluation for Asbestos, along with a description of the reasonably available information, conceptual models, analysis plan and science approaches, and plan for peer review for this chemical substance.

***General Information***

For the purposes of scoping and risk evaluation, EPA initially adopted the definition of asbestos as defined by TSCA Title II (added to TSCA in 1986), section 202 as the "asbestiform varieties of six fiber types – chrysotile (serpentine), crocidolite (riebeckite), amosite (cummingtonite-grunerite), anthophyllite, tremolite or actinolite." The latter five fiber types are amphibole varieties. However, given that Part 2 of the risk evaluation will focus on legacy asbestos uses and associated disposals, broader considerations are warranted. A unique consideration is the co-location of asbestos geologically with commercially mined substances. In particular, Libby Amphibole Asbestos (LAA) is known to be present with a silicate, mica-like mineral called vermiculite, extracted from an open pit mine near Libby,

Montana, until its closure in 1990 (U.S. EPA, 1988). Vermiculite was widely used in building materials that will be an important focus of the evaluation of legacy uses of asbestos. Thus, LAA (and its tremolite, winchite, and richterite constituents) will be considered in Part 2 of the Risk Evaluation. To identify these substances, EPA has used the following CAS Registry Numbers (CASRNs): 1332-21-4 (asbestos; this is the only asbestos on the TSCA Inventory), 12001-29-5 (chrysotile), 12001-28-4 (crocidolite), 12172-73-5 (amosite), 77536-67-5 (anthophyllite), 77536-68-6 (tremolite), 77536-66-4 (actinolite), 1318-09-8 (amphibole), 12425-92-2 (winchite), and 17068-76-7 (richterite). As described in the scope document for Part 1 of the Risk Evaluation for Asbestos (Section 2.2), the implementation of the TSCA Title II definition was initially appropriate because the focus of Part 1 was ongoing uses, and chrysotile asbestos was the only relevant fiber type. Given that the focus of Part 2 includes legacy uses of asbestos, it is appropriate to include Libby Amphibole Asbestos as it remains in buildings.

Additionally, another commercially mined substance, talc, has been implicated as a potential source of asbestos exposure. Talc can also be co-located geologically with asbestos, where asbestos can remain in small or trace amounts following extraction. Thus, EPA will determine the relevant conditions of use of asbestos-containing talc, including but not limited to any "legacy use" and "associated disposal" where asbestos is implicated.

***Reasonably Available Information***

To inform the development of this scope, EPA leveraged the data and information sources identified for Part 1 of the Risk Evaluation for Asbestos. To further develop this final scope document, EPA conducted a broader, comprehensive search to identify and screen multiple evidence streams (*i.e.,* chemistry, fate, release and engineering, exposure, hazard), and the search and screening results to date are provided in Section 2.1. EPA also updated the information identified from Part 1 to capture any additional information relevant to Part 2. The approach is thoroughly described in Section 2.1 and Appendix A.

***Conditions of Use***

EPA plans to the evaluate the industrial, commercial, and consumer legacy uses and associated disposal of asbestos in Part 2 of the Risk Evaluation for Asbestos. Legacy asbestos uses are uses for which manufacture (including import), processing, and distribution no longer occur, but the uses are still known, intended, or reasonably foreseen to occur. Associated disposals are disposals from legacy uses. As such, in Part 2 of the Risk Evaluation for Asbestos, EPA will be evaluating the conditions of use for the use and disposal phases of the life cycle. Depending on where information implicates the presence of asbestos in talc, the conditions of use may include manufacture, processing, and distribution. EPA did not revise the conditions of use in the final scope document for Part 2 but did provide some clarifications based on public comments received on the draft scope (Docket ID: EPA-HQ-OPPT-2021-0254). Section 2.2 provides additional details about the conditions of use within the scope of the risk evaluation.

***Conceptual Model***

The conceptual models for legacy uses of asbestos and associated disposal and asbestos-containing talc are presented in Section 2.6. Conceptual models are graphical depictions of the actual or predicted relationships of conditions of use, exposure pathways (*e.g.,* media), exposure routes (*e.g.,* inhalation, dermal, oral), hazards, and receptors throughout the life cycle of a chemical substance. EPA considered reasonably available information as well as public comments received on the draft scope document for Asbestos Part 2 in finalizing the exposure pathways, exposure routes, and hazards. As a result, EPA plans to focus Part 2 of the Risk Evaluation for Asbestos on the following exposures, hazards, and receptors:

- *Exposures (Pathways and Routes), PESS:* EPA plans to evaluate releases to the environment as well as human and environmental exposures resulting from the conditions of use of asbestos that EPA plans to consider in Part 2 of the Risk Evaluation. Exposures for asbestos are discussed in Section 2.3. Additional information gathered through systematic review searches will also inform expected exposures.

  In Section 2.6, EPA presents the conceptual models describing the identified exposures (pathways and routes), receptors and hazards associated with the conditions of use of asbestos within the scope of Part 2 of the Risk Evaluation.

  EPA considered reasonably available information and comments received on the draft scope document for Asbestos Part 2 in determining the human and environmental exposure pathways, routes, receptors, and PESS for inclusion in the final scope. As a result, EPA plans to evaluate the following human and environmental exposure pathways, routes, receptors, and PESS in the scope of Part 2 of the Risk Evaluation.

  - Occupational Exposure: EPA plans to evaluate exposures to workers and occupational non-users (ONUs) via the inhalation, dermal, and oral route associated with the use and disposal of asbestos, to include any implicated conditions of use (COUs) for asbestos-containing talc containing asbestos. EPA plans to analyze dermal exposure for workers and ONUs to asbestos fibers that deposit on surfaces.
  - Consumer and Bystander Exposure: EPA plans to evaluate inhalation, dermal, and oral exposure to asbestos for consumers and bystanders from the use of asbestos in construction, paint, electrical, and metal products; asbestos in furnishing, cleaning, treatment care products; asbestos in packaging, paper, plastic, toys, hobby products; asbestos in automotive, fuel, agriculture, outdoor use products; and asbestos in products not described by other codes; and the direct contact and/or mouthing of products or articles containing asbestos for consumers. In addition, any implicated COUs for asbestos-containing talc will be evaluated.
  - General Population Exposures: For the conditions of use within the scope of Part 2 of the Risk Evaluation for Asbestos, EPA plans to evaluate general population exposure to asbestos via the oral route from drinking water, surface water, groundwater, and soil; via the inhalation route from particulate in ambient air; and via the dermal route from contact with drinking water, surface water, groundwater, and soil.
  - PESS: EPA plans to consider children, workers, including firefighters, ONUs, consumers, individuals who smoke, and bystanders as receptors and PESS in Part 2 of the Risk Evaluation, as well as any other PESS identified in the screening and evaluation of the reasonably available information (Section 2.5).
  - Environmental Exposure: For the conditions of use within the scope of Part 2 of the Risk Evaluation for Asbestos, EPA plans to evaluate exposure to asbestos for aquatic and terrestrial receptors.

- *Hazards:* Hazards for asbestos are discussed in Section 2.4. In development of Part 1 of the Risk Evaluation for Asbestos and for this scope for Part 2, EPA completed preliminary reviews of the reasonably available information to identify potential environmental and human health hazards related to exposures to asbestos fibers. EPA also considered reasonably available information identified through systematic review methods as outlined in Appendix A to determine the broad categories of environmental and human health hazard effects to be evaluated in the risk evaluation. For Part 2 of the Risk Evaluation for Asbestos, EPA plans to evaluate the epidemiological literature examining exposure to asbestos and certain cancers and non-cancer

effects using revised systematic review strategies outlined in EPA's *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances* (Docket No. EPA-HQ-OPPT-2021-0414).

EPA plans to evaluate the potential environmental and human health hazard effects characterized for asbestos in Sections 2.4.1 and 2.4.2, respectively. The potential environmental hazard effects and related information that EPA plans to consider for the risk evaluation for asbestos include absorption, distribution, metabolism, and excretion (ADME), developmental, gastrointestinal, mortality, neurological, nutritional and metabolic, reproductive, and respiratory effects. Similarly, the potential human health hazard effects and related information identified through the data screening phase of systematic review for asbestos that EPA plans to consider for the risk evaluation include: ADME, physiologically based pharmacokinetic (PBPK) data, certain cancers, cardiovascular, developmental, endocrine, gastrointestinal, hematological and immune, hepatic, mortality, musculoskeletal, neurological, nutritional and metabolic ocular and sensory, renal, reproductive, respiratory, skin and connective tissue.

***Analysis Plan***

The analysis plan for the evaluation of asbestos in Part 2 is presented in Section 2.7. The analysis plan outlines the general science approaches that EPA plans to use for the various evidence streams (*i.e.,* chemistry, fate, release and engineering, exposure, hazard) supporting the risk evaluation. The analysis plan is based on EPA's knowledge of asbestos to date, which includes a review of identified information as described in Section 2.1, as well as consideration of public comments and recommendations from the SACC for Part 1 of the Risk Evaluation for Asbestos. EPA plans to consider new information submitted by the public. Should additional data or approaches become reasonably available, EPA may consider them for the risk evaluation.

***Peer Review***

The draft risk evaluation for Asbestos Part 2: Supplemental Evaluation Including Legacy Uses of Asbestos and Associated Disposals will be peer reviewed. Peer review will be conducted in accordance with relevant and applicable methods for chemical risk evaluations, including using EPA's *Peer Review Handbook* (U.S. EPA, 2015b) and other methods consistent with section 26 of TSCA (see 40 CFR 702.45).

# 1 INTRODUCTION

This document presents the final scope for Part 2 of the Risk Evaluation for Asbestos under the Frank R. Lautenberg Chemical Safety for the 21st Century Act, the legislation that amended TSCA on June 22, 2016. The law includes statutory requirements and deadlines for actions related to conducting risk evaluations of existing chemicals. TSCA section 6(b)(4)(A) directs EPA, in conducting risk evaluations for existing chemicals, to "determine whether a chemical substance presents an unreasonable risk of injury to health or the environment, without consideration of costs or other nonrisk factors, including an unreasonable risk to a potentially exposed or susceptible subpopulation identified as relevant to the risk evaluation by the Administrator, under the conditions of use." Furthermore, TSCA section 6(b)(4)(D) and implementing regulations require that EPA publish the scope of the risk evaluation to be conducted, including the hazards, exposures, conditions of use and PESS that the Administrator expects to consider. In addition, a draft scope document is to be published pursuant to 40 CFR 702.41.

Asbestos was designated as one of the first 10 chemical substances for the Agency's initial risk evaluations in December 2016 (81 FR 91927), pursuant to TSCA section 6(b)(2)(A). Initially, the Agency focused efforts on chrysotile asbestos, as this is the only asbestos fiber that is currently manufactured, processed, and distributed in commerce for use. The Agency communicated the decision to exclude legacy uses and associated disposals in a scope document published in June 2017 and the problem formulation document published in May 2018. EPA released the draft Risk Evaluation for Asbestos presenting risk determinations for conditions of use for chrysotile asbestos in March 2020. During the development of the draft risk evaluation, EPA was challenged on the Risk Evaluation Rule's exclusion of legacy uses of asbestos and associated disposals (82 FR 33726), and in late 2019, the court in *Safer Chemicals, Healthy Families v. EPA*, 943 F.3d 397 (9th Cir. 2019) held that EPA should not have excluded legacy uses or associated disposals from the definition of conditions of use. Following the court decision, EPA determined that the risk evaluation for asbestos would be issued in two parts:

- Risk Evaluation for Asbestos Part 1: Chrysotile Asbestos (December 2020); and
- Risk Evaluation for Asbestos Part 2: Supplemental Evaluation Including Legacy Uses and Associated Disposals of Asbestos.

The rationale to continue development and finalization of Part 1 focused on chrysotile asbestos was to prevent delay of risk management rulemaking for unreasonable risks identified in Part 1. A risk management rule has been proposed to address the unreasonable risks identified in Part 1 (87 FR 21706, April 12, 2022).

In Part 1 of the Risk Evaluation for Asbestos, EPA clarified its intent to evaluate risks associated with legacy uses of asbestos and associated disposals in a subsequent effort, which is now underway. This document presents the final scope for Part 2 of the Risk Evaluation for Asbestos that will focus on supplemental analyses, including legacy uses of asbestos and associated disposals and a limited consideration of asbestos-containing talc.

# 2 SCOPE OF THE EVALUATION

## 2.1 Reasonably Available Information

EPA conducted a comprehensive search for reasonably available information[1] to support the development of this draft scope document for Part 2 of the Risk Evaluation for Asbestos. EPA leveraged the data and information sources collected during the initial 2019 literature search and 2020 supplemental search for the systematic review process for Part 1 of the Risk Evaluation for Asbestos. The full details for the Part 1 literature strategy are available in the Risk Evaluation for Asbestos, Part 1: Chrysotile Asbestos (EPA-HQ-OPPT-2019-0501-0117). In addition, in development of Part 1, EPA conducted an independent search for additional data and information beyond the peer-reviewed literature on physical and chemical properties, environmental fate, engineering, exposure, environmental, and human health hazards that could be obtained from the following general categories of sources:

1. Databases containing publicly available, peer-reviewed literature;
2. Gray literature, which is defined as the broad category of data/information sources not found in standard, peer-reviewed literature databases, including data/information sources such as white papers, conference proceedings, technical reports, reference books, dissertations, information on various stakeholder websites, and other databases; and
3. Data and information submitted under TSCA sections 4, 5, 8(e), and 8(d), as well as "for your information" (FYI) submissions.

Additionally, the comprehensive search was updated to capture any other information relevant to Part 2 that was not captured in the Part 1 search.

Search terms were used to search each of the literature streams and gather studies. These terms and the methods used to develop them are listed in Appendix A. The studies resulting from the search process were loaded into the EPA Health and Environmental Research Online (HERO) database and then prioritized to screen the literature likely relevant for each of the disciplines: fate, physical and chemical properties, engineering, exposure, and hazard. The tools and methods used to manage the screening process are also outlined in Appendix A. The studies resulting from the search underwent a title/abstract screening process, which tagged them by topic or category. Following this, a determination was made to move studies forward into full-text screening. The criteria used in the screening process for each discipline are found in the population, exposure, comparator, and outcome (PECO) statements listed in Appendix A. The screening process results are presented in the form of literature inventory trees and heat maps in Section 2.1.2. The screening process was conducted based on EPA's planning, execution, and assessment activities outlined in Appendix A.

The subsequent sections summarize the data collection activities completed to date for the general categories of sources and topic areas (or disciplines) as outlined in Appendix A and described in EPA's *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances* (December 20, 2021) (Docket No. EPA-HQ-OPPT-2021-0414).

### 2.1.1 Search of Gray Literature

EPA surveyed the gray literature and identified 844 search results relevant to EPA's risk assessment needs for Asbestos. Appendix A.3.3 lists the gray literature sources that yielded 844 discrete data or

[1] *Reasonably available information* means information that EPA possesses or can reasonably generate, obtain, and synthesize for use in risk evaluations, considering the deadlines specified in TSCA section 6(b)(4)(G) for completing such evaluation. Information that meets the terms of the preceding sentence is reasonably available information whether or not the information is confidential business information, that is protected from public disclosure under TSCA section 14 (40 CFR 702.33).

information sources relevant to Asbestos. EPA further categorized the data and information into the various topic areas (or disciplines) supporting the risk evaluation (*e.g.,* physical chemistry, environmental fate, ecological hazard, human health hazard, exposure, engineering), and the breakdown is shown in Figure 2-1. EPA will consider additional reasonably available information from gray literature if it becomes available during the risk evaluation phase.

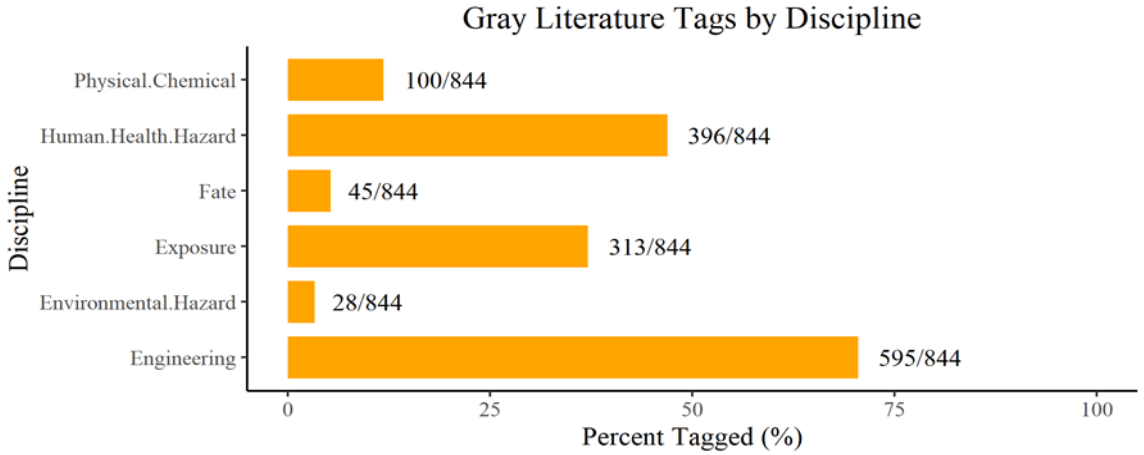


**Figure 2-1. Gray Literature Tags by Discipline for Asbestos**
The percentages across disciplines do not add up to 100% as each source may provide data or information for various topic areas (or disciplines). The gray literature sources depicted in this figure were those identified by EPA using systematic review methods outline in Appendix A.3.

### 2.1.2 Search of Literature from Publicly Available Databases (Peer-Reviewed Literature)

EPA has conducted searching and screening of the reasonably available literature using the process outlined in Appendix A. The literature strategy for Part 2 comprises the following three pieces: (1) reevaluation of all references used in Part 1, (2) evaluation of new literature produced by a Part 1 search update, and (3) evaluation of new literature produced by inclusion of additional asbestos fiber search terms. This search is comprehensive of peer-reviewed literature on physical and chemical properties; environmental fate and transport; engineering (environmental release and occupational exposure); exposure (environmental, general population, and consumer); and environmental and human health hazards of asbestos. Eligibility criteria were applied in the form of PECO statements (see Appendix A). Included references met the PECO criteria, whereas excluded references did not meet the criteria (*i.e.,* not relevant), and supplemental material was considered as potentially relevant (see Appendix A.2). EPA plans to evaluate the reasonably available information identified for each discipline during the development of the risk evaluation.

EPA created literature inventory trees to graphically illustrate the flow of data and information sources following full text screening (see Figure 2-2, Figure 2-3, Figure 2-5, Figure 2-7, and Figure 2-9). EPA used the Health Assessment Workplace Collaborative (HAWC) tool to develop web-based literature inventory trees illustrating, through interactive links, studies that were included or excluded. These literature inventory trees enhance the transparency of the decisions resulting from the screening process described in Appendix A. For each of the corresponding disciplines, the literature was tagged to be included for evaluation during the risk evaluation. Literature inventory trees for physical and chemical properties are provided as a static diagram (Figure 2-2). For all other disciplines, static screen captures are provided in addition to links within each figure's caption to the interactive trees. The links show individual studies that were tagged as included, excluded, or supplemental. Supplemental studies did not meet all inclusion criteria but may be considered during the risk evaluation as supporting information

(see Appendix A). These studies can be accessed through the hyperlink provided in the associated caption below each figure. In some figures, the sum of the numbers for the various sub-categories may be larger than the broader category because some studies may be included under multiple sub-categories. In other cases, the sum of the various sub-categories may be smaller than the main category because some studies may not be depicted in the sub-categories if their relevance to the risk evaluation was unclear.

In addition, EPA tabulated the number and characteristics of the data and information sources included in the full-text screening process in the form of literature inventory heat maps for the fate, engineering, exposure and hazard disciplines (see Figure 2-4, Figure 2-6, Figure 2-8, and Figure 2-10, respectively). For each of these four disciplines, a static image of the literature inventory heat map is provided, and a link to the interactive version presented in HAWC is included in the caption below each diagram.

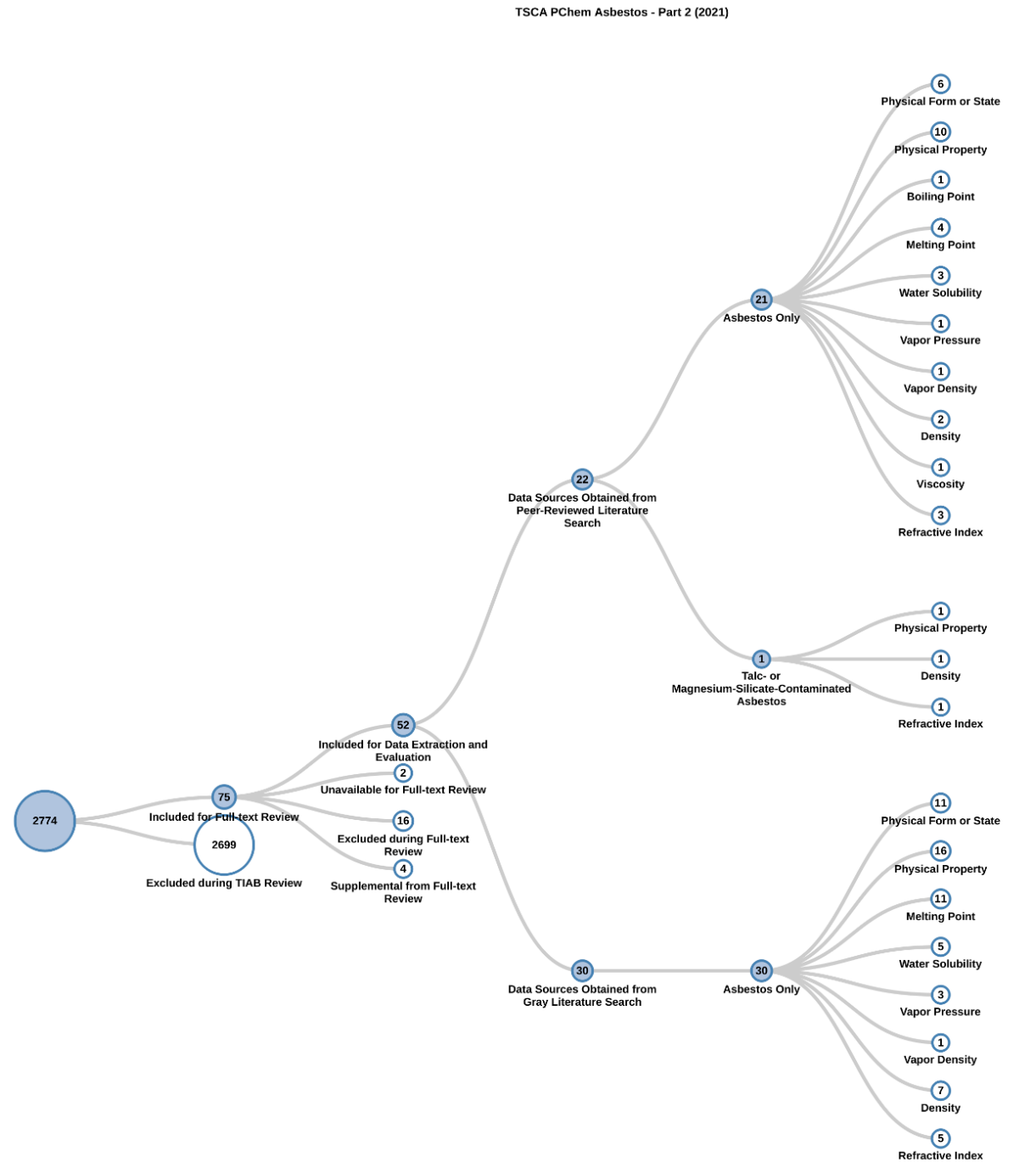


**Figure 2-2. Peer-Reviewed Literature – Physical and Chemical Properties Search Results for Asbestos**

View the interactive literature inventory tree in HAWC. Data in this static figure represent references obtained from the publicly available databases search (see Appendix A.1.3) that were included during full-text screening as of May 9, 2022. TIAB refers to "title and abstract" screening.

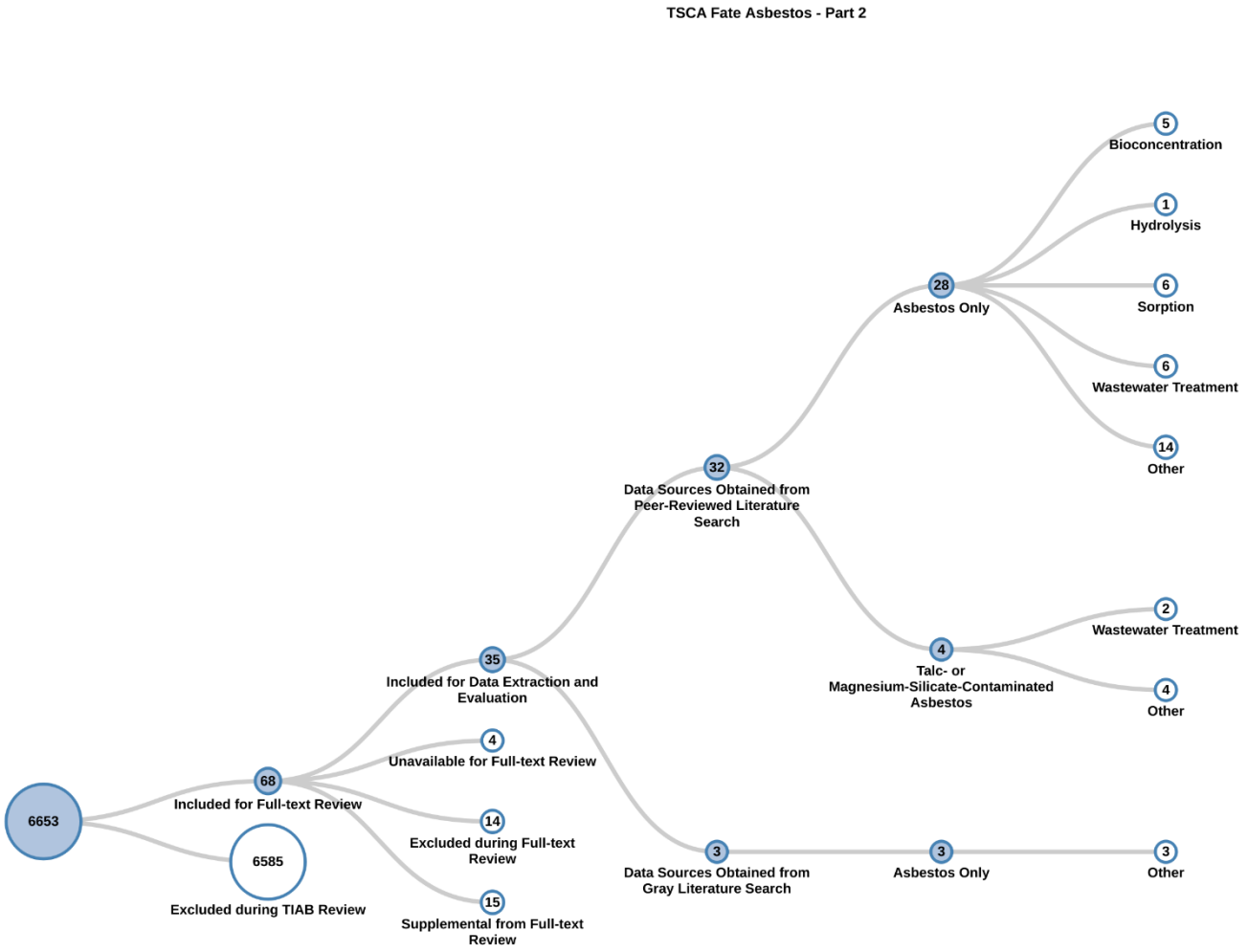


**Figure 2-3. Peer-Reviewed Literature – Fate and Transport Search Results for Asbestos**
View the interactive literature inventory tree in HAWC. Data in this figure represent references obtained from the publicly available databases search (see Appendix A.1.3) that were included during full-text screening as of May 12, 2022. Additional data may be added to the interactive version as they become available.

Fate Heat Map of Asbestos (Asbestos ONLY)

| Endpoint | Media: Air | Soil, Sediment | Wastewater, Biosolids | Water | Other | Grand Total |
|---|---|---|---|---|---|---|
| Bioconcentration | | | | 5 | | 5 |
| Biodegradation | | | | | | |
| Hydrolysis | | | | 1 | | 1 |
| Photolysis | | | | | | |
| Sorption | | 5 | | 2 | | 6 |
| Volatilization | | | | | | |
| Wastewater Treatment | | 2 | 5 | 4 | | 6 |
| Other | 10 | 6 | 3 | 2 | | 17 |
| Grand Total | 10 | 9 | 7 | 13 | | 31 |

**Figure 2-4. Peer-Reviewed Literature Inventory Heat Map – Fate and Transport Search Results for Asbestos**

View the interactive version in HAWC for additional study details. The column totals, row totals, and grand totals indicate total numbers of unique references, as some references may be included in multiple cells. The various shades of color visually represent the number of relevant references identified by exposure media or data type. The darker the color, the more references are available for a given exposure media or data type. Data in this figure represent references obtained from the publicly available databases search (see Appendix A.1.3) that were included during full-text screening as of May 12, 2022. Additional data may be added to the interactive version as they become available.

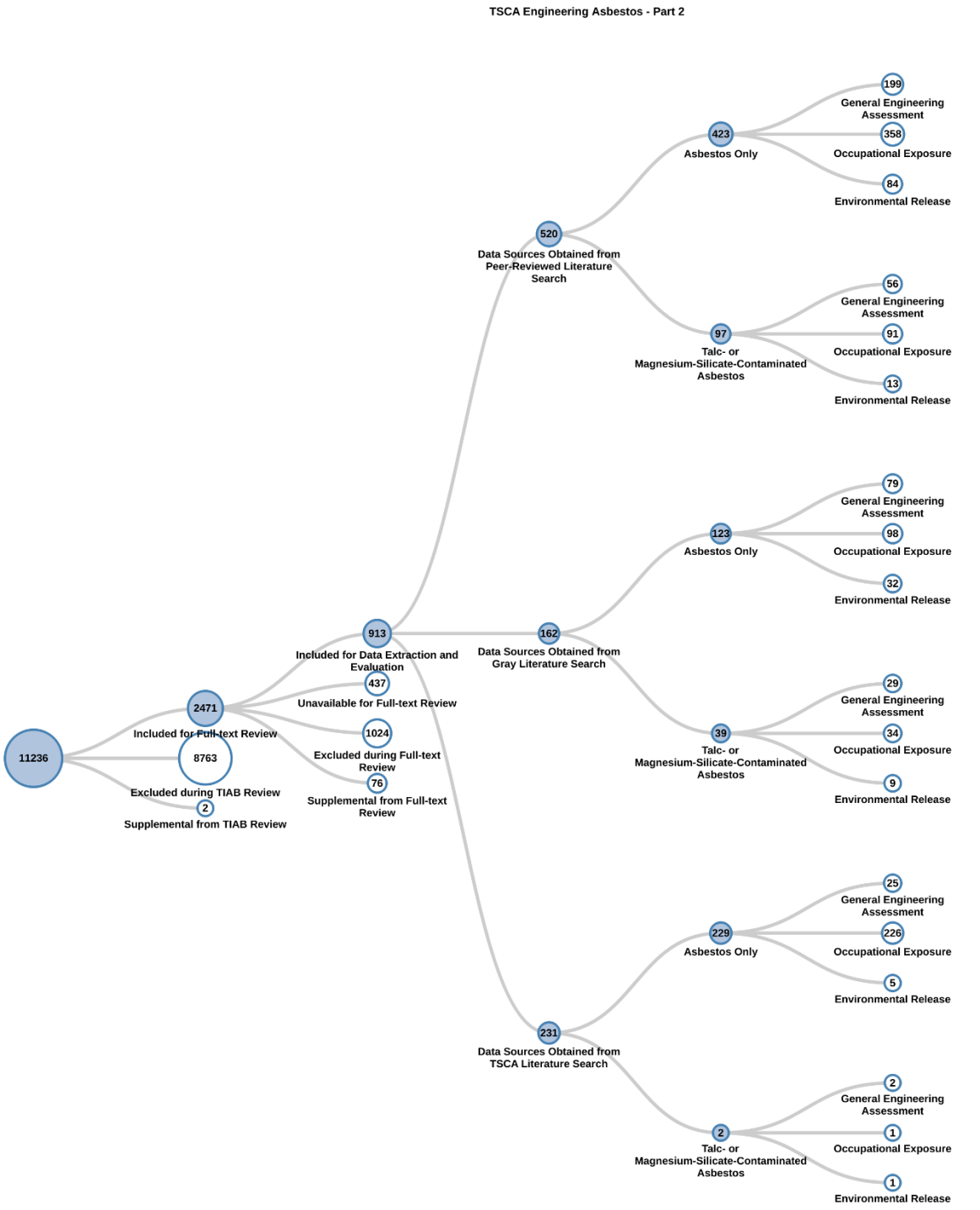


**Figure 2-5. Peer-Reviewed Literature Inventory Tree – Engineering Search Results for Asbestos**
View the interactive literature inventory tree in HAWC. Data in this figure represents references obtained from the publicly available databases search (see Appendix A.1.3.) that were included during full-text screening as of May 6, 2022. Additional data may be added to the interactive version as they become available.

| Engineering Heat Map of Asbestos (Asbestos ONLY) | | |
|---|---|---|
| Data Type | Evidence Tags | |
| Environmental Releases | Description of release source | 72 |
| | Release frequency | 2 |
| | Release or emission factors | 21 |
| | Release quantity | 24 |
| | Waste treatment methods and pollution control | 82 |
| | Total | 121 |
| General Engineering Assessment | Chemical concentration | 201 |
| | Exposure route | |
| | Life cycle description | 27 |
| | Number of sites | 54 |
| | Physical form | |
| | Process description | 115 |
| | Production, import, or use volume | 56 |
| | Throughput | 15 |
| | Total | 303 |
| Occupational Exposures | Area sampling data | 480 |
| | Dermal exposure data | 1 |
| | Engineering control | 248 |
| | Exposure duration | 152 |
| | Exposure frequency | 19 |
| | Exposure route | 318 |
| | Number of workers | 103 |
| | Particle size characterization | 81 |
| | Personal protective equipment | 221 |
| | Personal sampling data | 322 |
| | Physical form | 275 |
| | Worker activity description | 503 |
| | Total | 682 |
| Grand Total | | 775 |

**Figure 2-6. Peer-Reviewed Literature Inventory Heat Map – Engineering Search Results for Asbestos**

View the interactive version in HAWC for additional study details. Data in this figure represent references obtained from the publicly available databases search (see Appendix A.1.3) that were included during full-text screening as of May 6, 2022. Additional data may be added to the interactive version as they become available.

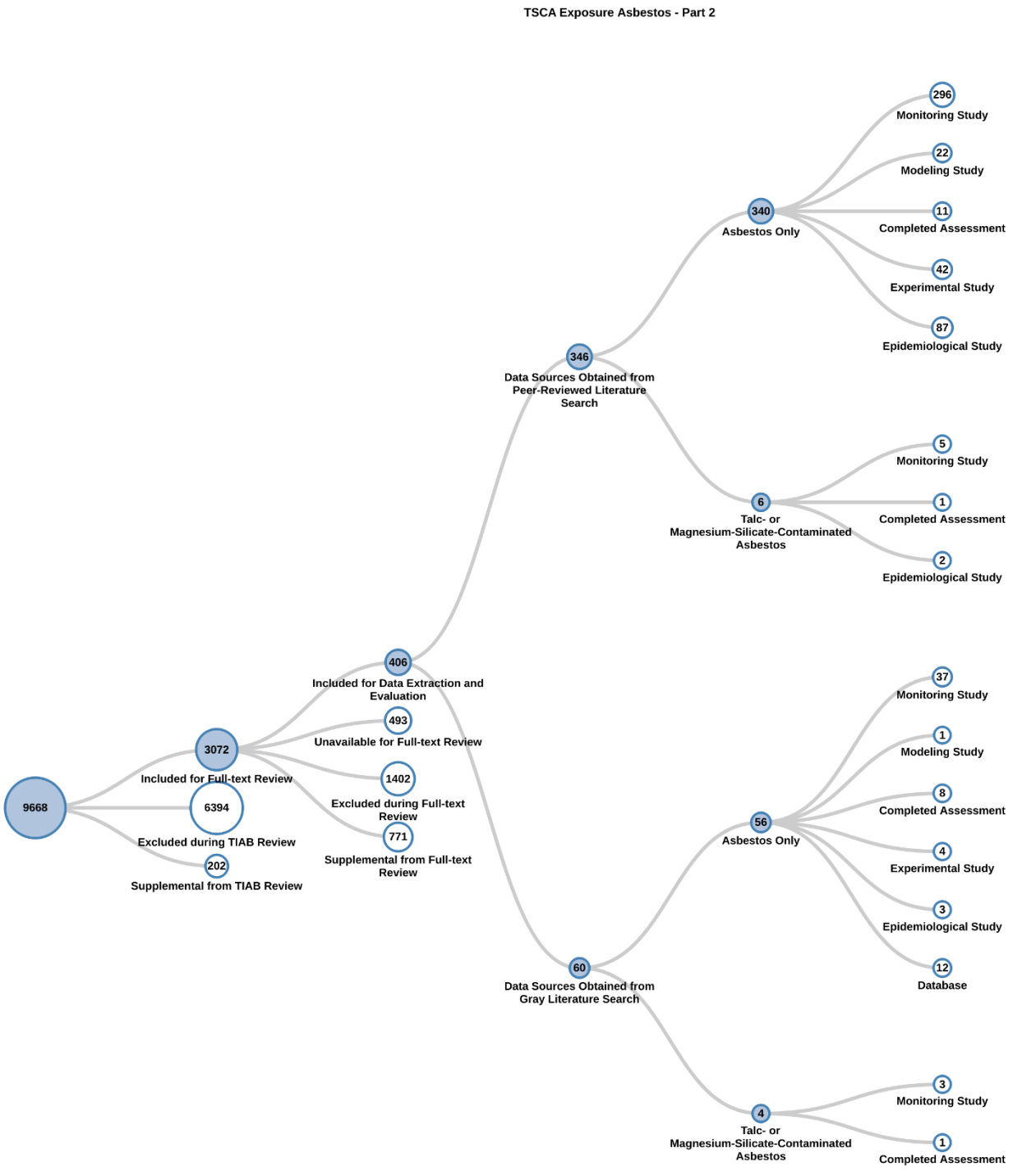


**Figure 2-7. Peer-Reviewed Literature and Gray Literature – Exposure Search Results for Asbestos**

View the interactive literature inventory tree in HAWC. Data in this figure represents references obtained from the publicly available databases search (see Appendix A.1.3.) and gray literature search (see Appendix A.3) that were included during full-text screening as of May 12, 2022. Additional data may be added to the interactive version as they become available.

**Exposure Heat Map of Asbestos (Asbestos ONLY)**

| Media (group) | Data Type | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Monitoring Study | Modeling Study | Completed Assessment | Experimental Study | Epidemiological Study | Database | Survey | Grand Total |
| Ambient Air | 141 | 15 | 17 | 12 | 21 | 2 | | 165 |
| Biosolids/Sludge | 3 | | | | | | | 3 |
| Drinking Water | 39 | 2 | 1 | 4 | 3 | 1 | | 42 |
| Groundwater | 14 | | 1 | 1 | | 1 | | 16 |
| Sediment | 16 | | 3 | 2 | | | | 16 |
| Soil | 24 | | 9 | 3 | 4 | | | 31 |
| Surface Water | 44 | 2 | 3 | 4 | | 1 | | 46 |
| Wastewater | 3 | | | | | | | 3 |
| Aquatic Species | 4 | 1 | 2 | | | | | 6 |
| Terrestrial Species | 16 | | 2 | 2 | 2 | | | 17 |
| Consumer | 45 | 8 | 3 | 37 | 1 | 11 | | 87 |
| Dietary | 1 | 1 | 1 | | | | | 3 |
| Dust | 35 | | 3 | 6 | 2 | | | 39 |
| Exposure Factors | 18 | 5 | 7 | 5 | 4 | | | 29 |
| Exposure Pathway | 67 | 8 | 10 | 7 | 14 | 1 | | 80 |
| Human Biomonitoring | 113 | 2 | | 7 | 73 | | | 116 |
| Indoor Air | 96 | 5 | 8 | 20 | 12 | 2 | | 116 |
| Isomers | | | | | | | | |
| Use Information | 25 | 4 | 6 | 15 | 3 | 1 | | 39 |
| Land Disposal/Landfill | 8 | 2 | 3 | 1 | 1 | | | 10 |
| Geology/Geochemistry | 13 | 1 | 2 | 1 | | | | 13 |
| Grand Total | 333 | 23 | 19 | 46 | 90 | 12 | | 396 |

**Figure 2-8. Peer-Reviewed and Gray Literature Inventory Heat Map – Exposure Search Results for Asbestos**

View the interactive version in HAWC for additional study details. The column totals, row totals, and grand totals indicate total numbers of unique references only, as some references may be included in multiple cells. The various shades of color visually represent the number of relevant references identified by exposure media or data type. The darker the color, the more references are available for a given exposure media or data type. Data in this figure represent all references obtained from the publicly available databases search (see Appendix A.1.3), and gray literature references search (see Appendix A.3) that were included during full-text screening as of May 17, 2022. Additional data may be added to the interactive version as they become available.

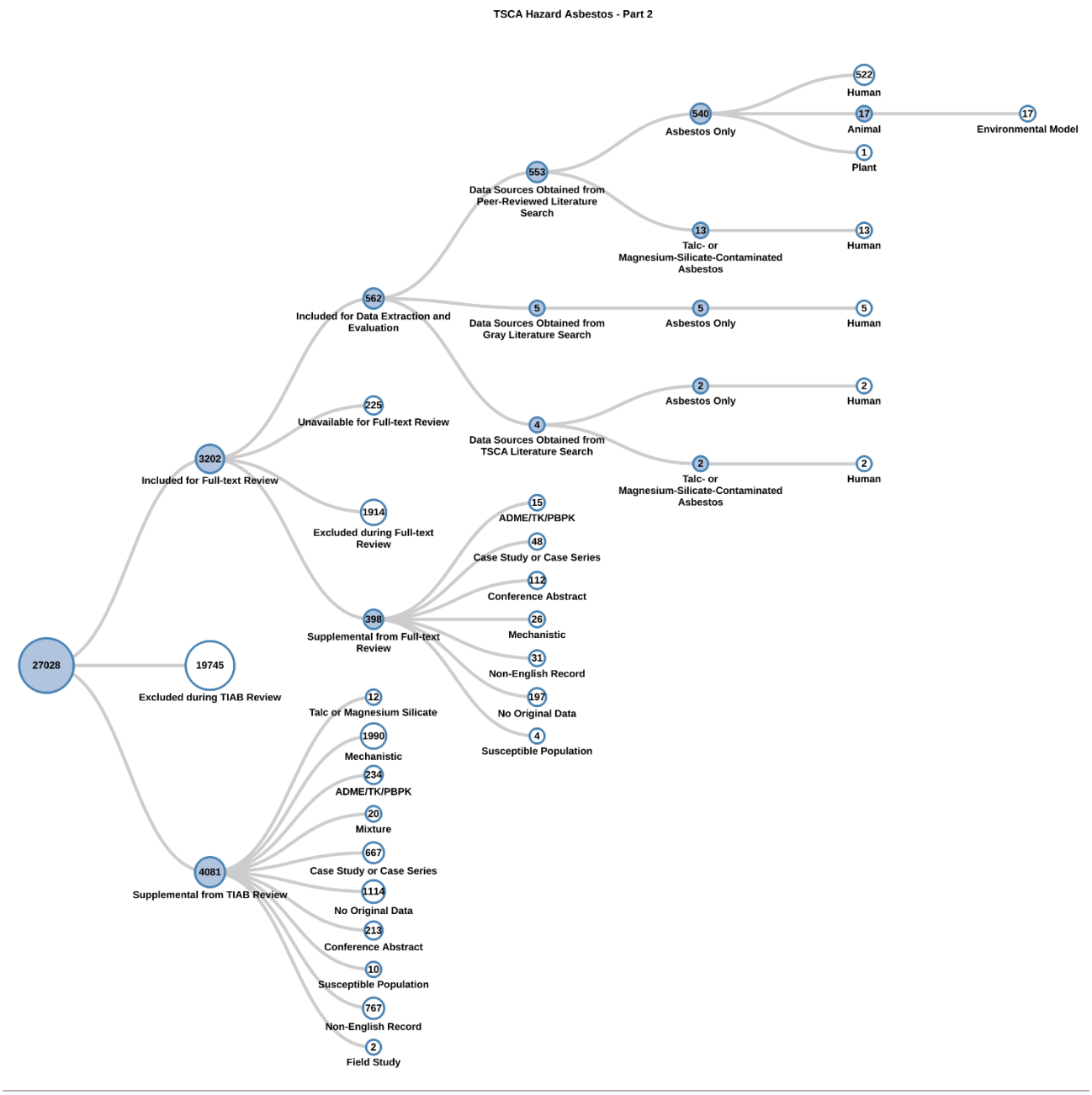


**Figure 2-9. Peer-Reviewed Literature Inventory Tree – Human Health and Environmental Hazards Search Results for Asbestos**

View the interactive literature inventory tree in HAWC. Data in this figure represents references obtained from the publicly available databases search (see Appendix A.1.3) that were included during full-text screening as of May 12, 2022. Additional data may be added to the interactive version as they become available.

**Heat Map**

| Health Outcomes | Evidence Type: Human | Evidence Type: Animal - Environmental Model | Evidence Type: Plant | Grand Total |
|---|---|---|---|---|
| ADME | 46 | 2 | | 48 |
| Cancer | 366 | 12 | | 378 |
| Cardiovascular | 14 | 1 | | 15 |
| Developmental | 117 | 8 | | 125 |
| Endocrine | 4 | 5 | | 9 |
| Gastrointestinal | 105 | 10 | | 115 |
| Hematological and Immune | 27 | 2 | | 29 |
| Hepatic | 11 | 4 | | 15 |
| Mortality | 161 | 11 | | 172 |
| Musculoskeletal | 10 | 1 | | 11 |
| Neurological | 11 | 1 | | 12 |
| Nutritional and Metabolic | 7 | 2 | 1 | 10 |
| Ocular and Sensory | 36 | | | 36 |
| PBPK | 16 | | | 16 |
| Renal | 9 | 3 | | 12 |
| Reproductive | 17 | 3 | | 20 |
| Respiratory | 410 | 5 | | 415 |
| Skin and Connective Tissue | 3 | 4 | | 7 |
| No Tag | 27 | | | 27 |
| Grand Total | 529 | 17 | 1 | 547 |

**Figure 2-10. Peer-Reviewed Literature Inventory Heat Map – Human Health and Environmental Hazards Search Results for Asbestos**

View the interactive version in HAWC for additional study details. The numbers indicate the number of studies with TIAB keywords related to a particular health outcome, not the number of studies that observed an association with asbestos. Evidence types were manually extracted, and Health Systems were determined via machine learning. Therefore, the studies examining multiple Health Outcomes and Evidence types, connections between health outcome, and evidence type may not be accurately represented. If a study evaluated multiple health outcomes or included multiple populations or study designs, it is shown here multiple times. Data in this figure represents references obtained from the publicly available databases search (see Appendix A.1.3) that were included during full-text screening as of May 11, 2022. Additional data may be added to the interactive version as they become available.

### 2.1.3 Search of TSCA Submissions

Table 2-1 presents the results of screening the titles of data sources and reports submitted to EPA under various sections of TSCA for asbestos. EPA screened a total of 590 submissions[2] using PECO or other statements that identify inclusion/exclusion criteria specific to individual disciplines (see Table 2-1 for the list of disciplines). The details about the criteria are presented in Appendix A.2.1. EPA identified 433 submissions that met the inclusion criteria in these statements and identified 6 submissions with supplemental data. EPA excluded 151 submissions because they were identified as one of the following: preliminary results of a final report that was included based on screening criteria, duplicate of a report

[2] Records for four additional submissions were located, but no corresponding title or document was available. These submissions were not screened due to insufficient information.

received in another submission that was included based on screening criteria, letter or notification containing no data, and type of study that did not meet the screening criteria (*i.e.,* study on animal model of human health effects, study on a chemical not in scope).

**Table 2-1. Results of Title Screening of Submissions to EPA under Various Sections of TSCA[a]**

| Discipline | Included | Supplemental[b] |
|---|---|---|
| Physical and Chemical Properties | 0 | 0 |
| Environmental Fate and Transport | 1 | 0 |
| Environmental and General Population Exposure | 42 | 0 |
| Occupational Exposure/Release Information | 418 | 0 |
| Environmental Hazard | 0 | 0 |
| Human Health Hazard | 96 | 6 |

[a] Individual submissions may be relevant to multiple disciplines.
[b] Included submissions may contain supplemental data for other disciplines that will be identified at full-text review.

## 2.2 Conditions of Use

EPA examined prior regulatory and information gathering efforts related to the July 12, 1989, Final Rule, *Prohibition of the Manufacture, Importation, Processing, and Distribution in Commerce of Certain Asbestos-Containing Products; Labeling Requirements* (54 FR 29507), including a review of the associated Regulatory Impacts Analysis to formulate the COUs[3] for legacy uses of asbestos and associated disposals. EPA also consulted a variety of other sources (including published literature, company websites, government publications, and commercial trade databases) to identify legacy uses of asbestos and associated disposals.

The categories and subcategories of conditions of use that EPA plans to consider in Part 2 of the Risk Evaluation are presented in Section 2.2.1 (Table 2-2). The conditions of use included in the scope of Part 2 are those reflected in the life cycle diagrams and conceptual models in Sections 2.2.3 and 2.6, respectively.

Talc, a hydrous magnesium silicate mineral, is of commercial interest. Talc deposits can contain impurities that may pose a risk to human health, including asbestos. Thus, Section 2.2.1 also describes the implicated uses of asbestos-containing talc that may be evaluated in the Part 2 of the Risk Evaluation.

After gathering reasonably available information related to the legacy use and associated disposal of legacy asbestos, EPA identified those activities the Agency determined not to be conditions of use. These excluded activities are described in Section 2.2.2.

[3] *Conditions of use* means the circumstances, as determined by the Administrator, under which a chemical substance is intended, known, or reasonably foreseen to be manufactured, processed, distributed in commerce, used, or disposed of (15 U.S.C. 2602(4)).

### 2.2.1 Categories and Subcategories of Conditions of Use Included in the Scope of Part 2 of the Risk Evaluation

Table 2-2 lists the conditions of use that are included in the scope of Part 2 of the Risk Evaluation.

**Table 2-2. Categories and Subcategories of Legacy Conditions of Use Included in the Scope of the Risk Evaluation**

| Life Cycle Stage[a] | Category[b] | Subcategory[c] | Item/Application | Reference(s) |
|---|---|---|---|---|
| Industrial/ Commercial Uses | Chemical Substances in Construction, Paint, Electrical, and Metal Products | Construction and building materials covering large surface areas, including paper articles; metal articles; stone, plaster, cement, glass, and ceramic articles | Siding; corrugated paper (for use in pipe wrap insulation and appliances); commercial papers, millboard; rollboard; specialty paper; roofing felt; cement; shingles; corrugated cement; ceiling tiles; loose-fill insulation (asbestos-containing vermiculite); asbestos cement pipes and ducts (water, sewer and air); Galbestos (wallboard & joint compound); wall protectors; air duct insulation; soldering and welding blocks and sheets; stove gaskets and rings; asbestos-coated steel pipelines; flooring felt; vinyl floor tiles | U.S. EPA (1989)<br><br>EPA 2021 (vermiculite webpage) |
| | | Machinery, mechanical appliances, electrical/electronic articles | Corrugated commercial and specialty papers; reinforced plastics for appliances such as ovens, dishwashers, boilers, and toasters; miscellaneous electro-mechanical parts for appliances including deep fryers, frying pans and grills, mixers, popcorn poppers, slow cookers, washers and dryers, refrigerators, curling irons, electric blankets, portable heaters, safes, safety boxes, filing cabinets, and kilns and incinerators | U.S. EPA (1989) |
| | | Other machinery, mechanical appliances, electronic/electronic articles | Braking and gear-changing (clutch) components in a variety of industrial and commercial machinery including combines, mining equipment, construction equipment such as cranes and hoists, heavy equipment used in various manufacturing industries (*e.g.,* machine tools and presses), military equipment, marine engine transmissions, and elevators; packings/seals in rotary, centrifugal, and reciprocating pumps, valves, expansion joints, | U.S. EPA (1989) |

| Life Cycle Stage[a] | Category[b] | Subcategory[c] | Item/Application | Reference(s) |
|---|---|---|---|---|
| Industrial/ Commercial Uses | | | soot blowers, and other types of mechanical equipment; electro-mechanical parts including commutators, switches, casings, and thermoplugs; arc chutes; electrical panels; transformers (high grade electrical paper) | |
| | | Fillers and putties | Adhesives and sealants; extruded sealant tape; rubber and vinyl sealants; epoxy adhesives | U.S. EPA (1989) |
| | | Solvent-based/water-based paint | Coatings; corrugated coatings; textured paints; vehicle undercoating | U.S. EPA (1989) |
| | | Electrical batteries and accumulators | Insulator for terminals | U.S. EPA (1989) |
| | Chemical Substances in Furnishing, Cleaning, Treatment Care Products | Construction and building materials covering large surface areas, including fabrics, textiles, and apparel | Asbestos textiles including yarn, thread, wick, cord, rope, tubing (sleeving), cloth, and tape | U.S. EPA (1989) |
| | | Furniture & furnishings including stone, plaster, cement, glass, and ceramic articles; metal articles; or rubber articles | Iron rests; burner mats; barbecue mitts; pot holders | CPSC-EPA 1979 (44 FR 60056) |
| | Chemical Substances in Packaging, Paper, Plastic, Toys, Hobby Products | Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft) | Asbestos reinforced plastics | U.S. EPA (1989) |
| | | Toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard) | Mineral kits | CPSC (1977) |
| | Chemical Substances in Products not | Other (artifacts) | Artifacts in museums and collections | |
| | | Other (aerospace applications) | Other aerospace applications including RS-25 engine thermal isolator blocks; high-performance | U.S. EPA (1989) |

| Life Cycle Stage[a] | Category[b] | Subcategory[c] | Item/Application | Reference(s) |
|---|---|---|---|---|
| | Described by Other Codes | | plastics for aerospace including heat shields, rocket motor casings, and rocket motor liners | |
| Consumer Uses | Chemical Substances in Construction, Paint, Electrical, and Metal Products | Construction and building materials covering large surface areas, including paper articles; metal articles; stone, plaster, cement, glass and ceramic articles | Siding; corrugated paper (for use in pipe wrap insulation and appliances); commercial papers; millboard; rollboard; specialty paper; roofing felt; cement; shingles; corrugated cement; ceiling tiles; loose-fill insulation (asbestos-containing vermiculite); asbestos cement pipes and ducts (water, sewer and air); Galbestos; fireplace embers; stove gaskets and rings; flooring felt; vinyl floor tiles | U.S. EPA (1989)<br><br>EPA 2021 (vermiculite webpage) |
| | | Machinery, mechanical appliances, electrical/electronic articles | Corrugated commercial and specialty papers; reinforced plastics for appliances such as ovens, dishwashers, boilers and toasters; miscellaneous electro-mechanical parts for appliances including deep fryers, frying pans and grills, mixers, popcorn poppers, slow cookers, washers and dryers, refrigerators, curling irons, electric blankets, portable heaters, safes, safety boxes, filing cabinets, and kilns and incinerators | U.S. EPA (1989) |
| | | Fillers and putties | Adhesives and sealants; extruded sealant tape | U.S. EPA (1989) |
| | | Solvent-based/water-based paint | Coatings; textured paints; vehicle undercoating | U.S. EPA (1989) |
| | Chemical Substances in Furnishing, Cleaning, | Construction and building materials covering large surface areas, including fabrics, textiles, and apparel | Asbestos textiles including yarn, thread, wick, cord, rope, tubing (sleeving), cloth, tape | U.S. EPA (1989) |

| Life Cycle Stage[a] | Category[b] | Subcategory[c] | Item/Application | Reference(s) |
|---|---|---|---|---|
| | Treatment Care Products | Furniture and furnishings, including stone, plaster, cement, glass, and ceramic articles; metal articles; or rubber articles | Iron rests; burner mats; barbecue mitts; pot holders and similar items | CPSC-EPA 1979 (44 FR 60056) |
| | Chemical Substances in Packaging, Paper, Plastic, Toys, Hobby Products | Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft) | Asbestos reinforced plastics | U.S. EPA (1989) |
| | | Toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard) | Mineral kits | CPSC (1977) |
| | Chemical Substances in Automotive, Fuel, Agriculture, Outdoor Use Products | Lawn and Garden Care Products | Asbestos-containing vermiculite soil treatment | U.S. EPA (2000a) |
| | Chemical Substances in Products not Described by Other Codes | Other (artifacts) | Vintage artifacts in private collections; vintage cars, articles, curios | CPSC-EPA 1979 (44 FR 60056) |
| Disposal, including Distribution for Disposal | Disposal, including Distribution for Disposal | Disposal, including Distribution for Disposal | Articles containing asbestos, demolition debris | |

[a] Life Cycle Stage Use Definitions (40 CFR 711.3)
- "Industrial use" means use at a site at which one or more chemicals or mixtures are manufactured (including imported) or processed.
- "Commercial use" means the use of a chemical or a mixture containing a chemical (including as part of an article) in a commercial enterprise providing saleable goods or services.
- "Consumer use" means the use of a chemical or a mixture containing a chemical (including as part of an article, such as furniture or clothing) when sold to or made available to consumers for their use.
- Although EPA has identified both industrial and commercial uses here for purposes of distinguishing scenarios in this document, the Agency interprets the authority over "any manner or method of commercial use" under TSCA section 6(a)(5) to reach both.

| Life Cycle Stage[a] | Category[b] | Subcategory[c] | Item/Application | Reference(s) |
|---|---|---|---|---|
| [b] These categories of conditions of use appear in the Life Cycle Diagram, reflect CDR codes, and broadly represent conditions of use of asbestos in industrial and/or commercial settings.<br>[c] These subcategories reflect more specific conditions of use of asbestos. | | | | |

***Talc and Vermiculite***

The COUs for a chemical substance are the circumstances under which a chemical substance is intended, known, or reasonably foreseen to be present. However, a unique challenge can arise when a chemical or substance is not intended but is known or reasonably foreseen to be present in a COU. In the case of asbestos, there is concern about the presence of asbestos as a contaminant due to its natural geologic colocation with other commercially mined substances, such as talc and vermiculite.

Vermiculite, a silicate, mica-like mineral, was widely used in building materials that will be a focus of much of Part 2 of the risk evaluation. It is well established that LAA—which consists mostly of winchite, richterite, and tremolite fibers with trace amounts of other amphiboles—is known to be present in vermiculite that was extracted from an open pit mine near Libby, Montana. Although the mine closed in 1990, it provided over 70 percent of all vermiculite sold in the United States from 1919 to 1990 (U.S. EPA, 2014). It has been demonstrated that asbestos has been detected in other vermiculite but not to the same degree or the same type of contamination. Thus, in Part 2 of the Risk Evaluation, it will be important to consider asbestos fibers in vermiculite.

Talc is a hydrous magnesium silicate mineral that is of commercial interest because of several properties including its chemical inertness, high dielectric strength, high thermal conductivity, and low electrical conductivity. Some talc deposits and articles containing talc have been shown to contain impurities that pose potential health risk, including asbestos. Thus, it is recognized that certain uses of asbestos-containing talc may present the potential for asbestos exposure. Where EPA identifies reasonably available information demonstrating asbestos-containing talc COUs that fall under TSCA authority, these will be evaluated in Part 2 of the Risk Evaluation for asbestos. Unlike the majority of COUs to be considered in Part 2, these uses of talc may not be strictly legacy. Preliminary information from title and abstract screening of literature from systematic review as well as review of information submitted during development of Part 1 led to the identification of the following COUs that may be evaluated in Part 2 of the Risk Evaluation:

- Manufacture – Import of talc-containing articles with asbestos;
- Distribution – Distribution in commerce of articles with talc containing asbestos;
- Industrial/Commercial/Consumer Uses – Use of filler/putty with talc containing asbestos;
- Commercial/Consumer Uses – Use of crayons with talc containing asbestos;
- Commercial/Consumer Uses – Use of toy crime scene kits with talc containing asbestos; and
- Disposal – Disposal of articles with talc containing asbestos.

### 2.2.2 Activities Excluded from the Scope of Part 2 of the Risk Evaluation

TSCA section 6(b)(4)(D) requires EPA to identify the hazards, exposures, conditions of use, and the PESS the Administrator expects to consider in a risk evaluation. TSCA section 3(4) also grants EPA discretion to determine the circumstances that are appropriately considered to be conditions of use for a particular chemical substance.[4] As a result, EPA does not plan to include in this scope or in the risk evaluation activities described below that the Agency does not consider to be conditions of use.

[4] *Chemical substance* means any organic or inorganic substance of a particular molecular identity, including any combination of such substances occurring in whole or in part as a result of a chemical reaction or occurring in nature, and any element or uncombined radical. Chemical substance does not include (1) any mixture; (2) any pesticide (as defined in the Federal Insecticide, Fungicide, and Rodenticide Act) when manufactured, processed, or distributed in commerce for use as a pesticide; (3) tobacco or any tobacco product; (4) any source material, special nuclear material, or byproduct material (as such terms are defined in the Atomic Energy Act of 1954 and regulations issued under such Act); (5) any article the sale of which is subject to

TSCA section 3(2) excludes from the definition of "chemical substance" "any food, food additive, drug, cosmetic, or device (as such terms are defined in section 201 of the Federal Food, Drug, and Cosmetic Act [21 U.S.C. 321]) when manufactured, processed, or distributed in commerce for use as a food, food additive, drug, cosmetic, or device" as well as "any pesticide (as defined in the Federal Insecticide, Fungicide, and Rodenticide Act [7 U.S.C. 136 et seq.]) when manufactured, processed, or distributed in commerce for use as a pesticide."

Asbestos may contaminate certain personal care products (*e.g.,* talcum powder and make-up) intended for use as drugs or cosmetics. EPA has determined that asbestos that may contaminate personal care products intended for use as drugs or cosmetics falls outside TSCA's definition of "chemical substance." Activities and releases associated with such personal care products use are therefore not "conditions of use" (defined as circumstances associated with "a chemical substance," TSCA section 3(4)) and will not be evaluated during risk evaluation.

### 2.2.3 Life Cycle Diagram

Figure 2-11 provides the life cycle diagram for asbestos. The life cycle diagram is a graphical representation of the various life stages of the industrial, commercial and consumer use categories included within the scope of the risk evaluation. The information in the life cycle diagram is grouped according to the CDR processing codes and use categories (including functional use codes for industrial uses and product categories for commercial and consumer uses). Appendix E contains additional descriptions (*e.g.,* process descriptions, worker activities, process flow diagrams) for each use and disposal category.

Figure 2-12 provides the life cycle diagram for the conditions of use for asbestos-containing talc identified from the reasonably available information identified for asbestos.

the tax imposed by section 4181 of the Internal Revenue Code of 1954 (determined without regard to any exemptions from such tax provided by section 4182 or 4221 or any other provision of such Code), and; (6) any food, food additive, drug, cosmetic, or device (as such terms are defined in section 201 of the Federal Food, Drug, and Cosmetic Act) when manufactured, processed, or distributed in commerce for use as a food, food additive, drug, cosmetic, or device (TSCA section 3(2)).

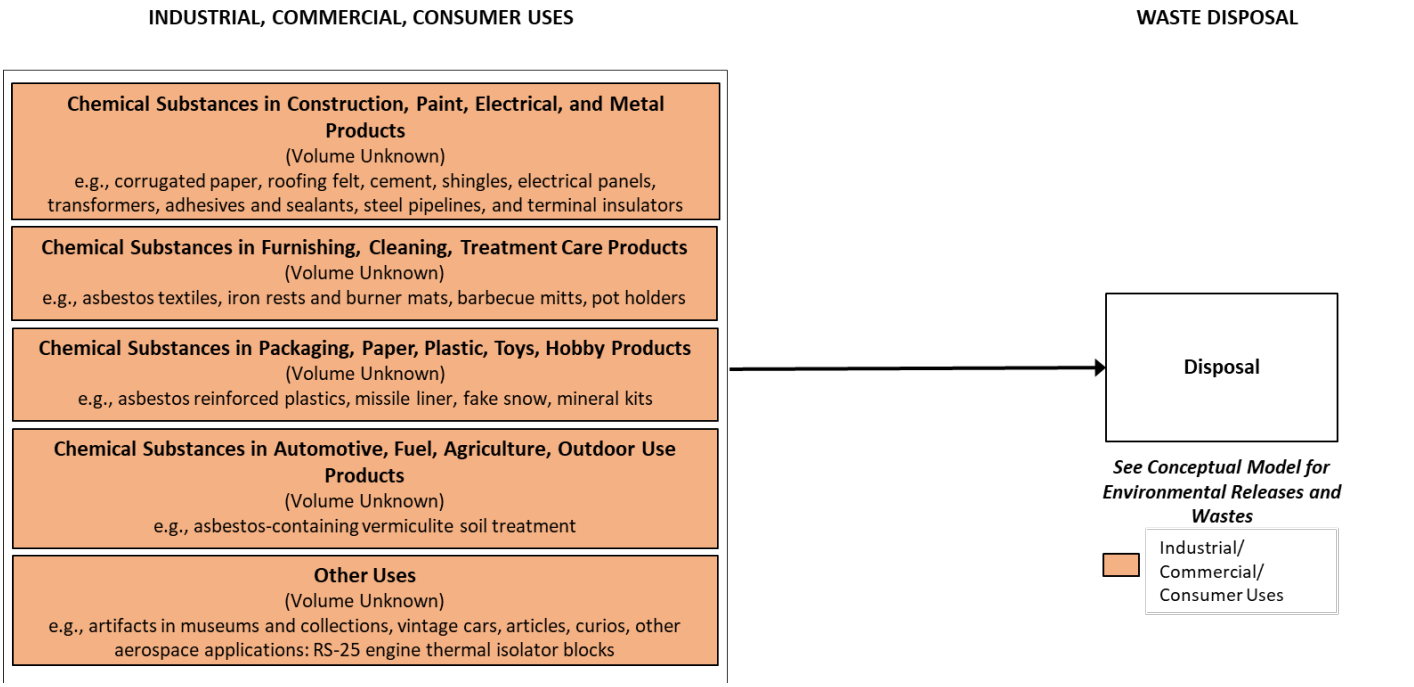


**Figure 2-11. Asbestos Life Cycle Diagram**

*Distribution in commerce not included in LCD*: For the purposes of the risk evaluation, distribution in commerce is the transportation associated with moving chemical substances in commerce. Unloading and loading activities are associated with other conditions of use.

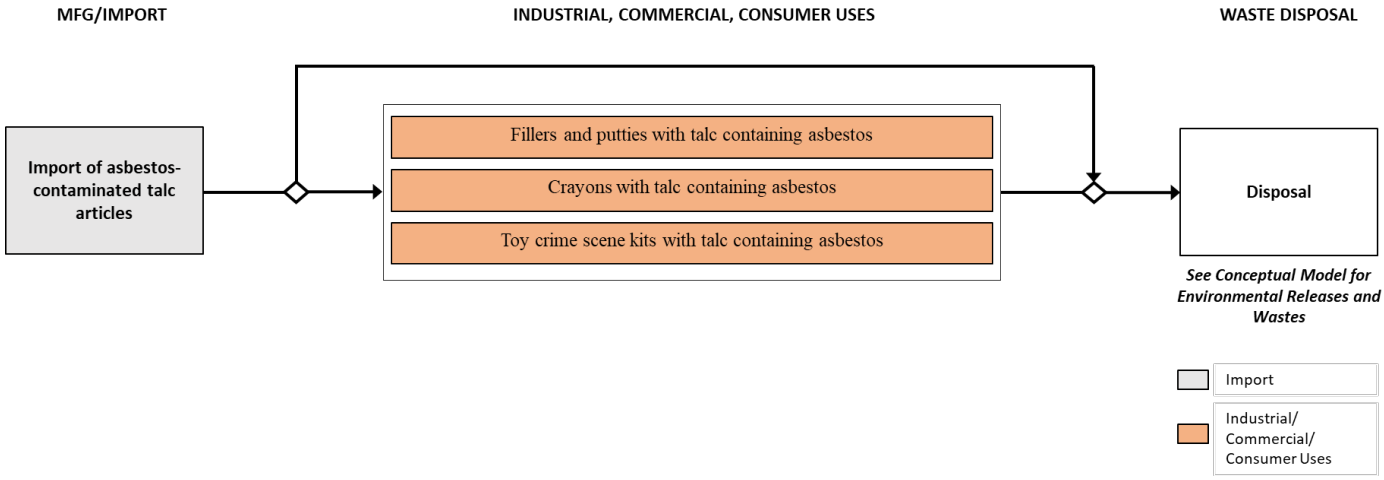


**Figure 2-12. Life Cycle Diagram for Asbestos-Containing Talc**

*Distribution in commerce not included in LCD*: For the purposes of the risk evaluation, distribution in commerce is the transportation associated with moving chemical substances in commerce. Unloading and loading activities are associated with other conditions of use.

## 2.3 Exposures

For TSCA exposure assessments, EPA plans to analyze human and environmental exposures and releases to the environment resulting from the conditions of use within the scope of Part 2 of the Risk Evaluation of asbestos. In this section, the physical and chemical properties, environmental fate and transport properties and releases to the environment are described in addition to potential human and environmental exposures from TSCA conditions of use and from other possible or known sources. Release pathways and routes will be described in Section 2.6 to characterize the relationship or connection between the conditions of use of the chemical and the exposure to human receptors, including PESS, and environmental receptors. EPA plans to consider, where relevant, the duration, intensity (concentration), frequency, and number of exposures in characterizing exposures to asbestos.

### 2.3.1 Physical and Chemical Properties

Consideration of physical and chemical properties is essential for a thorough understanding or prediction of environmental fate (*i.e.,* transport and transformation) and the eventual environmental concentrations. It can also inform the hazard assessment. Table 2-3 through Table 2-9 summarize the physical and chemical property values preliminarily selected for the asbestos fiber types and LAA. These values are for use in Part 2 of the Risk Evaluation from among the range of reported values collected as of September 2021. These tables may be updated as EPA continues to evaluate and integrate additional information through systematic review methods. Appendix B presents summary statistics for reported physical and chemical property values.

**Table 2-3. Physical and Chemical Properties for Chrysotile Asbestos (CASRN 12001-29-5)**

| Property | Value | Reference | Data Quality Rating |
|---|---|---|---|
| Essential composition | Silica sheet ($Si_2O_5$), with a layer of brucite ($Mg(OH)_2$) with every 3 hydroxyls replaced by oxygens | (NLM, 2021) | High |
| Color | Usually white to grayish green, may have tan coloring | (NLM, 2021) | High |
| Luster | Silky | (NLM, 2021) | High |
| Surface area ($m^2/g$) | 13.5–22.4 | (Addison et al., 1966) | Medium |
| Individual fiber diameter (µm) | 0.02– 0.03 | (NLM, 2021) | High |
| Average fiber outer diameter (A) | 200 | (NLM, 2021) | High |
| Particle dimension (µm) | Largest dimension (L): 1.00 ± 0.44 µm; Smallest dimension (S): 0.07 ± 0.02 µm; Aspect ratio L/S: 13.8 ± 5.1 | (Thorne et al., 1985) | High |
| Hardness (Mohs) | 2.5–4.0 | (NLM, 2021) | High |
| Density (g/mL) | 2.19–2.68 | (Elsevier, 2021c) | High |

| Property | Value | Reference | Data Quality Rating |
|---|---|---|---|
| Optical properties | Biaxial positive parallel extinction | (NLM, 2021) | High |
| Refractive index | 1.53–1.56 | (NLM, 2021) | High |
| Flexibility | High | (NLM, 2021) | High |
| Texture | Silky, soft to harsh | (NLM, 2021) | High |
| Spinnability | Very good | (Badollet, 1951) | High |
| Tensile strength (MPa) | 1,100–4,400 | (NLM, 2021) | High |
| Resistance to: Acids<br>Bases | Weak, undergoes fairly rapid attack<br>Very good | (Badollet, 1951) | High |
| Zeta potential (mV) | +13.6 to +54 | (Virta, 2011) | Medium |
| Decomposition temperature (°C) | 600–850 | (Virta, 2011) | High |
| Dielectric constant | 800 | (Elsevier, 2021c) | High |

**Table 2-4. Physical and Chemical Properties for Crocidolite (CASRN 12001-28-4)**

| Property | Value | Reference | Data Quality Rating |
|---|---|---|---|
| Essential composition | Na, Fe silicate with some water | (Badollet, 1951) | Medium |
| Color | Lavender, blue, greenish | (Badollet, 1951) | High |
| Luster | Silky to dull | (Badollet, 1951) | High |
| Surface area ($m^2/g$) | 4.62–14.80 | (Addison et al., 1966) | Medium |
| Individual fiber diameter (µm) | 0.09<br>(Median true diameter) | (Hwang, 1983) | Medium |
| Average fiber outer diameter (A) | – | – | – |
| Particle dimension (µm) | 1.16<br>(Median true length) | (Hwang, 1983) | Medium |
| Hardness (Mohs) | 4.0 | (Badollet, 1951) | Medium |
| Specific gravity | 3.2–3.3 | (Badollet, 1951) | Medium |

| Property | Value | Reference | Data Quality Rating |
|---|---|---|---|
| Optical properties | Biaxial extinction inclined | (Badollet, 1951) | Medium |
| Refractive index | 1.654–1.701 | (Lott, 1989) | High |
| Flexibility | Good | (Badollet, 1951) | High |
| Texture | Soft to harsh | (Badollet, 1951) | High |
| Spinnability | Fair | (Badollet, 1951) | High |
| Tensile strength (MPa) | 690–2100 MPa (100,000–300,000 lb./in.$^2$) | (Badollet, 1951) | Medium |
| Resistance to: Acids<br>Bases | Fair<br>Good | (Badollet, 1951) | High |
| Zeta potential (mV) | −32 | (Virta, 2011) | Medium |
| Decomposition temperature (°C) | 400–900 | (Virta, 2011) | High |
| Dielectric constant | – | – | – |

**Table 2-5. Physical and Chemical Properties for Amosite (CASRN 12172-73-5)**

| Property | Value | Reference | Data Quality Rating |
|---|---|---|---|
| Essential composition | Fe, Mg silicate | (Badollet, 1951) | Medium |
| Color | Ash gray, greenish, or brown | (Badollet, 1951) | High |
| Luster | Vitreous to pearly | (Badollet, 1951) | High |
| Surface area ($m^2/g$) | 2.25–7.10 | (Addison et al., 1966) | Medium |
| Individual fiber diameter (µm) | 0.26 (median true diameter) | (Hwang, 1983) | Medium |
| Average fiber outer diameter (A) | – | – | – |
| Particle dimension (µm) | 2.53 (median true length) | (Hwang, 1983) | Medium |
| Hardness (Mohs) | 5.5–6.0 | (Badollet, 1951) | Medium |
| Specific gravity | 3.1–3.25 | (Badollet, 1951) | Medium |

| Property | Value | Reference | Data Quality Rating |
|---|---|---|---|
| Optical properties | Biaxial positive parallel extinction | (Badollet, 1951) | Medium |
| Refractive index | 1.635–1.696 | (Lott, 1989) | High |
| Flexibility | Good | (Badollet, 1951) | High |
| Texture | Coarse, but somewhat pliable | (Badollet, 1951) | High |
| Spinnability | Fair | (Badollet, 1951) | High |
| Tensile strength (MPa) | 110–620 MPa (16,000–90,000 lb./in.$^2$) | (Badollet, 1951) | Medium |
| Resistance to: Acids<br>Bases | Fair, slowly attacked<br>Good | (Badollet, 1951) | High |
| Zeta potential (mV) | −20 to −40 | (Virta, 2011) | Medium |
| Decomposition temperature (°C) | 600–900 | (Virta, 2011) | High |
| Dielectric constant | – | – | – |

**Table 2-6. Physical and Chemical Properties for Anthophyllite (CASRN 77536-67-5)**

| Property | Value | Reference | Data Quality Rating |
|---|---|---|---|
| Essential composition | Magnesium and iron silicates | (Larrañaga et al., 2016) | High |
| Color | Grayish white, brown-gray or green | (Badollet, 1951) | High |
| Luster | Vitreous to pearly | (Badollet, 1951) | High |
| Surface area ($m^2/g$) | – | – | – |
| Individual fiber diameter (µm) | – | – | – |
| Average fiber outer diameter (A) | – | – | – |
| Particle dimension (µm) | – | – | – |
| Hardness (Mohs) | 5.5–6.0 | (Badollet, 1951) | Medium |
| Specific gravity | 2.85–3.1 | (Badollet, 1951) | Medium |
| Optical properties | Biaxial positive extinction parallel | (Badollet, 1951) | Medium |
| Refractive index | 1.596–1.652 | (Lott, 1989) | High |

| Property | Value | Reference | Data Quality Rating |
|---|---|---|---|
| Flexibility | Poor | (Badollet, 1951) | High |
| Texture | Harsh | (Badollet, 1951) | High |
| Spinnability | Poor | (Badollet, 1951) | High |
| Tensile strength (MPa) | ≤30 | (Badollet, 1951) | Medium |
| Resistance to: Acids<br>Bases | Fair<br>Very good | (Badollet, 1951) | High |
| Zeta potential (mV) | – | – | – |
| Decomposition temperature (°C) | 1,150–1,340 | (Elsevier, 2021b) | High |
| Dielectric constant | – | – | – |

**Table 2-7. Physical and Chemical Properties for Tremolite (CASRN 77536-68-6)**

| Property | Value | Reference | Data Quality Rating |
|---|---|---|---|
| Essential composition | Ca, Mg silicate with some water | (Badollet, 1951) | Medium |
| Color | White to light-green | (Larrañaga et al., 2016) | High |
| Luster | Silky | (Badollet, 1951) | High |
| Surface area ($m^2/g$) | – | – | – |
| Individual fiber diameter (µm) | 0.2–0.42 | (U.S. EPA, 2014) | – |
| Average fiber outer diameter (A) | – | – | – |
| Particle dimension (µm) | – | – | – |
| Hardness (Mohs) | 5 to 6 | (Larrañaga et al., 2016) | High |
| Density (g/m3) | 3.0–3.3 | (Larrañaga et al., 2016) | Medium |
| Optical properties | Biaxial negative extinction inclined | (Badollet, 1951) | Medium |
| Refractive index | 1.599–1.668 | (Lott, 1989) | High |
| Flexibility | Poor, generally brittle | (Badollet, 1951) | High |

| Property | Value | Reference | Data Quality Rating |
|---|---|---|---|
| Texture | Generally harsh, sometimes soft | (Badollet, 1951) | High |
| Spinnability | Generally poor, some are spinnable | (Badollet, 1951) | High |
| Tensile strength (MPa) | 7–60 MPa (1,000–8,000 lb./in.$^2$) | (Badollet, 1951) | Medium |
| Resistance to: Acids<br>Bases | Resistance to acids: fair<br>Resistance to bases: good | (Badollet, 1951) | High |
| Zeta potential (mV) | – | – | – |
| Decomposition temperature (°C) | 950–1,040 | (Virta, 2011) | High |
| Dielectric vonstant | 7.03 | (Elsevier, 2021d) | High |

**Table 2-8. Physical and Chemical Properties for Actinolite (CASRN 77536-66-4 )**

| Property | Value | Reference | Data Quality Rating |
|---|---|---|---|
| Essential composition | Ca, Mg, Fe silicate with some water | (Badollet, 1951) | Medium |
| Color | Greenish | (Badollet, 1951) | High |
| Luster | Silky, greasy to vitreous | (Badollet, 1951) and (Zhong et al., 2019) | High |
| Surface Area ($m^2/g$) | – | – | – |
| Individual fiber diameter (µm) | – | – | – |
| Average fiber outer diameter (A) | – | – | – |
| Particle dimension (µm) | 20×0.5 µm | (Zhong et al., 2019) | High |
| Hardness (Mohs) | 6.0 | (Badollet, 1951) | Medium |
| Specific gravity | 3.015–3.149 | (Zhong et al., 2019) | High |
| Optical properties | Biaxial negative extinction inclined | (Badollet, 1951) | Medium |
| Refractive index | 1.625–1.645 | (Zhong et al., 2019) | High |

| Property | Value | Reference | Data Quality Rating |
|---|---|---|---|
| Flexibility | Poor | (Badollet, 1951) | High |
| Texture | Harsh | (Badollet, 1951) | High |
| Spinnability | Poor | (Badollet, 1951) | High |
| Tensile strength (MPa) | ≤7 | (Badollet, 1951) | Medium |
| Resistance to: Acids<br>Bases | Fair<br>Fair | (Badollet, 1951) | High |
| Zeta potential (mV) | – | – | – |
| Decomposition temperature (°C) | 1,140–1,296 °C | (Elsevier, 2021a) | High |
| Dielectric constant | – | – | – |

**Table 2-9. Physical and Chemical Properties for Libby Amphibole Asbestos**

| Property | Value | Reference | Data Quality Rating |
|---|---|---|---|
| Essential composition | Winchite (84%), richterite (11%), and tremolite (6%). | U.S. EPA, 2014 | – |
| Color | – | – | – |
| Luster | – | – | – |
| Surface area ($m^2/g$) | 1.1–7.4 | U.S. EPA, 2014 | – |
| Individual fiber diameter (µm) | 0.61 ± 1.22 | U.S. EPA, 2014 | – |
| Average fiber outer diameter (A) | – | – | – |
| Particle dimension (µm) | Length (µm): 4.98–88 (20.6 average)<br>Width (µm): 0.44–1.76 (0.63 average)<br>Aspect ratio: 32.6 | U.S. EPA, 2014 | – |
| Hardness (Mohs) | – | – | – |
| Density (g/mL) | – | – | – |
| Optical properties | – | – | – |
| Refractive index | – | – | – |
| Flexibility | – | – | – |

| Property | Value | Reference | Data Quality Rating |
|---|---|---|---|
| Texture | – | – | – |
| Spinnability | – | – | – |
| Tensile strength (MPa) | – | – | – |
| Resistance to: Acids<br>Bases | – | – | – |
| Zeta potential (mV) | – | – | – |
| Decomposition temperature (°C) | – | – | – |
| Dielectric Constant | – | – | – |

### 2.3.2 Environmental Fate and Transport

Understanding of environmental fate and transport processes assists in the determination of the specific exposure pathways and potential human and environmental receptors that need to be assessed in Part 2 of the Risk Evaluation. EPA plans to use the environmental fate characteristics described in Appendix C to support the development of Part 2 of the Risk Evaluation for Asbestos. The values for the environmental fate properties may be updated as EPA evaluates and integrates additional information into the risk evaluation through systematic review methods.

### 2.3.3 Releases to the Environment

Releases to the environment from conditions of use are a component of potential exposure and may be derived from reported data that are obtained through direct measurement, calculations based on empirical data and/or assumptions and models.

EPA will consider multiple sources of information when characterizing releases of asbestos to the environment. One source of information that EPA plans to evaluate is data reported to the Toxics Release Inventory (TRI) program. EPA's TRI database contains information on chemical waste management activities that are reported by industrial and federal facilities, including quantities released into the environment (*i.e.,* to air, water, and disposed of to landfills), treated, burned for energy, recycled, or transferred off-site to other facilities for these purposes.

Under section 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA), asbestos is a TRI-reportable substance effective January 1, 1987 (40 CFR 372.65). For TRI reporting,[5] facilities in covered sectors in the United States are required to disclose releases and other waste management activity quantities of asbestos if they manufacture (including import) or process more than 25,000 pounds or otherwise use more than 10,000 pounds of the chemical in a given year by July 1 of the following year. Facilities are required to report releases or other waste management of only the friable form of asbestos, under the general CASRN 1332-21-4. According to the TRI Reporting Forms and Instructions, "friable" refers "to the physical characteristic of being able to be crumbled, pulverized, or

[5] View TRI reporting criteria on the EPA website.

reducible to a powder with hand pressure."[6] For purposes of TRI reporting, "asbestos" includes the six fiber types defined under Title II of TSCA.

Table 2-10 provides production-related waste managed data (also referred to as waste managed) for friable asbestos that industrial facilities reported to TRI for reporting year 2019. Table 2-11 summarizes the quantities that facilities reported releasing to air or water or disposed of on land.

**Table 2-10. Summary of Asbestos TRI Production-Related Waste Managed in 2019**

| Year | Number of Facilities | Recycled (lbs) | Recovered for Energy (lbs) | Treated (lbs) | Released[a b c] (lbs) | Total Production Related Waste (lbs) |
|---|---|---|---|---|---|---|
| 2019 | 38 | 0 | 0 | 1,499 | 12,084,362 | 12,085,861 |

Data source: 2019 TRI Data U.S. EPA (2019b)

[a] Terminology used in these columns may not match the more detailed data element names used in the TRI public data and analysis access points.

[b] Does not include releases due to one-time event not associated with production such as remedial actions or earthquakes.

[c] Counts all releases including release quantities transferred and release quantities disposed of by a receiving facility reporting to TRI.

In 2019, 38 facilities reported managing 12.1 million pounds of friable asbestos waste. Of this total, 0 pounds were recycled, 0 pounds were recovered for energy, approximately 1,500 pounds were treated, and the nearly 12.1 million pounds were released into the environment. Of these releases, the vast majority were released to land via Resource Conservation and Recovery Act (RCRA) Subtitle C landfills and all other land disposal methods (approximately 11 million pounds), and 77 pounds were released to air (stack and fugitive air emissions), and 0 pounds were released to water (surface water discharges). Although asbestos disposal occurs via Subtitle C landfills, asbestos is not currently listed as hazardous waste under RCRA.

[6] *Toxic Chemical Release Inventory Reporting Forms and Instructions; Revised 2019 Version*; U.S. Environmental Protection Agency; EPA 740-B-19-037; January 2020; https://ofmpub.epa.gov/apex/guideme_ext/guideme/file/ry_2019_rfi.pdf.

**Table 2-11. Summary of Releases of Asbestos to the Environment during 2019**

| Year | Number of Facilities | Air Releases | | Water Releases | Land Disposal | | | Other Releases (lbs) [a] | Total Releases (lbs) [b, c] |
|---|---|---|---|---|---|---|---|---|---|
| | | Stack Air Releases (lbs) | Fugitive Air Releases (lbs) | | Class I Under-ground Injection (lbs) | RCRA Subtitle C Landfills (lbs) | All other Land Disposal (lbs) [a] | | |
| 2019 | 38 | 38 | 38 | 0 | 0 | 7,052,146 | 4,001,623 | 0 | 11,053,846 |
| | | 77 | | | 11,053,769 | | | | |

Data source: 2019 TRI Data U.S. EPA (2019b)

[a] Terminology used in these columns may not match the more detailed data element names used in the TRI public data and analysis access points.

[b] These release quantities do include releases due to one-time events not associated with production such as remedial actions or earthquakes.

[c] Counts release quantities once at final disposition, accounting for transfers to other TRI reporting facilities that ultimately dispose of the chemical waste.

Although production-related waste managed shown in Table 2-10 excludes any quantities reported as catastrophic or one-time releases (TRI section 8 data), release quantities shown in Table 2-11 include both production-related and non-production-related quantities. The total release quantities between the two tables differ due to facilities treating a small amount of asbestos waste on-site and due to double counting of waste from facilities that transfer the waste off site and dispose of it at another reporting facility, where it is counted as on-site disposal (U.S. EPA, 2019a).

Using the TRI data available in TRI Explorer, Table 2-12 shows that there have been variable increases and decreases in total on-site and off-site disposal or other releases of friable asbestos since 2015. From 2015 to 2019, total on-site and off-site disposal or other releases of friable asbestos have decreased from 38.4 million pounds to 12.1 million pounds, respectively. The top 10 reporters of friable asbestos to TRI in 2019 comprised 80 percent of total releases. All these reporters are in the hazardous waste sector and release on-site, indicating that most friable asbestos releases are being reported from waste management facilities. However, the source of the asbestos containing material may be coming from abatement activities, demolition, and other various waste disposal activities, though the individual sources are not reported.

The vast majority of the total on-site and off-site disposal or other releases of friable asbestos are released to land (by means of RCRA Subtitle C landfills and other disposal landfills). As an example, in 2015, 36 industrial facilities reported a total of 38.4 million pounds of on- and off-site disposal or other releases of friable asbestos, in which 35.9 million pounds were released to land on-site and 2.5 million pounds were disposed of or otherwise released off-site. Release quantities to other media sources such as air and water are of much smaller magnitude. For the same 2015 reporting year, 310 pounds of friable asbestos were released to air (from both fugitive and point source air emissions), and 0 pounds were released to water (from surface water discharges). Quantities released from surface water discharges have been 0 pounds since 2015, but this observation may be driven by the fact that reporting is for friable asbestos and asbestos in wastewater may be interpreted as not being friable. The industry accounting for the highest release quantities of friable asbestos is the hazardous waste sector (presumably for landfill disposal), followed by the petroleum and other chemical and electric utility sectors (presumably for removal of asbestos-containing materials that are sent offsite for disposal).

**Table 2-12. Total On- and Off-Site Disposal or Other Releases of Friable Asbestos (2015–2019), Based on TRI Data**

| Year | Total On- and Off-Site Disposal or Other Releases (lbs) |
|---|---|
| 2015 | 38,419,830.93 |
| 2016 | 27,347,734.49 |
| 2017 | 31,318,282.85 |
| 2018 | 35,493,691.47 |
| 2019 | 11,938,882.35 |

Other sources of information provide evidence of releases of asbestos, including EPA effluent guidelines promulgated under the Clean Water Act (CWA), National Emission Standards for Hazardous Air Pollutants (NESHAPs) promulgated under the Clean Air Act (CAA), or other EPA standards and regulations that set legal limits on the amount of asbestos that can be emitted to a particular media. EPA expects to consider these data in conducting the exposure assessment component of the risk evaluation for asbestos.

The previous information sources pertain to asbestos releases primarily from industrial facilities. The risk evaluation will consider asbestos releases from many other activities beyond industrial releases. These other activities include, but are not limited to, asbestos in building materials and other products that may be released during construction and demolition activity. EPA will consider other information sources (*e.g.,* the peer-reviewed literature) when characterizing asbestos releases from these various other activities.

### 2.3.4 Environmental Exposures

The conditions of use described in Section 2.1.1 could result in releases to the environment and exposure to aquatic and terrestrial receptors (biota). Environmental exposures are informed by releases into the environment, overall persistence, and bioaccumulation within the environment, and partitioning across different media. Concentrations of chemical substances in biota provide evidence of exposure. EPA plans to review reasonably available environmental monitoring data for asbestos.

### 2.3.5 Occupational Exposures

EPA plans to evaluate worker activities where there is a potential for exposure under the various conditions of use (*e.g.,* industrial/commercial uses and disposal) described in Section 2.2. In addition, EPA plans to evaluate exposure to ONUs (*i.e.,* workers who do not directly handle the chemical but perform work in an area where the chemical is present). EPA generally intends not to make risk determinations based on assumptions about the use of PPE. However, EPA plans to develop exposure scenarios with and without the use of PPE and engineering controls to inform any potential risk management required subsequent to an unreasonable risk determination for workers or ONUs.

Examples of worker activities associated with the conditions of use within the scope for Part 2 of the risk evaluation for asbestos that EPA may analyze include, but are not limited to

- handling, loading/unloading, and disposing of waste containing asbestos;
- cleaning and maintaining equipment and appliances; and
- performing other work activities in or near areas where asbestos is being handled.

According to Occupational Safety and Health Administration (OSHA) asbestos standards, the employee permissible exposure limit (PEL) is 0.1 fibers per cubic centimeter (f/cc) as an 8-hour, time-weighted average (TWA) and an excursion limit of 1.0 f/cc as a 30-minute TWA (Asbestos General Standard 29 CFR 1910, Occupational Safety and Health Standards for Shipyard Employment 40 CFR 1915.1001, Safety and Health Regulations for Construction 40 CFR 1926.1101). EPA expects to consider inhalation exposure to asbestos fibers and dermal exposure, including skin contact with solids for workers and ONUs.

Workers and ONUs may inadvertently ingest inhaled particles that deposit in the upper respiratory tract. In addition, workers may transfer chemicals from their hands to their mouths. The frequency and significance of this exposure route are dependent on several factors including the physical and chemical properties of the substance during worker activities, the visibility of the chemicals on the hands while working, workplace training and practices, and personal hygiene that is difficult to predict (Cherrie et al., 2006). EPA will consider the relevance of this exposure route on a case-by-case basis, taking into consideration the aforementioned factors and any reasonably available information, and may assess oral exposure for workers and ONUs for certain COUs and worker activities where warranted. For certain conditions of use of asbestos, EPA plans to consider inhalation exposure to fibers for workers and ONUs. As inhalation exposure to fibers may occur, EPA plans to consider potential exposure for particulates that deposit in the upper respiratory tract from inhalation exposure and may be ingested via the oral route.

### 2.3.6 Consumer Exposures

As described in Section 2.2, the presence of the asbestos fibers included in Part 2 is indicated in a number of consumer products and articles including: construction, paint, electrical, and metal products; furnishing, cleaning, treatment care products; packaging, paper, plastic, toys, hobby products; automotive, fuel, agriculture, outdoor use products; and products not described by other codes (see Section 2.6.2 and Figure 2-13) (U.S. EPA (1989), CPSC-EPA 1979 44 FR 60056). These uses can result in exposures to consumers and bystanders (non-product users that are incidentally exposed to the product). Part 2 will focus on legacy uses and associated disposals of asbestos meaning that products and articles in consideration are no longer being manufactured, processed, or distributed for use. Products and articles in consideration are typically those that have long-term uses, secondhand sales, and hand-me-downs.

Based on reasonably available information on consumer conditions of use, inhalation of asbestos is possible through inhalation of asbestos fibers during product usage and/or indoor air/dust. Oral exposure of asbestos is possible through either ingestion through product use via transfer from hand to mouth or through mouthing of articles containing asbestos. Dermal exposure may occur via contact with asbestos fibers deposited onto the skin or direct dermal contact of articles containing asbestos. Based on these potential sources and pathways of exposure, EPA plans to analyze oral, dermal, and inhalation exposures to consumers and inhalation exposures to bystanders that may result from the COUs of asbestos as described in Section 2.6.2 and the analysis plan.

### 2.3.7 General Population Exposures

Releases of asbestos from certain COUs or disposal activities may result in general population exposures. The general population may be exposed via oral, dermal, or inhalation routes (ATSDR, 2001). Prior reports stated that the primary source of exposure to asbestos fibers for the general population is expected to be via inhalation of the fibers from naturally occurring sources of asbestos or from the wearing down or disturbance of manufactured products (ECHA, 2021; ATSDR, 2001). Dermal exposure is possible via contact of skin with asbestos fibers. Oral exposure is possible via ingestion of

asbestos fibers in drinking water and ingestion of inhaled fibers that are captured by throat mucus and swallowed. Related to these possible exposures, it is worth noting that children may also ingest fibers from soil and hand-to-mouth activities (IARC, 2012; ATSDR, 2001), and formula-fed infants drink more water per unit of body weight than adults. In addition, take-home exposures may result from workers performing renovations or activities that may result in asbestos fibers release or friable asbestos fiber release and subsequent transportation and exposure in the home environment. EPA plans to review the reasonably available information for the presence of asbestos in environmental media relevant to general population exposure.

Human biomonitoring data for asbestos fibers is difficult to collect and currently there is no direct human data on absorption or deposition of inhaled fibers (ECHA, 2021). Asbestos fibers can transport through the digestive system and be measured in urine and feces to indicate recent exposure due to their insoluble characteristics (Finn and Hallenbeck (1984); Cook and Olson (1979)). Long-term exposure can be quantified by measuring retained asbestos fibers in lung tissue via biopsy (ATSDR, 2001), which is done by removing parts of the lungs of targeted tissue or after death.

The presence in environmental media and biomonitoring data suggest that general population exposures are occurring. EPA plans to review reasonably available information related to general population exposures in Part 2 of the Risk Evaluation. The general population pathways in the scope of this evaluation are described in Section 2.6.3.

## 2.4 Hazards (Effects)

### 2.4.1 Environmental Hazards

EPA will consider reasonably available information as described in Section 2.1,

Using automated techniques during the data screening phase of systematic review, EPA identified the following potential environmental hazard effects for aquatic and terrestrial organisms, along with related information that may be considered for Part 2 of the Risk Evaluation (as explained in Appendix A): ADME, cancer, cardiovascular, developmental, endocrine, hematological and immune, hepatic, mortality, musculoskeletal, nutritional and metabolic, renal, reproductive, and respiratory (Figure 2-10). A summary of references identified during the screening step of systematic review is included in the interactive literature inventory tree (Figure 2-9). As EPA continues to evaluate reasonably available and relevant hazard information identified through systematic review, EPA may update the list of potential hazard effects to be analyzed in the risk evaluation.

### 2.4.2 Human Health Hazards

EPA will consider reasonably available information as described in Section 2.1. Broad human health hazard effects indicated in previous assessments include the development of cancers including mesothelioma and lung, ovarian, and laryngeal cancer and non-cancer effects, notably asbestosis.

Using automated techniques during the data screening phase of systematic review, EPA identified the following additional potential human health hazards along with related information that may be considered for Part 2 of the risk evaluation (as explained in Appendix A): ADME, PBPK, cancer, cardiovascular, developmental, endocrine, gastrointestinal, hematological and immune, hepatic, mortality, musculoskeletal, neurological, nutritional and metabolic ocular and sensory, renal, reproductive, respiratory, skin and connective tissue (Figure 2-10). A summary of references identified during the screening step of systematic review is included in the interactive literature inventory tree (Figure 2-9). As EPA continues to evaluate reasonably available and relevant hazard information

identified through systematic review, EPA may update the list of potential hazard effects to be analyzed in Part 2 of the risk evaluation.

## 2.5 Potentially Exposed or Susceptible Subpopulations

TSCA section 6(b)(4) requires EPA to determine whether a chemical substance or category of chemical substances presents an unreasonable risk to "a potentially exposed or susceptible subpopulation identified as relevant to the risk evaluation." TSCA section 3(12) states that "the term 'potentially exposed or susceptible subpopulation' means a group of individuals within the general population identified by the Administrator who, due to either greater susceptibility or greater exposure, may be at greater risk than the general population for adverse health effects from exposure to a chemical substance or mixture, such as infants, children, women who are or may become pregnant, workers, or the elderly." General population is "the total of individuals inhabiting an area or making up a whole group" and refers here to the U.S. general population (U.S. EPA, 2011a).

EPA plans to consider the following groups as PESS: children, women of reproductive age (*e.g.,* women who are or may become pregnant), workers, including firefighters, ONUs, consumers and bystanders, individuals who smoke, and indigenous, native populations as receptors and PESS in Part 2 of the Risk Evaluation. Other PESS may be identified based on reasonably available information.

EPA plans to increase consideration of environmental justice[7] issues by evaluating reasonably available information on factors that may make population groups of concern more vulnerable to adverse effects (*e.g.,* unique pathways; cumulative exposure from multiple stressors; and behavioral, biological, or environmental factors that increase susceptibility); identifying unique considerations for subsistence populations when relevant; and following best practices from EPA's *Technical Guidance for Assessing Environmental Justice in Regulatory Analysis* (U.S. EPA, 2016). For Part 2 of the Risk Evaluation, EPA plans to include fenceline analyses where appropriate to screen for potential effects with emphasis on PESS and environmental justice communities, followed by more in-depth analysis where warranted. EPA will continue to develop the science of how to better consider different dimensions of susceptibility when selecting critical endpoints, point of departures (PODs), determination of uncertainty factors, and margins of exposure.

In developing exposure scenarios, EPA plans to analyze reasonably available information in order to determine whether some human receptor groups may be exposed via exposure pathways that may be distinct to a particular subpopulation or life stage (*e.g.,* children at various developmental stages in life, and elderly) and whether some human receptor groups may have higher exposure via identified pathways of exposure due to unique characteristics (*e.g.,* activities, duration or location of exposure) when compared with the general population (U.S. EPA, 2006). In particular, for asbestos, age at first exposure is an important consideration due to the long latency between exposure and effect, as described in Part 1. Because asbestos consist of insoluble fibers and does not undergo absorption, distribution, metabolism, or excretion in a fashion similar to most other chemicals, which are characteristics that are unique to asbestos, infants are not likely to be exposed to asbestos through human milk (ATSDR, 2001). EPA plans to evaluate reasonably available human health hazard information in order to determine whether some human receptor groups may have greater susceptibility than the general population to the chemical's hazard(s). Based on these analyses, EPA may expand the PESS considered in the risk evaluation.

[7] Additional information is available regarding EPA's Office of Environmental Justice.

## 2.6 Conceptual Models

In this section, EPA presents the conceptual models describing the identified exposures (pathways and routes), receptors and hazards associated with the conditions of use. Pathways and routes of exposure associated with workers and ONUs are described in Section 2.6.1, and pathways and routes of exposure associated with consumers are described in Section 2.6.2. Pathways and routes of exposure associated with environmental releases and wastes are discussed and depicted the conceptual model shown in Section 2.6.3. Note that conceptual models have not been developed for potential exposures to asbestos via COUs of asbestos-containing talc due to the preliminary nature of the information that EPA is reviewing.

### 2.6.1 Conceptual Model for Legacy Industrial and Commercial Activities and Uses

Figure 2-12 illustrates the conceptual model for the pathways of exposure from legacy industrial and commercial uses and associated disposal of asbestos that EPA plans to include in Part 2 of the risk evaluation. There is potential for asbestos exposures to workers and/or ONUs via inhalation, oral, and dermal routes from fugitive dust emissions. Also, workers and ONUs may be exposed to asbestos suspended in liquid or asbestos in solid form through dermal and oral routes, as asbestos can be used/transported in liquid or solid form. EPA plans to evaluate activities resulting in exposures associated with distribution in commerce (*e.g.,* loading, unloading) throughout the various life cycle stages and conditions of use (*e.g.,* industrial use, commercial use, and disposal) rather than a single distribution scenario.

Appendix F presents the combinations of exposure pathways, routes, and receptors for each COU identified in Table 2-2 along with supporting rationale for whether EPA plans to evaluate each combination.

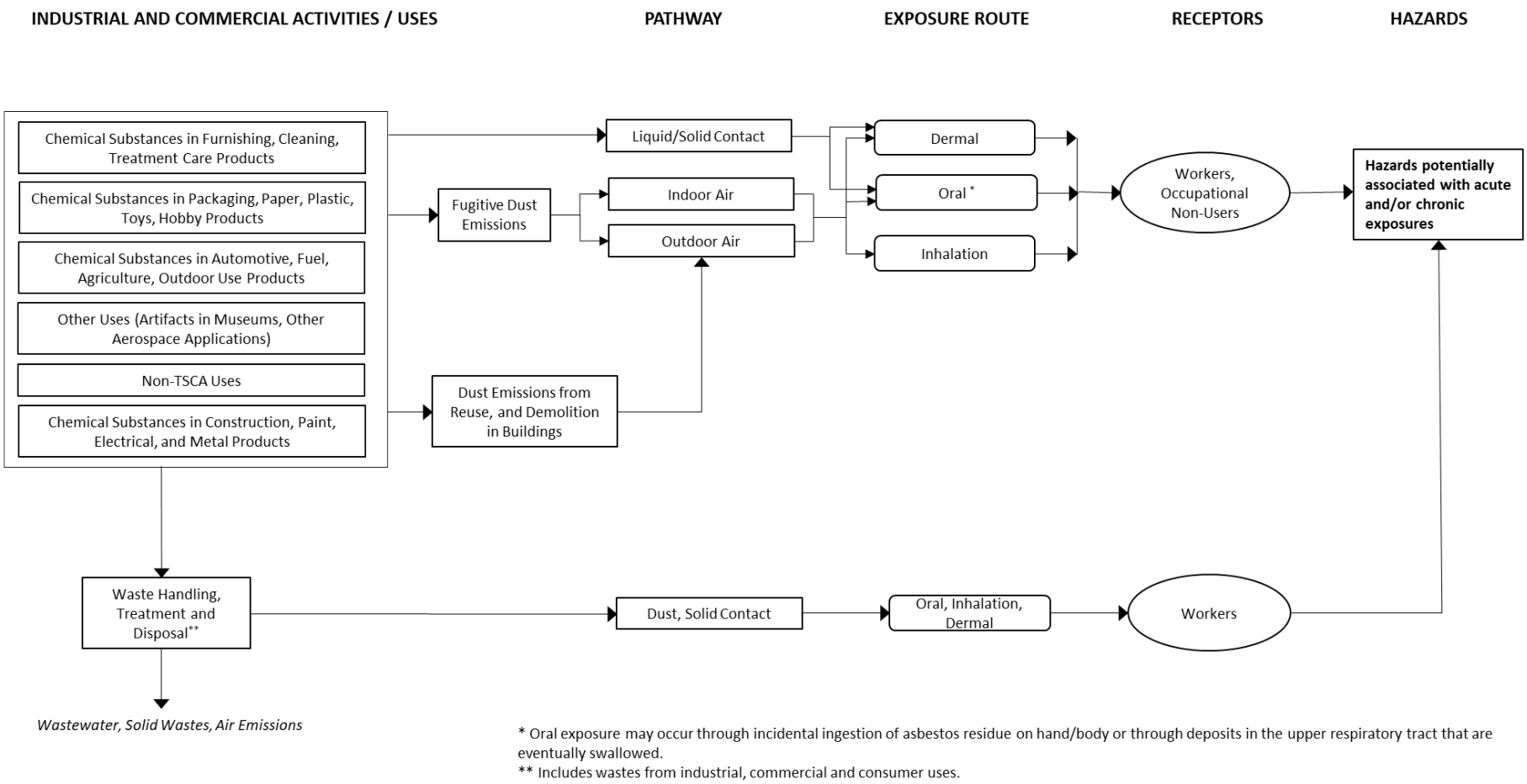


**Figure 2-12. Asbestos Conceptual Model for Legacy Industrial and Commercial Activities and Uses: Worker and ONU Exposures and Hazards**

The conceptual model presents the exposure pathways, exposure routes, and hazards to human receptors from legacy industrial and commercial activities and uses of asbestos.

### 2.6.2 Conceptual Model for Legacy Consumer Activities and Uses

The conceptual model in Figure 2-13 presents the exposure pathways, exposure routes and hazards to human receptors from legacy consumer uses and associated disposal of asbestos. EPA expects that consumers and bystanders may be exposed through use of products or articles containing asbestos via oral, dermal, and inhalation routes. An "article," as defined at 40 CFR 704.3, is distinct from a "product" in that an article is, "a manufactured item:

1. which is formed to a specific shape or design during manufacture;
2. which has end use function(s) dependent in whole or in part upon its shape or design during end use; and
3. which has either no change of chemical composition during its end use or only those changes of composition which have no commercial purpose separate from that of the article, and that result from a chemical reaction that occurs upon end use of other chemical substances, mixtures, or articles; except that fluids and particles are not considered articles regardless of shape or design."

Additionally, during use of articles, EPA expects that consumers may also be exposed via direct dermal contact or mouthing (Figure 2-13). EPA plans to analyze pathways and routes of exposure that may occur during the identified consumer activities and uses. The supporting rationale for consumer pathways considered for asbestos are included in Appendix G.

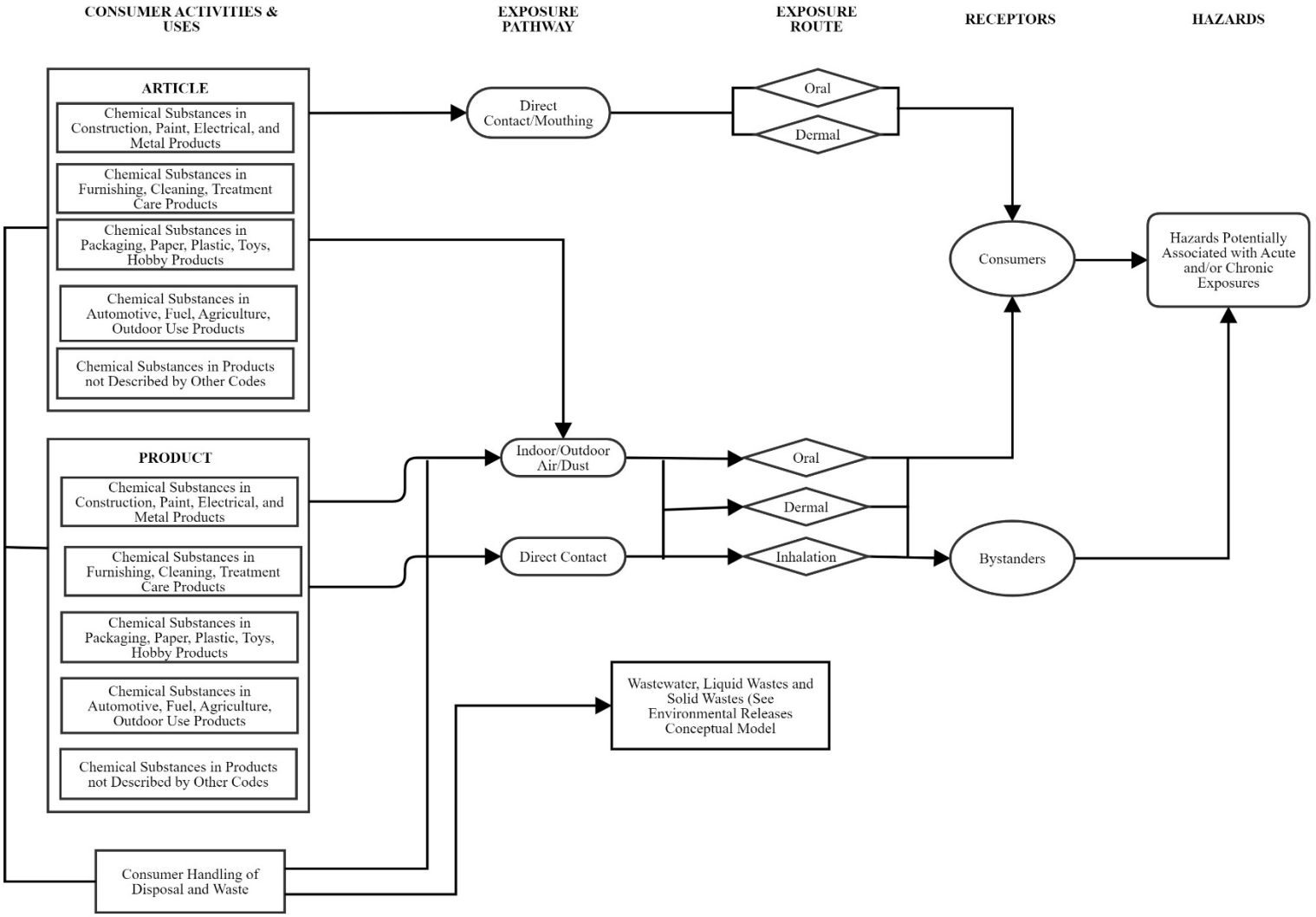


**Figure 2-13. Asbestos Conceptual Model for Legacy Consumer Activities and Uses: Consumer Exposures and Hazards**[a]

The conceptual model presents the exposure pathways, exposure routes, and hazards to human receptors from legacy consumer activities and uses of asbestos.

[a] Receptors include PESS (see Section 2.5).

### 2.6.3 Conceptual Model for Environmental Releases and Wastes: Potential Exposures and Hazards

In this section, EPA presents the conceptual model describing the identified exposures (pathways and routes from environmental releases and wastes) and hazards to general population and environmental receptors associated with the COUs of asbestos within the scope for Part 2 of the risk evaluation.

The conceptual model in Figure 2-14 presents the potential exposure pathways, exposure routes and hazards to general population and environmental receptors from releases and waste streams associated with legacy industrial, commercial and consumer uses of asbestos within the scope for Part 2 of the risk evaluation. EPA plans to evaluate exposures to receptors (*e.g.,* general population, aquatic, terrestrial species) that may occur from releases to air, drinking water, ground water, and land, including biosolids and soil. EPA expects the general population to be exposed to asbestos from air emissions via inhalation of particulate and asbestos fibers as well as from solid waste releases containing asbestos fibers; orally via drinking water, and soil ingestion; and dermally from contact with groundwater and soil. The supporting rationale for general population and environmental pathways considered for asbestos are included in Appendix H.

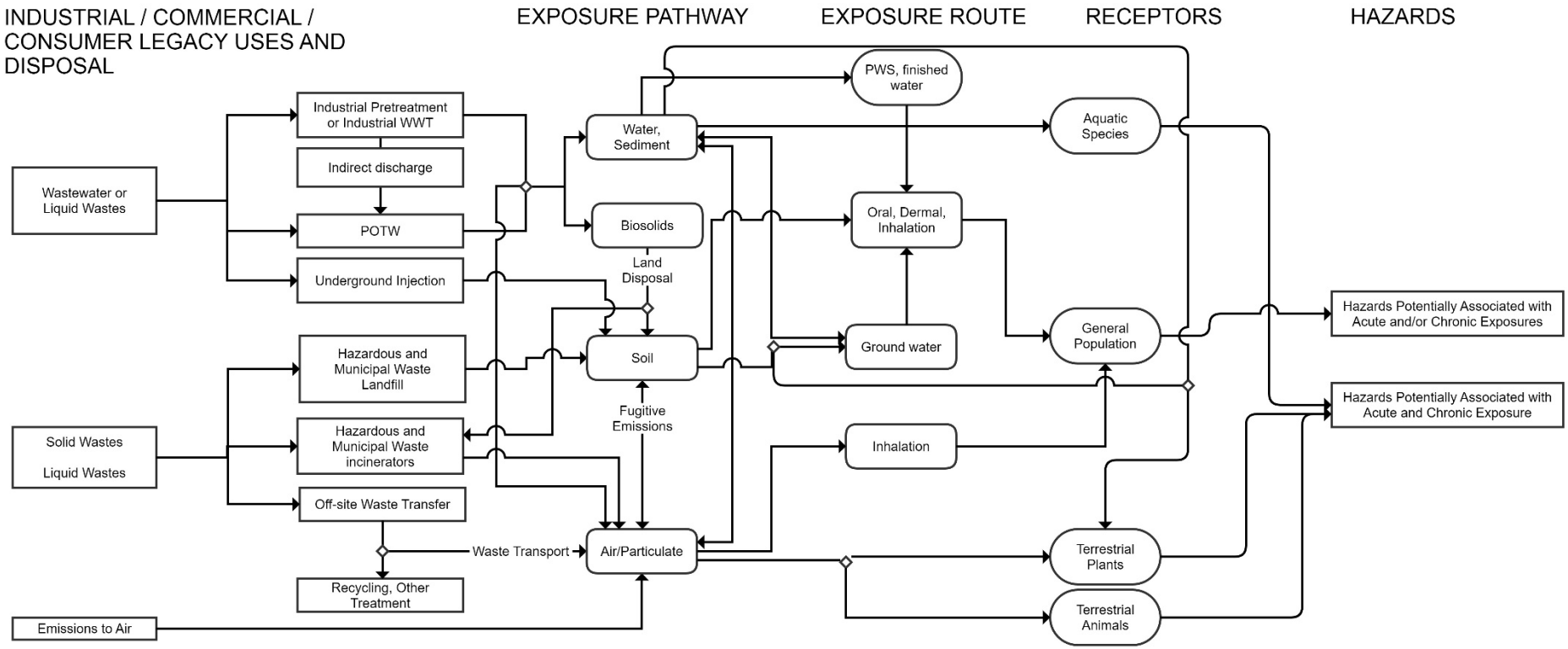


**Figure 2-14. Asbestos Conceptual Model for Environmental Releases and Wastes: Environmental and General Population Exposures and Hazards[a] [b]**

The conceptual model presents the exposure pathways, exposure routes and hazards to human and environmental receptors from releases and wastes from legacy industrial, commercial, and consumer uses of asbestos that EPA plans to consider in the risk evaluation.

[a] Industrial wastewater or liquid wastes may be treated on-site and then released to surface water (direct discharge), or pre-treated and released to publicly owned treatment works (POTW) (indirect discharge). For consumer uses, such wastes may be released directly to POTW. Drinking water will undergo further treatment in drinking water treatment plant. Groundwater may also be a source of drinking water. Inhalation from drinking water may occur via showering.

[b] Receptors include PESS (see Section 2.5).

## 2.7 Analysis Plan

The analysis plan is based on EPA's knowledge of asbestos resulting from the full-text screening of reasonably available information identified in Section 2.1 and is additionally informed by the development of Part 1 of the Risk Evaluation for Asbestos, including comments from the public and peer-review. EPA encourages submission of additional existing information, such as full study reports or workplace monitoring from industry sources, that may be relevant to EPA's evaluation of conditions of use, exposures, hazards and PESS during Part 2 of the Risk Evaluation. Targeted supplemental searches during the analysis phase may be necessary to identify additional reasonably available information (*e.g.,* commercial mixtures) for Part 2 of the Risk Evaluation of Asbestos.

### 2.7.1 Physical and Chemical Properties and Environmental Fate

EPA plans to analyze the physical and chemical properties and environmental fate and transport of asbestos fibers as follows:

1) **Review reasonably available measured or estimated physical and chemical properties and environmental fate endpoint data.**
   EPA plans to evaluate data and information collected through the systematic review process and public comments about the physical and chemical properties (Appendix B) and fate endpoints (Appendix C). EPA plans to evaluate all sources cited in EPA's analysis plan according to the procedures and metrics described in EPA's *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances* (Docket No. EPA-HQ-OPPT-2021-0414). Where experimentally measured values for chemical properties are not reasonably available or of sufficiently high quality, values will be estimated using chemical parameter estimation models as appropriate. Model-estimated fate properties will be reviewed for applicability and quality.

2) **Using measured data and/or modeling, determine the influence of physical and chemical properties and environmental fate endpoints (*e.g.,* persistence, bioaccumulation, partitioning, transport) on exposure pathways and routes of exposure to human and environmental receptors.**
   Measured data and, where necessary, model predictions of physical and chemical properties and environmental fate endpoints will be used to characterize the persistence and movement of asbestos within and across environmental media. The fate endpoints of interest include wastewater treatment removal information, sorption to organic matter in soil and sediments, suspension and resuspension, atmospheric deposition, particle transport, potential bioconcentration and bioaccumulation. EPA plans to use these endpoints in exposure calculations.

3) **Conduct a weight of the scientific evidence evaluation of physical and chemical properties and environmental fate data, including qualitative and quantitative sources of information.**
   Using information identified, evaluated, integrated using systematic review methods described in EPA's *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances* (Docket No. EPA-HQ-OPPT-2021-0414), in developing Part 2 of the Risk Evaluation EPA plans to conduct a weight of the scientific evidence evaluation of physical and chemical properties and environmental fate data, including qualitative and quantitative sources of information.

### 2.7.2 Exposure

EPA plans to analyze exposure levels for indoor dust, indoor air, ambient air, surface water, drinking water, groundwater, sediment, soil, biosolids, aquatic biota, and terrestrial biota associated to exposure to asbestos. Based on their physical and chemical properties, expected sources, and transport and transformation within the outdoor and indoor environment, asbestos fibers are more likely to be present in some of these media and less likely to be present in others. EPA has not yet determined the exposure levels in these media. Exposure level(s) can be characterized using a combination of reasonably available monitoring data and estimated exposure levels from modeling approaches. Exposure scenarios are combinations of sources (uses), exposure pathways, and exposed receptors. Draft exposure scenarios corresponding to various conditions of use for asbestos are presented in Appendix F, Appendix G, and Appendix H. EPA plans to analyze scenario-specific exposures.

#### 2.7.2.1 Environmental Releases

EPA plans to analyze releases to environmental media as follows:

1) **Review reasonably available published literature and other reasonably available information on processes and activities associated with the conditions of use to analyze the types of releases and wastes generated.**
   EPA has reviewed some sources containing information on processes and activities resulting in releases, and the information found is described in Appendix E. EPA plans to review additional data sources identified. Potential sources of environmental release data are summarized in Table 2-13.

**Table 2-13. Categories and Sources of Environmental Release Data**

| |
|---|
| U.S. EPA TRI Data |
| EPA Generic Scenarios |
| OECD Emission Scenario Documents |
| EU Risk Assessment Reports |
| EPA 1984 Analysis of Fiber Release from Asbestos Products |

2) **Review reasonably available chemical-specific release data, including measured or estimated release data (*e.g.*, data from risk assessments by other environmental agencies).**
   EPA has reviewed key release data sources including the TRI, and the data from this source is summarized in Section 2.3.3. EPA plans to evaluate additional reasonably available information during development of Part 2 of the Risk Evaluation. EPA plans to match identified data to applicable conditions of use and identify conditions of use for which data are limited. EPA plans to augment and/or supplement data through the use of models and potential surrogate data where appropriate.

   Additionally, for conditions of use where no measured data on releases are reasonably available, EPA may use various methods including release estimation approaches and assumptions in the Chemical Screening Tool for Exposures and Environmental Releases (ChemSTEER) (U.S. EPA, 2015a).

3) **Review reasonably available data that may be used in developing, adapting, or applying exposure models to the particular risk evaluation.**
   This item will be performed after completion of #1 and #2, above. EPA plans to evaluate relevant data to determine whether the data can be used to develop, adapt, or apply models for specific conditions of use (and corresponding release scenarios). EPA has identified information

from various EPA statutes and sources (including, for example, regulatory limits, reporting thresholds or disposal requirements) that may be relevant to release estimation and environmental exposures. EPA plans to consider relevant regulatory requirements in estimating releases in development of Part 2 risk evaluation.

4) **Review and determine applicability of OECD Emission Scenario Documents (ESDs) and EPA Generic Scenarios (GSs) to estimation of environmental releases.**
EPA will review OECD ESDs and GSs to determine if any are relevant to the asbestos conditions of use. If relevant ESDs and GSs are not available, other methods may be considered to estimate environmental releases. EPA may also perform supplemental targeted searches of peer-reviewed or gray literature for applicable models and associated parameters that EPA may use to estimate releases for certain conditions of use. Additionally, for conditions of use where no measured data on releases are reasonably available, EPA may use various methods including the application of default assumptions.

5) **Map or group each condition of use to a release assessment scenario(s).**
EPA has completed initial mapping of release scenarios to relevant conditions of use as shown in Appendix F. EPA plans to refine the mapping/grouping of release scenarios based on factors (*e.g.,* handling practices and exposure/release sources) corresponding to conditions of use using reasonably available information. EPA may perform supplemental targeted searches of peer-reviewed or gray literature to better understand certain conditions of use to further develop these release scenarios.

6) **Evaluate the weight of the scientific evidence of environmental release data.**
In development of Part 2 of the Risk Evaluation, EPA plans to evaluate and integrate the environmental release evidence identified in the literature inventory using revised systematic review methods described in EPA's *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances* (Docket No. EPA-HQ-OPPT-2021-0414). EPA plans to integrate the data using systematic review methods to assemble the relevant data, evaluate the data for quality and relevance, including strengths and limitations, followed by synthesis and integration of the evidence.

#### 2.7.2.2 Environmental Exposures

EPA plans to analyze the following in developing its environmental exposure assessment of asbestos:

1) **Review reasonably available environmental and biological monitoring data for all media relevant to environmental exposure.**
For asbestos, environmental media which EPA plans to analyze are sediment, soil, biosolids, air, drinking water, groundwater, and surface water.

2) **Review reasonably available information on releases to determine how modeled estimates of concentrations near industrial point sources compare with reasonably available monitoring data.**
EPA plans to analyze and consider reasonably available environmental exposure models that meet the scientific standards under TSCA section 26(h) and that estimate air, surface water, groundwater, sediment, biosolids, and soil concentrations alongside reasonably available air, surface water, groundwater, sediment, and soil monitoring data to characterize environmental exposures. Modeling approaches to estimate air concentrations, surface water concentrations, sediment concentrations, biosolids concentrations, and soil concentrations may generally include

the following inputs: direct release into air, groundwater, surface water, sediment, or soil; indirect release into air, groundwater, surface water, sediment, or soil *(i.e.,* air deposition); fate and transport (partitioning within media); and characteristics of the environment (*e.g.,* river flow, volume of lake, meteorological data).

3) **Determine applicability of existing additional contextualizing information for any monitored data or modeled estimates during risk evaluation.**
EPA plans to evaluate any studies which relate levels of asbestos in the environment or biota with specific sources or groups of sources. EPA plans to review and characterize monitoring data or modeled estimates to determine how representative they are of ongoing use patterns.

4) **Group each condition(s) of use to environmental assessment scenario(s).**
EPA plans to refine and finalize exposure scenarios for environmental receptors by considering combinations of sources (use descriptors), exposure pathways including routes, and populations exposed. For asbestos, the following are noteworthy considerations in constructing exposure scenarios for environmental receptors:

   - Estimates of air/particle concentrations, groundwater concentrations, surface water concentrations, sediment concentrations and soil concentrations near point sources based on reasonably available monitoring data;
   - Consider the following modeling inputs – release into the media of interest, fate and transport and characteristics of the environment;
   - Reasonably available biomonitoring data. Monitoring data could be used to compare with species or taxa-specific toxicological benchmarks;
   - Applicability of existing additional contextualizing information for any monitored data or modeled estimates during risk evaluation. Review and characterize the spatial and temporal variability, to the extent that data are reasonably available, and characterize exposed aquatic and terrestrial populations; and
   - Weight of the scientific evidence of environmental occurrence data and modeled estimates.

5) **Evaluate the weight of the scientific evidence of environmental occurrence data and modeled estimates.**
In development of Part 2 of the Risk Evaluation, EPA plans to evaluate and integrate the exposure evidence identified in the literature inventory using revised systematic review methods described in EPA's *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances* (Docket No. EPA-HQ-OPPT-2021-0414).

#### 2.7.2.3 Occupational Exposures

EPA plans to analyze both worker and occupational non-user exposures as follows:

1) **Review reasonably available exposure monitoring data for specific condition(s) of use.**
EPA plans to review exposure data including workplace monitoring data collected by government agencies such as OSHA and NIOSH, as well as monitoring data found in published literature. These workplace monitoring data include personal exposure monitoring data (direct exposures) and area monitoring data (indirect exposures).

   EPA has preliminarily reviewed reasonably available monitoring data collected by NIOSH (identified in Table 2-7) and will match these data to applicable conditions of use. EPA has also identified additional data sources that may contain relevant monitoring data for the various

conditions of use. EPA plans to review these sources (identified in Table 2-14) and extract relevant data for consideration and analysis in development of Part 2 of the Risk Evaluation. EPA also plans to consider any relevant, reasonably available information collected pursuant to the final reporting and recordkeeping requirements for asbestos under TSCA section 8(a)(1) (87 FR 27060, May 6, 2022).

**Table 2-14. Potential Sources of Occupational Exposure Data**

| |
|---|
| U.S. NIOSH Health Hazard Evaluation (HHE) Program reports |
| 2001 ATSDR Toxicological Profile for Asbestos |
| U.S. OSHA Chemical Exposure Health Data (CEHD) program data |
| EPA 1984 Analysis of Fiber Release from Asbestos Products |

2) **For conditions of use where data are limited or not reasonably available, review existing exposure models that may be applicable in estimating exposure levels.**
EPA plans to critically review potentially relevant OECD ESDs and EPA GSs to determine their applicability to the conditions of use assessed. EPA may conduct or perform supplemental targeted searches of peer-reviewed or gray literature to understand those conditions of use, which may inform identification of exposure scenarios. EPA may also need to perform targeted supplemental searches to identify applicable models that EPA may use to estimate exposures for certain conditions of use.

3) **Review reasonably available data that may be used in developing, adapting, or applying exposure models to a particular risk evaluation scenario.**
This step will be performed after #1 and #2 are completed. Based on information developed from #1 and #2, EPA plans to evaluate relevant data to determine whether the data can be used to develop, adapt, or apply models for specific conditions of use (and corresponding exposure scenarios). EPA may use existing, peer-reviewed exposure models developed by EPA, other government agencies, or reasonably available in the scientific literature, or EPA may elect to develop additional models to assess specific condition(s) of use. Inhalation exposure models may be simple box models or two-zone (near-field/far-field) models. In two-zone models, the near-field exposure represents potential inhalation exposures to workers, and the far-field exposure represents potential inhalation exposures to ONUs.

4) **Consider and incorporate applicable engineering controls and PPE into exposure scenarios.**
In Part 2 of the risk evaluation, EPA plans to examine the effects of engineering controls and PPE on occupational exposures to support any potential risk management required in the event of an unreasonable risk determination. OSHA recommends employers use the hierarchy of controls to address hazardous exposures in the workplace. The hierarchy of controls strategy outlines, in descending order of priority, the use of elimination, substitution, engineering controls, administrative controls, and lastly PPE. EPA plans to identify the engineering controls and PPE relevant to occupational exposure scenarios based on reasonably available information on control technology and effectiveness. Furthermore, to better inform any potential risk management, EPA plans to assess in the risk evaluation worker exposure pre- and post-implementation of engineering controls (*e.g.,* local exhaust ventilation) and with and without the use of PPE (*e.g.,* respirator) when characterizing risk.

5) **Map or group each condition of use to occupational exposure assessment scenario(s).**
EPA has identified occupational exposure scenarios and mapped them to relevant conditions of use (see Appendix F). As presented in the fourth column in Table_Apx F-1, EPA has completed

an initial mapping of exposure scenarios to conditions of use. EPA plans to refine mapping or grouping of occupational exposure scenarios based on factors (*e.g.,* handling practices or exposure/release sources) corresponding to conditions of use as additional information is identified. EPA plans to consider information submitted through public comment and may perform supplemental targeted searches of peer-reviewed or gray literature to better understand certain conditions of use to further develop exposure scenarios.

6) **Evaluate the weight of the scientific evidence of occupational exposure data, which may include qualitative and quantitative sources of information.**
In development of Part 2 of the risk evaluation, EPA plans to evaluate and integrate the exposure evidence identified in the literature inventory using revised systematic review methods described in EPA's *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances* (Docket No. EPA-HQ-OPPT-2021-0414). EPA plans to rely on the weight of the scientific evidence when evaluating and integrating occupational data. EPA plans to integrate the data using systematic review methods to assemble the relevant data, evaluate the data for quality and relevance, including strengths and limitations, followed by synthesis and integration of the evidence.

#### 2.7.2.4 Consumer Exposures

EPA plans to analyze both consumers using a consumer product and bystanders associated with the consumer using the product as follows:

1) **Group each condition of use to consumer exposure assessment scenario(s).**
EPA plans to refine and finalize exposure scenarios for consumers by considering combinations of sources (ongoing consumer uses), exposure pathways including routes, and exposed populations.

   For asbestos, the following are noteworthy considerations in constructing consumer exposure scenarios:

   - Conditions of use and type of consumer product;
   - Duration, frequency and magnitude of exposure;
   - Weight fraction of chemical in products; and
   - Amount of chemical used.

2) **Evaluate the relative potential of indoor exposure pathways based on reasonably available data.**
Indoor exposures may include dust ingestion, mouthing of products, inhalation of indoor air and dust, and dermal contact with dust, articles, and product use. EPA plans to evaluate all reasonably available information in developing the consumer exposure scenarios and evaluating the exposure pathways in indoor environments.

3) **Review existing indoor exposure models that may be applicable in estimating indoor air concentrations.**
Indoor exposure models that estimate emissions from consumer products are available. These models generally consider physical and chemical properties (*e.g.,* molecular weight), product specific properties (*e.g.,* weight fraction of the chemical in the product), use patterns (*e.g.,* duration and frequency of use), user environment (*e.g.,* room of use, ventilation rates), and receptor characteristics (*e.g.,* exposure factors, activity patterns). The OPPT's Consumer

Exposure Model (CEM) and other similar models can be used to estimate indoor air exposures from consumer products.

The OPPT's Indoor Environmental Concentrations in Buildings with Conditioned and Unconditioned Zones (IECCU) model and other similar models can be used to estimate indoor air and dust exposures from indoor sources.

4) **Review reasonably available empirical data that may be used in developing, adapting or applying exposure models to a particular risk evaluation scenario. For example, existing models developed for a chemical assessment may be applicable to another chemical assessment if model parameter data are reasonably available.**
To the extent other organizations have already modeled an asbestos consumer exposure scenario that is relevant to the OPPT's assessment (*e.g.,* ECHA, 2021; ATSDR, 2001), EPA plans to evaluate those modeled estimates as well as modeled estimates for any other chemicals similar to asbestos that have been modeled for similar uses. The underlying parameters and assumptions of the models will also be evaluated.

5) **Review reasonably available consumer product-specific sources to determine how those exposure estimates compare with each other and with indoor monitoring data reporting asbestos in specific media (*e.g.*, indoor air).**
EPA plans to evaluate the availability of asbestos concentration for various ongoing uses. These data provide the source term for any subsequent indoor modeling. EPA plans to analyze source attribution between overall indoor air levels and various indoor sources.

6) **Review reasonably available population- or subpopulation-specific exposure factors and activity patterns to determine if PESS need to be further refined.**
For asbestos, EPA plans to evaluate exposure scenarios that involve PESS and plans to consider age-specific behaviors, activity patterns and exposure factors unique to those subpopulations. For some exposure scenarios related to consumer uses, EPA plans to consider whether exposures for adults may differ from those of children due to different activities (*e.g.,* children may mouth certain products) or exposure factors (*e.g.,* inhalation rates).

7) **Evaluate the weight of the scientific evidence of consumer exposure estimates based on different approaches.**
EPA plans to rely on the weight of the scientific evidence when evaluating and integrating data related to consumer exposure. The weight of the scientific evidence may include qualitative and quantitative sources of information. EPA plans to integrate the data using systematic review methods to assemble the relevant data, evaluate the data for quality and relevance, including strengths and limitations, followed by synthesis and integration of the evidence.

#### 2.7.2.5 General Population

EPA plans to analyze general population exposures as follows:

1) **Refine and finalize exposure scenarios for general population by considering combinations of sources and uses, exposure pathways including routes, and exposed populations.**
For asbestos, the following are noteworthy considerations in constructing exposure scenarios for the general population:

   – Review reasonably available environmental and biological monitoring data for media to which general population exposures are expected;

- For exposure pathways where data are not reasonably available, review existing exposure models that may be applicable in estimating exposure levels;
- Consider and incorporate applicable media-specific regulations into exposure scenarios or modeling;
- Review reasonably available data that may be used in developing, adapting, or applying exposure models to the particular risk evaluation. For example, existing models developed for a chemical assessment may be applicable to another chemical assessment if model parameter data are reasonably available;
- Review reasonably available information on releases to determine how modeled estimates of concentrations near point sources compare with reasonably available monitoring data;
- Review reasonably available population- or subpopulation-specific exposure factors and activity patterns to determine if PESS need to be further defined;
- Review reasonably available information that may be used to build take-home exposure scenarios;
- Evaluate the weight of the scientific evidence of general population exposure data; and
- Map or group each condition of use to general population exposure assessment scenario(s).

EPA plans to evaluate a variety of data types to determine which types are most appropriate when quantifying exposure scenarios. Environmental monitoring data, biomonitoring data, modeled estimates, experimental data, epidemiological data, and survey-based data can all be used to quantify exposure scenarios. EPA anticipates that there will be a range in the potential exposures associated with the exposure scenarios identified in Section 2.6.

After refining and finalizing exposure scenarios, EPA plans to quantify concentrations and/or doses for these scenarios. The number of scenarios will depend on how combinations of uses, exposure pathways, and receptors are characterized. The number of scenarios is also dependent upon the reasonably available data and approaches to quantify scenarios. When quantifying exposure scenarios, EPA plans to use a tiered approach. First-tier analysis is based on data that is reasonably available without a significant number of additional inputs or assumptions, and may be qualitative, semi-quantitative, or quantitative. The results of first tier analyses inform whether scenarios require more refined analysis. Refined analyses will be iterative and require careful consideration of variability and uncertainty.

2) **For exposure pathways where empirical data are not reasonably available, review existing exposure models that may be applicable in estimating exposure levels.**
For asbestos, media where exposure models may be considered for general population exposure include models that estimate ambient air/particulate concentrations, drinking water concentrations, surface water concentrations, groundwater concentrations, sediment concentrations, soil concentrations, and uptake from aquatic and terrestrial environments.

3) **Review reasonably available exposure modeled estimates. For example, existing models developed for a previous asbestos chemical assessment may be applicable to EPA's assessment. In addition, another chemical's assessment may also be applicable if model parameter data are reasonably available.**
To the extent other organizations have already modeled asbestos general population exposure scenario that is relevant to this assessment, EPA plans to evaluate those modeled estimates. In addition, if modeled estimates for other chemicals with similar physical and chemical properties

and similar uses are reasonably available, EPA plans to evaluate those modeled estimates, along with their underlying parameters and assumptions.

4) **Review reasonably available information on releases to determine how modeled estimates of concentrations near point sources compare with reasonably available monitoring data.**
The expected releases from landfills and waste management facilities are changing over time. EPA plans to carefully compare any modeled concentrations based on recent release/emission estimates with reasonably available monitoring data to determine representativeness.

5) **Review reasonably available information about population- or subpopulation-specific exposure factors and activity patterns to determine if PESS need to be further defined (*e.g.,* early life and/or puberty as a potential critical window of exposure).**
EPA plans to consider age-specific behaviors, activity patters, and exposure factors unique to any PESS for exposure scenarios that involve those subpopulations. For example, children will have different intake rates for soil than adults.

6) **Evaluate the weight of the scientific evidence of general population exposure estimates based on different approaches.**
During risk evaluation, EPA plans to evaluate and integrate the exposure evidence identified in the literature inventory using revised systematic review methods described in EPA's *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances* (Docket No. EPA-HQ-OPPT-2021-0414).

### 2.7.3 Hazards (Effects)

#### 2.7.3.1 Environmental Hazards

For Part 2 of the Risk Evaluation for Asbestos, EPA plans to conduct an environmental hazard assessment of asbestos as described below. The hazard assessment may be tailored to the results of the environmental exposure analyses, where the evaluation of hazards could be based on results indicating exposures to the environment from the relevant COUs.

1) **Review reasonably available environmental hazard data, including data from alternative test methods (*e.g.,* computational toxicology and bioinformatics; high-throughput screening methods; data on categories and read-across; *in vitro* studies).**
EPA plans to analyze the hazards of asbestos to aquatic and/or terrestrial organisms, including plants, invertebrates (*e.g.,* insects, arachnids, mollusks, crustaceans), and vertebrates (*e.g.,* mammals, birds, amphibians, fish, reptiles) across exposure durations and conditions if potential environmental hazards are identified through systematic review results and public comments. EPA also plans to consider additional types of environmental hazard information (*e.g.,* analogue and read-across data) when characterizing the potential hazards of asbestos to aquatic and/or terrestrial organisms.

   EPA plans to evaluate environmental hazard data using revised evaluation strategies described in EPA's *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances* (Docket No. EPA-HQ-OPPT-2021-0414). The study evaluation results will be documented in the risk evaluation phase and data from acceptable studies will be extracted and integrated in the risk evaluation process.

Mechanistic data may include analyses of alternative test data such as novel *in vitro* test methods and high throughput screening. The association between acute and chronic exposure scenarios to the agent and each health outcome will also be integrated. Study results will be extracted and presented in evidence tables or another appropriate format by organ/system.

2) **Derive hazard thresholds for aquatic and/or terrestrial organisms.**
Depending on the robustness of the evaluated data for a particular organism or taxa (*e.g.,* aquatic invertebrates), environmental hazard values (*e.g.,* $EC_x$, $LC_x$, NOEC, LOEC) may be derived and used to further understand the hazard characteristics of asbestos to aquatic and/or terrestrial species. Identified environmental hazard thresholds may be used to derive concentrations of concern (COC) based on endpoints that may affect populations of organisms or taxa analyzed.

3) **Evaluate the weight of the scientific evidence of environmental hazard data.**
In development of Part 2 of the risk evaluation, EPA plans to evaluate and integrate the environmental hazard evidence identified in the literature inventory using revised systematic review methods described in EPA's *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances* (Docket No. EPA-HQ-OPPT-2021-0414).

4) **Consider the route(s) of exposure, based on reasonably available monitoring and modeling data and other reasonably available approaches to integrate exposure and hazard assessments.**
EPA plans to consider aquatic (*e.g.,* water and sediment exposures) and terrestrial pathways in the asbestos conceptual model (Figure 2-14). These organisms may be exposed to asbestos via a number of environmental pathways (*e.g.,* air, surface water, sediment, soil, diet).

5) **Consider a persistent, bioaccumulative, and toxic (PBT) assessment of asbestos.**
EPA plans to consider the persistence, bioaccumulation, and toxic (PBT) potential of asbestos after reviewing relevant physical and chemical properties and exposure pathways. EPA plans to assess the reasonably available studies collected from the systematic review process relating to bioaccumulation and bioconcentration (*e.g.,* BAF, BCF) of asbestos. In addition, EPA plans to integrate traditional environmental hazard endpoint values (*e.g.,* $LC_{50}$, LOEC) and exposure concentrations (*e.g.,* surface water concentrations, tissue concentrations) for asbestos with the fate parameters (*e.g.,* BAF, BCF, BMF, TMF).

#### 2.7.3.2 Human Health Hazards

EPA plans to analyze human health hazards as follows:

1) **Review reasonably available human health hazard data. It is expected that the hazard data reviewed will be limited to human health studies, given the extensive information available. If gaps in human health data are identified, animal studies (human health animal models defined in Table_Apx A-1) may be considered.**
EPA plans to evaluate human health studies using revised evaluation strategies described in EPA's *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances* (Docket No. EPA-HQ-OPPT-2021-0414). EPA plans to document the study evaluation results in the risk evaluation phase, to extract data from acceptable studies, and to integrate those data into the risk evaluation process.

The association between acute and/or chronic exposure scenarios to the relevant asbestos fibers and each relevant health outcome will also be integrated. Study results will be extracted and presented in evidence tables or another appropriate format by organ/system.

2) **In evaluating reasonably available data, identify any PESS that may have greater susceptibility to the chemical's hazard(s) than the general population.**
Reasonably available human health hazard data will be evaluated to ascertain whether some human receptor groups may have greater susceptibility than the general population to asbestos hazard(s). Susceptibility of particular human receptor groups to asbestos will be determined by evaluating information on factors that influence susceptibility.

   EPA has reviewed some sources containing hazard information associated with PESS such as children. Childhood is a susceptible lifestages for asbestos exposure given the long latency between exposure to asbestos and human health effects (*e.g.,* mesothelioma, lung cancer). EPA may conduct age-specific analyses to account for this.

3) **Conduct hazard identification (the qualitative process of identifying non-cancer and cancer endpoints) and dose-response assessment (the quantitative relationship between hazard and exposure) for identified human health hazard endpoints.**
Human health hazards from acute and chronic exposures will be identified by evaluating the human and animal data that meet the revised systematic review data quality criteria described in EPA's *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances* (Docket No. EPA-HQ-OPPT-2021-0414). Hazards identified by studies meeting data quality criteria will be grouped by routes of exposure relevant to humans (*e.g.,* oral, dermal, inhalation) and by cancer and non-cancer endpoints identified in Section 2.4.2.

   Dose-response assessment will be performed in accordance with EPA guidance (U.S. EPA, 2012, 2011b, 1994) developing POD for either margins of exposure (MOEs), cancer slope factors (CSFs), oral slope factors (OSFs), and/or inhalation unit risks (IURs). Dose-response analyses may be used if the data meet data quality criteria and if additional information on the identified hazard endpoints are not reasonably available or would not alter the analysis.

   If necessary, the cancer mode of action (MOA) analyses will be used to determine the relevancy of animal data to human risk and how data can be quantitatively evaluated. EPA may evaluate information on genotoxicity and the MOA for all cancer endpoints to determine the appropriate approach for quantitative cancer assessment in accordance with the *U.S. EPA Guidelines for Carcinogen Risk Assessment* (U.S. EPA, 2005a), in the context of the available evidence from human studies. In accordance with EPA's *Supplemental Guidance for Assessing Susceptibility from Early-life Exposures to Carcinogens* (U.S. EPA, 2005b), EPA plans to determine whether age-dependent adjustment factors (ADAFs) are appropriate for asbestos for specific conditions of use based upon potential exposures to children.

4) **Derive points of departure (PODs) where appropriate; conduct benchmark dose modeling depending on the reasonably available data. Adjust the PODs as appropriate to conform (*e.g.,* adjust for duration of exposure) to the specific exposure scenarios evaluated.**
EPA plans to evaluate hazard data to determine the type of dose-response modeling that is applicable. Where modeling is feasible, a set of dose-response models that are consistent with a variety of potentially underlying biological processes will be applied to empirically model the dose-response relationships in the range of the observed data consistent with EPA's *Benchmark*

*Dose Technical Guidance Document* (U.S. EPA, 2012). Where dose-response modeling is not feasible, NOAELs or LOAELs will be identified. Non-quantitative data will also be evaluated for contribution to weight of the scientific evidence or for evaluation of qualitative endpoints that are not appropriate for dose-response assessment.

EPA plans to evaluate whether the reasonably available PBPK and empirical kinetic models are adequate for route-to-route and interspecies extrapolation of the POD, or for extrapolation of the POD to standard exposure durations (*e.g.,* lifetime continuous exposure). If application of the PBPK model is not possible, oral PODs may be adjusted by $BW^{3/4}$ scaling in accordance with (U.S. EPA, 2011b), and inhalation PODs may be adjusted by exposure duration and chemical properties in accordance with (U.S. EPA, 1994).

It is anticipated that the exposures resulting from the relevant COUs will be from several types of asbestos fibers. Thus, EPA does not plan to evaluate hazard for individual fiber types.

5) **Evaluate the weight of the scientific evidence of human health hazard data.**
In development of Part 2 of the Risk Evaluation, EPA plans to evaluate and integrate the human health hazard evidence identified in the literature inventory under acute and chronic exposure conditions using revised systematic review methods described in EPA's *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances* (Docket No. EPA-HQ-OPPT-2021-0414). EPA will reference and build from prior assessments of asbestos (*e.g.,* (U.S. EPA, 2014); U.S (1988)), as appropriate.

6) **Consider the route(s) of exposure (*e.g.,* oral, inhalation, dermal), reasonably available route-to-route extrapolation approaches, biomonitoring data, and approaches to correlate internal and external exposures to integrate exposure and hazard assessment.**
Based on previous assessments of asbestos (*e.g.,* see EPA IRIS) (U.S. EPA, 2014; U.S, 1988) EPA believes there will be sufficient reasonably available data to conduct dose-response analysis and/or benchmark dose modeling for the inhalation route of exposure. EPA plans to also evaluate any potential human health hazards following dermal and oral exposure to asbestos, which could be important for worker, consumer, and general population risk analysis. Reasonably available data will be assessed to determine whether or not a point of departure can be identified for the dermal and inhalation routes.

### 2.7.4 Summary of Risk Approaches for Characterization

EPA plans to conduct a risk estimation and characterization of the asbestos conditions of use in the scope of Part 2 of the Risk Evaluation to identify if there are risks to the environment or human health. For environmental risk characterization, EPA plans to identify if there are risks to aquatic and/or terrestrial environments from the measured and/or predicted concentrations of asbestos in environmental media (*e.g.,* air, water, sediment, soil). Risk quotients (RQs) may be derived by the application of hazard and exposure benchmarks to characterize environmental risk (U.S. EPA, 1998; Barnthouse et al., 1982). Similarly, for human health risk characterization, EPA plans to integrate exposure estimates from measured and/or modeled data with hazard data to characterize risk to human health. Analysis of environmental or human health risk for characterization includes a confidence statement in risk estimation. This confidence statement is based on qualitative judgment describing the certainty of the risk estimate considering the strength of the evidence scores for hazard and exposure along with their limitations and relevance. The lowest confidence evaluation for either hazard or exposure will drive the overall confidence estimate.

Risk characterization is an integral component of the risk assessment process for both environmental and human health risks. EPA plans to derive the risk characterization in accordance with EPA's *Risk Characterization Handbook* (U.S. EPA, 2000b). As defined in EPA's Risk Characterization Policy, "the risk characterization integrates information from the preceding components of the risk evaluation and synthesizes an overall conclusion about risk that is complete, informative and useful for decision makers." Risk characterization is considered to be a conscious and deliberate process to bring all important considerations about risk, not only the likelihood of the risk but also the strengths and limitations of the assessment, and a description of how others have assessed the risk into an integrated picture.

The level of information contained in each risk characterization varies according to the type of assessment for which the characterization is written. Regardless of the level of complexity or information, the risk characterization for TSCA risk evaluations will be prepared in a manner that is transparent, clear, consistent, and reasonable (TCCR) (U.S. EPA, 2000b) and consistent with the requirements of the Procedures for Chemical Risk Evaluation Under the Amended Toxic Substances Control Act (82 FR 33726, July 20, 2017). As discussed in 40 CFR 702.43, risk characterization has a number of considerations. This is the step where EPA integrates the hazard and exposure assessments into risk estimates for the identified populations (including any PESS) and ecological characteristics and weighs the scientific evidence for the identified hazards and exposures. The risk characterization does not consider costs or other non0risk factors, and takes into account, "where relevant, the likely duration, intensity, frequency, and number of exposures under the condition(s) of use…." The risk characterization also summarizes the following considerations: (1) uncertainty and variability in each step of the risk evaluation; (2) data quality, and any applicable assumptions used; (3) alternative interpretations of data and analyses, where appropriate; and (4) any considerations for environmental risk evaluations, if necessary (*e.g.,* related to nature and magnitude of effects).

EPA also plans to be guided by EPA's Information Quality Guidelines (U.S. EPA, 2002) as it provides guidance for presenting risk information. Consistent with those guidelines, EPA plans to identify the following in the risk characterization (1) each population addressed by an estimate of applicable risk effects; (2) the expected risk or central estimate of risk for the PESS affected; (3) each appropriate upper-bound or lower-bound estimate of risk; (4) each significant uncertainty identified in the process of the assessment of risk effects and the studies that would assist in resolving the uncertainty; and (5) peer-reviewed studies known to the Agency that support, are directly relevant to, or fail to support any estimate of risk effects and the methodology used to reconcile inconsistencies in the scientific information.

## 2.8 Peer Review

The draft Risk Evaluation for Asbestos Part 2 will be peer reviewed. Peer review will be conducted in accordance with EPA's regulatory procedures for chemical risk evaluations, including using EPA's *Peer Review Handbook* (U.S. EPA, 2015b) and other methods consistent with section 26 of TSCA (see 40 CFR 702.45). As explained in the final rule, *Procedures for Chemical Risk Evaluation Under the Amended Toxic Substances Control Act* (82 FR 33726, 33744; July 20, 2017), the purpose of peer review is for the independent review of the science underlying the risk assessment. Peer review will therefore address aspects of the underlying science as outlined in the charge to the peer review panel such as hazard assessment, assessment of dose-response, exposure assessment, and risk characterization.

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# APPENDICES

# Appendix A ABBREVIATED METHODS FOR SEARCHING AND SCREENING

## A.1 Literature Search of Publicly Available Databases

### A.1.1 Special Considerations and Query Strings for Asbestos: Part 2 Literature

The literature strategy for Asbestos Part 2 comprises three pieces: (1) reevaluation of all references used in Part 1; (2) evaluation of new literature produced by performing a Part I search update; and (3) evaluation of new literature produced by inclusion of additional asbestos fiber types (*i.e.,* winchite, richterite, and Libby Amphibole Asbestos [LAA]). These are the search terms compiled for asbestos used in the search strategies for each of the databases listed below:

*Asbestos Search Terms:*
"Asbestos" OR "12001-28-4" OR "12001-29-5" OR "12172-67-7" OR "12172-73-5" OR "1332-21-4" OR ("Asbestos" AND "exposure") OR ("Asbestos" AND ("fiber*" OR "fibre*")) OR "chrysotile" OR "Asbestos, exposure" OR ("Asbestos" AND "dust") OR "crocidolite" OR "chrysotile asbestos" OR "tremolite" OR "actinolite" OR ("chrysotile" AND "serpentine") OR "amosite" OR "Crocidolite asbestos" OR "Asbestos crocidolite" OR "Asbestos, crocidolite" OR "anthophyllite" OR "asbestos, amphibole" OR "amphibole asbestos" OR "Amosite asbestos" OR "Asbestos dust" OR "Asbestos, amosite" OR "riebeckite" OR "14567-73-8" OR "grunerite" OR ("Silicates" AND ("tremolite" OR "asbestiform")) OR "Amiante" OR "blue asbestos" OR "17068-78-9" OR "asbestos, chrysotile" OR "Man-made mineral fibres" OR "Chrysotile A" OR "Tremolite asbestos" OR "Asbestiform minerals" OR "Asbest" OR "Asbesto" OR "Asbestose" OR "magnesioriebeckite" OR "Asbestos substitutes" OR ("Asbestos" AND "synthetic fibers") OR "white asbestos" OR "Ascarite" OR "Asbestos, tremolite" OR "serpentine chrysotile" OR "grunerite asbestos" OR "Brown asbestos" OR "riebeckite asbestos" OR "Amianthus" OR ("asbestos" AND ("Mountain" AND ("cork" OR "leather" OR "wood"))) OR ("asbestos" AND "MTM") OR "Asbestos, grunerite" OR "Chrysotile A asbestos" OR "Amorphous crocidolite asbestos" OR "Calidria RG 144" OR "Cassiar AK" OR "Fibrous crocidolite asbestos" OR "Fibrous grunerite" OR "metaxite" OR "winchite" OR "12425-92-2" OR "richterite" OR "17068-76-7" OR "Libby amphibole" OR "Libby asbestos" OR "1318-09-8" OR "Hornblendeasbest" OR "77536-66-4" OR "132207-32-0" OR "77536-68-6" OR "77536-67-5" OR "14567-61-4" OR "12135-86-3" OR "Antigorite" OR "17787-87-0"

**Table_Apx A-1. Summary of Data Sources, Search Dates, and Number of Peer-Reviewed Literature Search Results for Asbestos**

| Source | Source-Specific Search Strategy | Results |
|---|---|---|
| **Agricola**<br>Search Date: 9/30/2021 | TIAB("Asbestos" OR "12001-28-4" OR "12001-29-5" OR "12172-67-7" OR "12172-73-5" OR "1332-21-4" OR ("Asbestos" AND "exposure") OR ("Asbestos" AND ("fiber*" OR "fibre*")) OR "chrysotile" OR "Asbestos, exposure" OR ("Asbestos" AND "dust") OR "crocidolite" OR "chrysotile asbestos" OR "tremolite" OR "actinolite" OR ("chrysotile" AND "serpentine") OR "amosite" OR "Crocidolite asbestos" OR "Asbestos crocidolite" OR "Asbestos, crocidolite" OR "anthophyllite" OR "asbestos, amphibole" OR "amphibole asbestos" OR "Amosite asbestos" OR "Asbestos dust" OR "Asbestos, amosite" OR "riebeckite" OR "14567-73-8" OR "grunerite" OR | 771 |

| Source | Source-Specific Search Strategy | Results |
|---|---|---|
| | (“Silicates” AND (“tremolite” OR “asbestiform”)) OR “Amiante” OR “blue asbestos” OR “17068-78-9” OR “asbestos, chrysotile” OR “Man-made mineral fibres” OR “Chrysotile A” OR “Tremolite asbestos” OR “Asbestiform minerals” OR “Asbest” OR “Asbesto” OR “Asbestose” OR “magnesioriebeckite” OR “Asbestos substitutes” OR (“Asbestos” AND “synthetic fibers”) OR “white asbestos” OR “Ascarite” OR “Asbestos, tremolite” OR “serpentine chrysotile” OR “grunerite asbestos” OR “Brown asbestos” OR “riebeckite asbestos” OR “Amianthus” OR (“asbestos” AND (“Mountain” AND (“cork” OR “leather” OR “wood”))) OR (“asbestos” AND “MTM”) OR “Asbestos, grunerite” OR “Chrysotile A asbestos” OR “Amorphous crocidolite asbestos” OR “Calidria RG 144” OR “Cassiar AK” OR “Fibrous crocidolite asbestos” OR “Fibrous grunerite” OR “metaxite” OR “winchite” OR “12425-92-2” OR “richterite” OR “17068-76-7” OR “Libby amphibole” OR “Libby asbestos” OR “1318-09-8” OR “Hornblendeasbest” OR “77536-66-4” OR “132207-32-0” OR “77536-68-6” OR “77536-67-5” OR “14567-61-4” OR “12135-86-3” OR “Antigorite” OR “17787-87-0”)<br>(Part I Update limited to September 30, 2019 to September 30, 2021) | |
| **Current Contents**<br>Search Date: 9/30/2021 | TS=(“Asbestos” OR “12001-28-4” OR “12001-29-5” OR “12172-67-7” OR “12172-73-5” OR “1332-21-4” OR (“Asbestos” AND “exposure”) OR (“Asbestos” AND (“fiber*” OR “fibre*”)) OR “chrysotile” OR “Asbestos, exposure” OR (“Asbestos” AND “dust”) OR “crocidolite” OR “chrysotile asbestos” OR “tremolite” OR “actinolite” OR (“chrysotile” AND “serpentine”) OR “amosite” OR “Crocidolite asbestos” OR “Asbestos crocidolite” OR “Asbestos, crocidolite” OR “anthophyllite” OR “asbestos, amphibole” OR “amphibole asbestos” OR “Amosite asbestos” OR “Asbestos dust” OR “Asbestos, amosite” OR “riebeckite” OR “14567-73-8” OR “grunerite” OR (“Silicates” AND (“tremolite” OR “asbestiform”)) OR “Amiante” OR “blue asbestos” OR “17068-78-9” OR “asbestos, chrysotile” OR “Man-made mineral fibres” OR “Chrysotile A” OR “Tremolite asbestos” OR “Asbestiform minerals” OR “Asbest” OR “Asbesto” OR “Asbestose” OR “magnesioriebeckite” OR “Asbestos substitutes” OR (“Asbestos” AND “synthetic fibers”) OR “white asbestos” OR “Ascarite” OR “Asbestos, tremolite” OR “serpentine chrysotile” OR “grunerite asbestos” OR “Brown asbestos” OR “riebeckite asbestos” OR “Amianthus” OR (“asbestos” AND (“Mountain” AND (“cork” OR “leather” OR “wood”))) OR (“asbestos” AND “MTM”) OR “Asbestos, grunerite” OR “Chrysotile A asbestos” OR “Amorphous crocidolite asbestos” OR “Calidria RG 144” OR “Cassiar AK” OR “Fibrous crocidolite asbestos” OR “Fibrous grunerite” OR “metaxite” OR “winchite” OR “12425-92-2” OR “richterite” OR “17068-76-7” OR “Libby amphibole” OR “Libby asbestos” OR “1318-09-8” OR “Hornblendeasbest” OR “77536-66-4” OR “132207-32-0” OR “77536-68-6” OR “77536-67-5” OR “14567-61-4” OR “12135-86-3” OR “Antigorite” OR “17787-87-0”) AND PY=2019-2021 | 7,587 |
| **ProQuest Dissertations & Theses**<br>Search Date: 9/30/2021 | TIAB(“Asbestos” OR “12001-28-4” OR “12001-29-5” OR “12172-67-7” OR “12172-73-5” OR “1332-21-4” OR (“Asbestos” AND “exposure”) OR (“Asbestos” AND (“fiber*” OR “fibre*”)) OR “chrysotile” OR “Asbestos, exposure” OR (“Asbestos” AND “dust”) OR “crocidolite” OR “chrysotile asbestos” OR “tremolite” OR “actinolite” OR (“chrysotile” AND “serpentine”) OR “amosite” OR “Crocidolite asbestos” OR “Asbestos crocidolite” OR “Asbestos, crocidolite” OR “anthophyllite” OR “asbestos, amphibole” OR “amphibole asbestos” OR “Amosite asbestos” OR “Asbestos dust” OR “Asbestos, amosite” OR “riebeckite” OR “14567-73-8” OR “grunerite” OR | 20 |

| Source | Source-Specific Search Strategy | Results |
|---|---|---|
| | (“Silicates” AND (“tremolite” OR “asbestiform”)) OR “Amiante” OR “blue asbestos” OR “17068-78-9” OR “asbestos, chrysotile” OR “Man-made mineral fibres” OR “Chrysotile A” OR “Tremolite asbestos” OR “Asbestiform minerals” OR “Asbest” OR “Asbesto” OR “Asbestose” OR “magnesioriebeckite” OR “Asbestos substitutes” OR (“Asbestos” AND “synthetic fibers”) OR “white asbestos” OR “Ascarite” OR “Asbestos, tremolite” OR “serpentine chrysotile” OR “grunerite asbestos” OR “Brown asbestos” OR “riebeckite asbestos” OR “Amianthus” OR (“asbestos” AND (“Mountain” AND (“cork” OR “leather” OR “wood”))) OR (“asbestos” AND “MTM”) OR “Asbestos, grunerite” OR “Chrysotile A asbestos” OR “Amorphous crocidolite asbestos” OR “Calidria RG 144” OR “Cassiar AK” OR “Fibrous crocidolite asbestos” OR “Fibrous grunerite” OR “metaxite” OR “winchite” OR “12425-92-2” OR “richterite” OR “17068-76-7” OR “Libby amphibole” OR “Libby asbestos” OR “1318-09-8” OR “Hornblendeasbest” OR “77536-66-4” OR “132207-32-0” OR “77536-68-6” OR “77536-67-5” OR “14567-61-4” OR “12135-86-3” OR “Antigorite” OR “17787-87-0”)<br>(Part I Update limited to September 30, 2019 to September 30, 2021) | |
| **ProQuest Agricultural & Scientific Database**<br>Search Date: 9/30/2021 | TIAB(“Asbestos” OR “12001-28-4” OR “12001-29-5” OR “12172-67-7” OR “12172-73-5” OR “1332-21-4” OR (“Asbestos” AND “exposure”) OR (“Asbestos” AND (“fiber*” OR “fibre*”)) OR “chrysotile” OR “Asbestos, exposure” OR (“Asbestos” AND “dust”) OR “crocidolite” OR “chrysotile asbestos” OR “tremolite” OR “actinolite” OR (“chrysotile” AND “serpentine”) OR “amosite” OR “Crocidolite asbestos” OR “Asbestos crocidolite” OR “Asbestos, crocidolite” OR “anthophyllite” OR “asbestos, amphibole” OR “amphibole asbestos” OR “Amosite asbestos” OR “Asbestos dust” OR “Asbestos, amosite” OR “riebeckite” OR “14567-73-8” OR “grunerite” OR (“Silicates” AND (“tremolite” OR “asbestiform”)) OR “Amiante” OR “blue asbestos” OR “17068-78-9” OR “asbestos, chrysotile” OR “Man-made mineral fibres” OR “Chrysotile A” OR “Tremolite asbestos” OR “Asbestiform minerals” OR “Asbest” OR “Asbesto” OR “Asbestose” OR “magnesioriebeckite” OR “Asbestos substitutes” OR (“Asbestos” AND “synthetic fibers”) OR “white asbestos” OR “Ascarite” OR “Asbestos, tremolite” OR “serpentine chrysotile” OR “grunerite asbestos” OR “Brown asbestos” OR “riebeckite asbestos” OR “Amianthus” OR (“asbestos” AND (“Mountain” AND (“cork” OR “leather” OR “wood”))) OR (“asbestos” AND “MTM”) OR “Asbestos, grunerite” OR “Chrysotile A asbestos” OR “Amorphous crocidolite asbestos” OR “Calidria RG 144” OR “Cassiar AK” OR “Fibrous crocidolite asbestos” OR “Fibrous grunerite” OR “metaxite” OR “winchite” OR “12425-92-2” OR “richterite” OR “17068-76-7” OR “Libby amphibole” OR “Libby asbestos” OR “1318-09-8” OR “Hornblendeasbest” OR “77536-66-4” OR “132207-32-0” OR “77536-68-6” OR “77536-67-5” OR “14567-61-4” OR “12135-86-3” OR “Antigorite” OR “17787-87-0”)<br>(Part I Update limited to September 30, 2019 to September 30, 2021) | 14,493 |
| **PubMed**<br>Search Date: 9/30/2021 | (“Asbestos”[tw] OR “12001-28-4”[rn] OR “12001-29-5”[rn] OR “77536-66-4”[rn] OR “12172-73-5”[rn] OR “1332-21-4”[rn] OR (“Asbestos”[tw] OR “12001-28-4”[rn] OR “12001-29-5”[rn] OR “12172-67-7”[rn] OR “12172-73-5”[rn] OR “1332-21-4”[rn] OR (“Asbestos”[tw] AND “exposure”[tw]) OR (“Asbestos”[tw] AND (“fiber*”[tw] OR “fibre*”[tw])) OR “chrysotile”[tw] OR “Asbestos, exposure”[tw] OR (“Asbestos”[tw] AND “dust”[tw]) OR “crocidolite”[tw] OR “chrysotile asbestos”[tw] OR “tremolite”[tw] OR “actinolite”[tw] OR (“chrysotile”[tw] AND “serpentine”[tw]) OR “amosite”[tw] | 14,291 |

| Source | Source-Specific Search Strategy | Results |
|---|---|---|
| | OR “Crocidolite asbestos”[tw] OR “Asbestos crocidolite”[tw] OR “Asbestos, crocidolite”[tw] OR “anthophyllite”[tw] OR “asbestos, amphibole”[tw] OR “amphibole asbestos”[tw] OR “Amosite asbestos”[tw] OR “Asbestos dust”[tw] OR “Asbestos, amosite”[tw] OR “riebeckite”[tw] OR “14567-73-8”[rn] OR “grunerite”[tw] OR (“Silicates”[tw] AND (“tremolite”[tw] OR “asbestiform”[tw])) OR “Amiante”[tw] OR “blue asbestos”[tw] OR “17068-78-9”[rn] OR “asbestos, chrysotile”[tw] OR “Man-made mineral fibres”[tw] OR “Chrysotile A”[tw] OR “Tremolite asbestos”[tw] OR “Asbestiform minerals”[tw] OR “Asbest”[tw] OR “Asbesto”[tw] OR “Asbestose”[tw] OR “magnesioriebeckite”[tw] OR “Asbestos substitutes”[tw] OR (“Asbestos”[tw] AND “synthetic fibers”[tw]) OR “white asbestos”[tw] OR “Ascarite”[tw] OR “Asbestos, tremolite”[tw] OR “serpentine chrysotile”[tw] OR “grunerite asbestos”[tw] OR “Brown asbestos”[tw] OR “riebeckite asbestos”[tw] OR “Amianthus”[tw] OR (“asbestos”[tw] AND (“Mountain”[tw] AND (“cork”[tw] OR “leather”[tw] OR “wood”[tw]))) OR (“asbestos”[tw] AND “MTM”[tw]) OR “Asbestos, grunerite”[tw] OR “Chrysotile A asbestos”[tw] OR “Amorphous crocidolite asbestos”[tw] OR “Calidria RG 144”[tw] OR “Cassiar AK”[tw] OR “Fibrous crocidolite asbestos”[tw] OR “Fibrous grunerite”[tw] OR “metaxite”[tw] OR “winchite”[tw] OR “12425-92-2”[rn] OR “richterite”[tw] OR “17068-76-7”[rn] OR “Libby amphibole”[tw] OR “Libby asbestos”[tw] OR “1318-09-8”[rn] OR “Hornblendeasbest”[tw] OR “Amphibole”[tw] OR “Amphybole”[tw] OR “14567-61-4”[rn] OR “12135-86-3”[rn] OR “Antigorite”[tw] OR “17787-87-0”[rn] OR “77536-66-4”[rn] OR “132207-32-0”[rn] OR “77536-68-6”[rn] OR “77536-67-5”[rn]) AND (2019/09/30 : 2021/09/30 [dp]) | |
| **Scopus**<br>Search Date: 9/30/2021 | TITLE-ABS({Asbestos} OR {12001-28-4} OR {12001-29-5} OR {12172-67-7} OR {12172-73-5} OR {1332-21-4} OR ({Asbestos} AND {exposure}) OR ({Asbestos} AND ({fiber*} OR {fibre*})) OR {chrysotile} OR {Asbestos, exposure} OR ({Asbestos} AND {dust}) OR {crocidolite} OR {chrysotile asbestos} OR {tremolite} OR {actinolite} OR ({chrysotile} AND {serpentine}) OR {amosite} OR {Crocidolite asbestos} OR {Asbestos crocidolite} OR {Asbestos, crocidolite} OR {anthophyllite} OR {asbestos, amphibole} OR {amphibole asbestos} OR {Amosite asbestos} OR {Asbestos dust} OR {Asbestos, amosite} OR {riebeckite} OR {14567-73-8} OR {grunerite} OR ({Silicates} AND ({tremolite} OR {asbestiform})) OR {Amiante} OR {blue asbestos} OR {17068-78-9} OR {asbestos, chrysotile} OR {Man-made mineral fibres} OR {Chrysotile A} OR {Tremolite asbestos} OR {Asbestiform minerals} OR {Asbest} OR {Asbesto} OR {Asbestose} OR {magnesioriebeckite} OR {Asbestos substitutes} OR ({Asbestos} AND {synthetic fibers}) OR {white asbestos} OR {Ascarite} OR {Asbestos, tremolite} OR {serpentine chrysotile} OR {grunerite asbestos} OR {Brown asbestos} OR {riebeckite asbestos} OR {Amianthus} OR ({asbestos} AND ({Mountain} AND ({cork} OR {leather} OR {wood}))) OR ({asbestos} AND {MTM}) OR {Asbestos, grunerite} OR {Chrysotile A asbestos} OR {Amorphous crocidolite asbestos} OR {Calidria RG 144} OR {Cassiar AK} OR {Fibrous crocidolite asbestos} OR {Fibrous grunerite} OR {metaxite} OR {winchite} OR {12425-92-2} OR {richterite} OR {17068-76-7} OR {Libby amphibole} OR {Libby asbestos} OR {1318-09-8} OR {Hornblendeasbest} OR {77536-66-4} OR {132207-32-0} OR {77536-68-6} OR {77536-67-5} OR {14567-61-4} OR {12135-86-3} OR {Antigorite} OR {17787-87-0}) AND | 16,892 |

| Source | Source-Specific Search Strategy | Results |
|---|---|---|
| | (LIMIT-TO (PUBYEAR,2021) OR LIMIT-TO (PUBYEAR,2020) OR LIMIT-TO (PUBYEAR,2019)) AND (LIMIT-TO (LANGUAGE,"English")) | |
| **ToxLine**<br>Search Date: 9/30/2021 | tox [subset] AND ("Asbestos"[tw] OR "12001-28-4"[rn] OR "12001-29-5"[rn] OR "77536-66-4"[rn] OR "12172-73-5"[rn] OR "1332-21-4"[rn] OR ("Asbestos"[tw] OR "12001-28-4"[rn] OR "12001-29-5"[rn] OR "12172-67-7"[rn] OR "12172-73-5"[rn] OR "1332-21-4"[rn] OR ("Asbestos"[tw] AND "exposure"[tw]) OR ("Asbestos"[tw] AND ("fiber*"[tw] OR "fibre*"[tw])) OR "chrysotile"[tw] OR "Asbestos, exposure"[tw] OR ("Asbestos"[tw] AND "dust"[tw]) OR "crocidolite"[tw] OR "chrysotile asbestos"[tw] OR "tremolite"[tw] OR "actinolite"[tw] OR ("chrysotile"[tw] AND "serpentine"[tw]) OR "amosite"[tw] OR "Crocidolite asbestos"[tw] OR "Asbestos crocidolite"[tw] OR "Asbestos, crocidolite"[tw] OR "anthophyllite"[tw] OR "asbestos, amphibole"[tw] OR "amphibole asbestos"[tw] OR "Amosite asbestos"[tw] OR "Asbestos dust"[tw] OR "Asbestos, amosite"[tw] OR "riebeckite"[tw] OR "14567-73-8"[rn] OR "grunerite"[tw] OR ("Silicates"[tw] AND ("tremolite"[tw] OR "asbestiform"[tw])) OR "Amiante"[tw] OR "blue asbestos"[tw] OR "17068-78-9"[rn] OR "asbestos, chrysotile"[tw] OR "Man-made mineral fibres"[tw] OR "Chrysotile A"[tw] OR "Tremolite asbestos"[tw] OR "Asbestiform minerals"[tw] OR "Asbest"[tw] OR "Asbesto"[tw] OR "Asbestose"[tw] OR "magnesioriebeckite"[tw] OR "Asbestos substitutes"[tw] OR ("Asbestos"[tw] AND "synthetic fibers"[tw]) OR "white asbestos"[tw] OR "Ascarite"[tw] OR "Asbestos, tremolite"[tw] OR "serpentine chrysotile"[tw] OR "grunerite asbestos"[tw] OR "Brown asbestos"[tw] OR "riebeckite asbestos"[tw] OR "Amianthus"[tw] OR ("asbestos"[tw] AND ("Mountain"[tw] AND ("cork"[tw] OR "leather"[tw] OR "wood"[tw]))) OR ("asbestos"[tw] AND "MTM"[tw]) OR "Asbestos, grunerite"[tw] OR "Chrysotile A asbestos"[tw] OR "Amorphous crocidolite asbestos"[tw] OR "Calidria RG 144"[tw] OR "Cassiar AK"[tw] OR "Fibrous crocidolite asbestos"[tw] OR "Fibrous grunerite"[tw] OR "metaxite"[tw] OR "winchite"[tw] OR "12425-92-2"[rn] OR "richterite"[tw] OR "17068-76-7"[rn] OR "Libby amphibole"[tw] OR "Libby asbestos"[tw] OR "1318-09-8"[rn] OR "Hornblendeasbest"[tw] OR "Amphibole"[tw] OR "Amphybole"[tw] OR "14567-61-4"[rn] OR "12135-86-3"[rn] OR "Antigorite"[tw] OR "17787-87-0"[rn] OR "77536-66-4"[rn] OR "132207-32-0"[rn] OR "77536-68-6"[rn] OR "77536-67-5"[rn]) AND (2019/09/30 : 2021/09/30 [dp])<br><br>TIAB("Asbestos" OR "12001-28-4" OR "12001-29-5" OR "12172-67-7" OR "12172-73-5" OR "1332-21-4" OR ("Asbestos" AND "exposure") OR ("Asbestos" AND ("fiber*" OR "fibre*")) OR "chrysotile" OR "Asbestos, exposure" OR ("Asbestos" AND "dust") OR "crocidolite" OR "chrysotile asbestos" OR "tremolite" OR "actinolite" OR ("chrysotile" AND "serpentine") OR "amosite" OR "Crocidolite asbestos" OR "Asbestos crocidolite" OR "Asbestos, crocidolite" OR "anthophyllite" OR "asbestos, amphibole" OR "amphibole asbestos" OR "Amosite asbestos" OR "Asbestos dust" OR "Asbestos, amosite" OR "riebeckite" OR "14567-73-8" OR "grunerite" OR ("Silicates" AND ("tremolite" OR "asbestiform")) OR "Amiante" OR "blue asbestos" OR "17068-78-9" OR "asbestos, chrysotile" OR "Man-made mineral fibres" OR "Chrysotile A" OR "Tremolite asbestos" OR "Asbestiform minerals" OR "Asbest" OR "Asbesto" OR "Asbestose" OR "magnesioriebeckite" OR "Asbestos substitutes" OR ("Asbestos" AND "synthetic fibers") OR "white | 12,289 |

| Source | Source-Specific Search Strategy | Results |
|---|---|---|
| | asbestos" OR "Ascarite" OR "Asbestos, tremolite" OR "serpentine chrysotile" OR "grunerite asbestos" OR "Brown asbestos" OR "riebeckite asbestos" OR "Amianthus" OR ("asbestos" AND ("Mountain" AND ("cork" OR "leather" OR "wood"))) OR ("asbestos" AND "MTM") OR "Asbestos, grunerite" OR "Chrysotile A asbestos" OR "Amorphous crocidolite asbestos" OR "Calidria RG 144" OR "Cassiar AK" OR "Fibrous crocidolite asbestos" OR "Fibrous grunerite" OR "metaxite" OR "winchite" OR "12425-92-2" OR "richterite" OR "17068-76-7" OR "Libby amphibole" OR "Libby asbestos" OR "1318-09-8" OR "Hornblendeasbest" OR "77536-66-4" OR "132207-32-0" OR "77536-68-6" OR "77536-67-5" OR "14567-61-4" OR "12135-86-3" OR "Antigorite" OR "17787-87-0")<br>(Part I Update limited to September 30, 2019 to September 30, 2021) | |
| **WoS**<br>Search Date: 9/30/2021 | TS=("Asbestos" OR "12001-28-4" OR "12001-29-5" OR "12172-67-7" OR "12172-73-5" OR "1332-21-4" OR ("Asbestos" AND "exposure") OR ("Asbestos" AND ("fiber*" OR "fibre*")) OR "chrysotile" OR "Asbestos, exposure" OR ("Asbestos" AND "dust") OR "crocidolite" OR "chrysotile asbestos" OR "tremolite" OR "actinolite" OR ("chrysotile" AND "serpentine") OR "amosite" OR "Crocidolite asbestos" OR "Asbestos crocidolite" OR "Asbestos, crocidolite" OR "anthophyllite" OR "asbestos, amphibole" OR "amphibole asbestos" OR "Amosite asbestos" OR "Asbestos dust" OR "Asbestos, amosite" OR "riebeckite" OR "14567-73-8" OR "grunerite" OR ("Silicates" AND ("tremolite" OR "asbestiform")) OR "Amiante" OR "blue asbestos" OR "17068-78-9" OR "asbestos, chrysotile" OR "Man-made mineral fibres" OR "Chrysotile A" OR "Tremolite asbestos" OR "Asbestiform minerals" OR "Asbest" OR "Asbesto" OR "Asbestose" OR "magnesioriebeckite" OR "Asbestos substitutes" OR ("Asbestos" AND "synthetic fibers") OR "white asbestos" OR "Ascarite" OR "Asbestos, tremolite" OR "serpentine chrysotile" OR "grunerite asbestos" OR "Brown asbestos" OR "riebeckite asbestos" OR "Amianthus" OR ("asbestos" AND ("Mountain" AND ("cork" OR "leather" OR "wood"))) OR ("asbestos" AND "MTM") OR "Asbestos, grunerite" OR "Chrysotile A asbestos" OR "Amorphous crocidolite asbestos" OR "Calidria RG 144" OR "Cassiar AK" OR "Fibrous crocidolite asbestos" OR "Fibrous grunerite" OR "metaxite" OR "winchite" OR "12425-92-2" OR "richterite" OR "17068-76-7" OR "Libby amphibole" OR "Libby asbestos" OR "1318-09-8" OR "Hornblendeasbest" OR "77536-66-4" OR "132207-32-0" OR "77536-68-6" OR "77536-67-5" OR "14567-61-4" OR "12135-86-3" OR "Antigorite" OR "17787-87-0") AND PY=2019-2021 | 40,781 |
| **Total** | **Represents totals across all databases and strategies after deduplication** | **54,431** |

### A.1.2 Search Term Genesis and Chemical Verification

To develop the chemical terms for the subsequent literature search for asbestos, several online sources were queried. From these sources, all validated chemical names, synonyms, CAS number(s), and trade names are documented and used to generate terms for the database searches. Prior to inclusion in the search string, all search terms are subjected to verification from multiple potential sources (*e.g.,* CompTox Chemicals Dashboard, PubMed), including

- ChemSpider
- ChemID*plus*
- FDA Substance Registration System
- European Chemicals Agency (ECHA)

- CompTox Chemicals Dashboard
- Pesticide Info Database
- Pesticide Properties DataBase (PPDB)
- OPP Pesticide Chemical Search

### A.1.3 Publicly Available Database Searches

The databases listed below were searched for literature containing the chemical search terms. Initial database searching occurred during April and May of 2019 by an information specialist and the results were stored in the Health and Environmental Research Online (HERO) database and assigned a HERO reference identification number.[8] The present literature search focused only on the chemical identifiers (*e.g.,* names, CASRNs, synonyms and trade names) with no additional limits. Full details of the search strategy for each database are presented in Appendix A.1.1.

After initial deduplication in HERO,[9] these studies were imported into SWIFT Review software (Howard et al., 2016) to identify those references most likely to be applicable to each discipline area (*i.e.,* consumer, environmental, and general population exposure; occupational exposure and environmental releases; environmental hazards; human health hazards; and fate and physical chemistry).

#### A.1.3.1 Data Prioritization for Environmental Hazard, Human Health Hazard, Fate, and Physical Chemistry

In brief, SWIFT Review has pre-set literature search strategies ("filters") developed by information specialists that can be applied to identify studies that are more likely to be useful for identifying human health and ecotoxicity content from those that likely do not (*e.g.,* analytical methods). The filters function like a typical search strategy where studies are tagged as belonging to a certain filter if the terms in the filter literature search strategy appear in title, abstract, keyword or medical subject headings (MeSH*)* fields content. The applied SWIFT Review filters focused on lines of evidence: human, animal models for human health, ecological taxa (which includes ecotoxicological animal models, plants, and other taxa), and *in vitro* studies. The details of the search strategies that underlie the filters are available online. Studies not retrieved using these filters were not considered further. Studies that included one or more of the search terms in the title, abstract, keyword, or MeSH fields were exported as a RIS file for screening in SWIFT-ActiveScreener or DistillerSR.[10]

#### A.1.3.2 Data Prioritization for Occupational Exposures and Environmental Releases and Gen Pop, Consumer, and Environmental Exposures

To prioritize references related to occupational exposure, environmental release, general population exposure, consumer exposure, and environmental exposure, EPA used positive and negative seed studies to build a classification model in SWIFT Review. The positive seeds were identified using relevant literature pool for the first ten TSCA risk evaluations, while the negative seeds were identified from a subset of literature for the current high-priority substances. The model was then applied to the unclassified literature to generate a classification score for each reference. Scores above a certain threshold value were then prioritized for further review in SWIFT-ActiveScreener.

[8] EPA's HERO database provides access to the scientific literature behind EPA science assessments. The database includes more than 600,000 scientific references and data from the peer-reviewed literature used by EPA to develop its regulations.
[9] Deduplication in HERO involves first determining whether a matching unique ID exists (*e.g.,* PMID, WOSid, or DOI). If one matches one that already exists in HERO, HERO will tag the existing reference instead of adding the reference again. Second, HERO checks if the same journal, volume, issue, and page number are already in HERO. Third, HERO matches on the title, year, and first author. Title comparisons ignore punctuation and case.
[10] DistillerSR is a web-based systematic review software used to screen studies.

## A.2 Peer-Reviewed Screening Process

The studies identified from publicly available database searches and SWIFT-Review filtering/prioritization were housed in the HERO system and imported into SWIFT-ActiveScreener or DistillerSR for title/abstract and full-text screening. Both title/abstract and full-text screening were conducted by two independent reviewers. Screening is initiated with a pilot phase of screening (between 10 and 50) studies to identify areas where clarification in screening criteria might be needed or chemical-specific supplemental material tags might be identified. Records that met PECO (or equivalent criteria (Appendix A.2.1) during title and abstract screening were considered for full-text screening. At both the title/abstract and full-text review levels, screening conflicts were resolved by topic-specific experts and/or discussion among the primary screeners. For citations with no abstract, the articles are initially screened based on all or some of the following: title relevance (titles that suggest a record is not relevant can be excluded rather than marked as unclear), and page numbers (articles two pages in length or less were assumed to be conference reports, editorials, or letters). During title/abstract or full-text level screening in DistillerSR, studies that did not meet the PECO criteria, but which could provide supporting information were categorized (or "tagged") as supplemental information.

It is important to emphasize that being tagged as supplemental material does not mean the study would necessarily be excluded from consideration in an assessment. The initial screening level distinctions between a study meeting the PECO criteria and a supplemental study are often made for practical reasons and the tagging structures (as seen in the literature inventory trees and heat maps in Section 2.1 of this document) are designed to ensure the supplemental studies are categorized for easy retrieval if needed while conducting the assessment. The impact on the assessment conclusions of individual studies tagged as supporting material is often difficult to assess during the screening phase of the assessment. These studies may emerge as being critically important to the assessment and need to be evaluated and summarized at the individual study level (*e.g.,* cancer MOA mechanistic or non-English-language studies), or be helpful to provide context (*e.g.,* summarize current levels of exposure, provide hazard evidence from routes or durations of exposure not pertinent to the PECO), or not be cited at all in the assessment (*e.g.,* individual studies that contribute to a well-established scientific conclusion). Studies maybe be tagged as supplemental material during either title and abstract or full-text screening. When tagged as supplemental material during title and abstract screening, it may not be completely clear whether the chemical of interest is reported in the study (*i.e.,* abstracts may not describe all chemicals investigated). In these cases, studies are still tagged with the expectation that if full-text retrieval is pursued, then additional screening would be needed to clarify if the study is pertinent.

### A.2.1 Inclusion/Exclusion Criteria

A PECO statement is typically used to focus the research question(s), search terms, and inclusion/exclusion criteria in a systematic review. PECO criteria were developed *a priori* to screening and modified to fit the various discipline areas supporting the TSCA risk evaluations. Variations include the RESO (receptor, exposure, scenario/setting, and outcome) used for the occupational exposure and environmental releases discipline and PESO (pathways/processes, exposures, setting/scenario, and outcomes) used by the fate and transport discipline. All PECOs and PECO-equivalent criteria can be found in the following sections.

#### A.2.1.1 PECO for Environmental and Human Health Hazards

The PECO used in this evidence map to identify literature pertinent to asbestos effects on human health and environmental hazard is presented in Table_Apx A-1. In addition to the PECO criteria, studies containing potentially relevant supplemental material were tracked and categorized during the literature screening process as outlined in Table_Apx A-2.

**Table_Apx A-1. Hazards Title and Abstract and Full-Text PECO Criteria for Asbestos Part 2**

| PECO Element | Evidence |
|---|---|
| Population | **Human:** Any population and lifestage (*e.g.,* occupational or general population, including children and other sensitive populations).<br><br>**Animal:** Aquatic and terrestrial species (live, whole organism) from any lifestage (*e.g.,* preconception, in utero, lactation, peripubertal, and adult stages). Animal models will be inventoried according to the categorization below:<br>• Ecotoxicological models: invertebrates (*e.g.,* insects, spiders, crustaceans, mollusks, and worms) and vertebrates (*e.g.,* mammals and all amphibians, birds, fish, and reptiles).<br><br>**Plants:** All aquatic and terrestrial species (live), including algal, moss, lichen and fungi species.<br><br>**Screener notes:**<br>• All non-human animal (*e.g.,* rodents, rabbits, hens, amphibians, fish, insects) and plant models listed above are relevant as an ecotoxicological model.<br>• PECO considerations should be directed toward effects on target species only and not on the indirect effects expressed in taxa as a result of chemical treatment (*e.g.,* substance is lethal to a targeted pest species leading to positive effects on plant growth due to diminished presence of the targeted pest species).<br>• Tests of single toxicants in in vitro and ex vivo systems or on gametes, embryos, or plant or fungal sections capable of forming whole, new organisms will be tagged as potentially supplemental (mechanistic studies). Bacteria and yeast studies specific for assessing genotoxicity or mutagenicity (*e.g.,* Ames assay) will also be tagged as potentially supplemental (mechanistic studies) but are otherwise excluded. Studies on viruses are excluded. |
| Exposure | **Relevant forms:**<br>Asbestos, as defined by the following fiber types (or combinations of fiber types):<br>• asbestos: 1332-21-4<br>• chrysotile (serpentine): 12001-29-5<br>• crocidolite (riebeckite): 12001-28-4<br>• amosite (grunerite): 12172-73-5<br>• anthophyllite: 77536-67-5<br>• tremolite: 77536-68-6<br>• actinolite: 77536-66-4<br>• winchite: 12425-92-2<br>• richterite: 17068-76-7<br>• Libby amphibole: 1318-09-8<br>• Exposure reported as PCM or TEM (including conversion factors for dust)<br>• Talc (or Magnesium silicate) contaminated with asbestos<br><br>For **synonyms** see and a list of validated synonyms on the EPA Chemistry Dashboard.<br><br>***Human: Any exposure to one or more of the 9 asbestos fiber types listed, singularly or in combination, that meets the following conditions:***<br>• Exposure based on measured or estimated concentrations of asbestos |

| PECO Element | Evidence |
|---|---|
| | • May be combined with estimates of duration of exposure, such as exposure biomonitoring data (*e.g.,* lung tissue specimens), environmental or occupational-setting monitoring data (*e.g.,* ambient air levels), job title or residence.<br>• Quantitative measures or estimates of exposure *only*<br>• For categorical exposures, a minimum of 2 exposure groups (referent group + 1)<br><br>**Eco Animal:** Any **oral exposure** to one or more of the asbestos fiber types, regardless of the exposure media (*e.g.,* water, diet, soil, sediment), singularly or in combination. All other exposure pathways (*e.g.,* dermal, inhalation, injection) should be tagged as excluded (please select the correct supplemental tag: apical/mechanistic and the non-oral exposure pathway). **For organism exposures to asbestos or PECO-relevant asbestos fibers where oral exposures cannot be discerned from other exposure pathways that are more characteristic of mammalian and avian studies, please select include (e.g., fish or invertebrates exposed to asbestos in surface water, sediment, and/or soil.**<br>**Plants:** Any exposure to one or more of the 9 asbestos fiber types, regardless of the exposure media (*e.g.,* water, soil, sediment), singularly or mixed<br>**Plants:** Any exposure to one or more of the 9 asbestos fiber types, regardless of the exposure media (*e.g.,* water, soil, sediment), singularly or in combination<br><br>**Screener notes:**<br>• Field studies with media concentrations (*e.g.,* surface water, interstitial water, soil, sediment) and/or body/tissue concentrations of animals or plants are to be identified as **Supplemental** if any biological effects are reported.<br>• Controlled outdoor experimental studies (*e.g.,* controlled crop/greenhouse studies, mesocosm studies, artificial stream studies) are considered to be laboratory studies (**not field studies**) because there is a known and prescribed exposure dose(s) and an evaluation of hazardous effect(s). Whereas field studies (*e.g.,* biomonitoring) where there is no prescribed exposure dose(s) will be **excluded** if there is no evaluated hazardous effect, and tagged as **Supplemental** field, if there is an evaluated hazardous effect.<br>• Papers reporting exposure to "asbestos" generally and not specific fiber type of asbestos will be included for further consideration. |
| Comparator | **Human:** the source meets either of the following conditions:<br>• Contains a comparison or referent population exposed to lower levels (or no exposure/exposure below detection limits) of asbestos, and other relevant forms listed above.<br>**Eco Animal and Plants:** A concurrent control group exposed to vehicle-only treatment and/or untreated control (control could be a baseline measurement).<br><br>**Screener note:**<br>• If no control group is explicitly stated or implied (*e.g.,* by mention of statistical results that could only be obtained if a control group was present), the study will be marked as ***Unclear*** during Title/Abstract Screening. |

| PECO Element | Evidence |
|---|---|
| **O**utcomes | **Human:** Health outcomes including lung cancer, mesothelioma, laryngeal cancer, and ovarian cancer and all non-cancer at the system level (*e.g.,* immune, cardiovascular, respiratory) or higher.<br>**Eco Animal and Plants**: All apical biological effects (effects measured at the organ level or higher) and bioaccumulation from laboratory studies with concurrently measured media and/or tissue concentrations. Apical endpoints include but are not limited to reproduction, survival, and growth.<br><br>**Screener notes:**<br>• **Measurable biological effects relevant for humans, animals and plants may include but are not limited to:** mortality, behavioral, population, physiological, growth, reproduction, systemic, point of contact (irritation and sensitization) effects.<br>• Effects measured at the cellular level of biological organization and below are to be tagged as supplemental, mechanistic. **However, if there are apical and mechanistic endpoints, the study will be marked as Yes- PECO relevant/include**. |

**Table_Apx A-2. Major Categories of "Potentially Relevant" Supplemental Materials for Asbestos**

| Category | Evidence |
|---|---|
| **Mechanistic studies** | All studies that report results at the cellular level and lower in both mammalian and non-mammalian model systems, including *in vitro*, *in vivo*, *ex vivo*, and *in silico* studies. These studies include assays for genotoxicity or mutagenicity using bacteria or yeast. |
| **ADME, PBPK, and toxicokinetic** | Studies designed to capture information regarding absorption, distribution, metabolism, and excretion (ADME), toxicokinetic studies, or physiologically based pharmacokinetic (PBPK) models. |
| **Case reports or case series** | Case reports ($n \leq 3$ cases) and case series (non-occupational) will be tracked as potentially relevant supplemental information. |
| **Susceptible populations (no health outcome)** | Studies that identify potentially susceptible subgroups; for example, studies that focus on a specific demographic, lifestage, or genotype. This tag applies primarily during full text screening.<br><br>**Screener note:** if biological susceptibility issues are clearly present or *strongly* implied in the title/abstract, this supplemental tag may be applied at the title abstract level. If uncertain at title/abstract, do not apply this tag to the reference during title/abstract screening. |
| **Mixture studies** | Experimental mixture studies that are not considered PECO-relevant because they do not contain an exposure or treatment group assessing only the chemical of interest. Human health animal model and eco animal model/plant will be tagged separately for mixture studies. |
| **Non-English records** | Non-English records will be tracked as potentially relevant supplemental information. |

| Category | Evidence |
|---|---|
| **Records with no original data** | Records that do not contain original data, such as other agency assessments, informative scientific literature reviews, editorials, or commentaries. |
| **Conference abstracts** | Records that do not contain sufficient documentation to support study evaluation and data extraction. |
| **Field studies** | Field studies with media concentrations (*e.g.,* surface water, interstitial water, soil, sediment) and/or body/tissue concentrations of animals or plants if biological effects reported |
| **Studies that investigate talc or magnesium silicate** | Studies with measured hazard endpoints (apical or mechanistic) where the exposure is to talc or magnesium silicate as defined below should be tagged as supplemental:<br>• *Talc:* 14807-96-6, 35592-05-3, talcum, agalite, antimyst, asbestine, trimagnesium, soapstone, steatite, french chalk<br>• *Magnesium silicate:* 1343-88-0, magnesium silicate, magnesium oxosilanediolate, Silicic acid, magnesium salt, Florisil, magnesium silandiolate<br>However, please exclude synthetic magnesium silicate (lab-synthesized and thus, not asbestos-relevant) or synthetic magnesium silicate-products. |

#### A.2.1.2 PECO for Consumer, Environmental, and General Population Exposures

**Table_Apx A-3. Generic Inclusion Criteria for the Data Sources Reporting Exposure Data on General Population, Consumers, and Environmental Receptors**

| PECO Element | Evidence |
|---|---|
| **P**opulation | **Human:** General population; consumers; bystanders in the home; near-facility populations (includes industrial and commercial facilities processing/handling during disposal or using product containing the chemical substance); children; susceptible populations (life stages, preexisting conditions, genetic factors, pregnant women, lactating women, women of child-bearing age). Many human population groups may be exposed. No chemical-specific exclusions are suggested at this time. |
| | **Environmental:** Aquatic species, terrestrial species, terrestrial plants, aquatic plants (field studies only) |
| **E**xposure | **Expected Primary Exposure Sources, Pathways, Routes:**<br>**Pathways:** Indoor air; indoor dust; particles; fibers; outdoor/ambient air; surface water; biosolids; sediment; consumer product uses in the home (including consumer product containing chemical)<br>**Routes of Exposure:** Inhalation, Oral, Dermal |
| **C**omparator (Scenario) | **Human:** Consider media-specific background exposure scenarios and use/source specific exposure scenarios as well as which receptors are and are not reasonably exposed across the projected exposure scenarios. |
| | **Environmental:** Consider media-specific background exposure scenarios and use/source specific exposure scenarios as well as which receptors are and are not reasonably exposed across the projected exposure scenarios. |

| PECO Element | Evidence |
|---|---|
| **O**utcomes for Exposure Concentration or Dose | **Human:** Acute, subchronic, chronic, and/or Indoor or outdoor air concentration estimates (fibers/cc) and water concentration estimates (mg/m3 or mg/L). Both external potential dose and internal dose based on biomonitoring and reverse dosimetry will be considered. Characteristics of consumer products or articles (weight fraction, emission rates, etc) containing asbestos fibers |
| | **Environmental:** A wide range of ecological receptors will be considered (range depending on available ecotoxicity data) using surface water concentrations, sediment concentrations. |

### A.2.1.3 RESO for Occupational Exposure and Environmental Releases

EPA developed a generic RESO statement to guide the screening of engineering and occupational exposure data or information sources for the TSCA risk evaluations. Data or information sources that comply with the inclusion criteria specified in the RESO statement are eligible for inclusion, considered for evaluation, and possibly included in the environmental release and occupational exposure assessments. On the other hand, data or information sources that fail to meet the criteria in the RESO statement are excluded from further consideration.

Assessors seek information on various chemical-specific engineering and occupational exposure data needs as part of the process of developing the exposure assessment for each risk evaluation. EPA uses the RESO statement (Table_Apx A-4) along with the information in Table_Apx A-5 when screening the engineering and occupational exposure data and information.

**Table_Apx A-4. Inclusion Criteria for Data Sources Reporting Engineering and Occupational Exposure Data for Asbestos Part 2**

| RESO Element | Evidence |
|---|---|
| **R**eceptors | • Humans:<br>Workers, including ONUs<br>• Environment:<br>All ecological receptors (relevant release estimates input to exposure)<br><br>Please refer to the conceptual models for more information about the ecological and human receptors included in the TSCA risk evaluation. |
| **E**xposure | • Exposure to a relevant fiber:<br>  • Asbestos, as defined by the following fiber types: chrysotile, amosite, anthophylite, crocidolite, tremolite, and actinolite (includes studies of multiple asbestos fiber types); or<br>  • Winchite and/or richterite<br>• Worker exposure to and relevant environmental releases of the chemical substance from occupational scenarios:<br>  o Inhalation exposure routes (as indicated in the conceptual model)<br>  o Oral route (as indicated in the conceptual model)<br>  o Dermal route (as indicated in the conceptual model)<br>Please refer to the conceptual models for more information about the routes and media/pathways included in the TSCA risk evaluation. |

| RESO Element | Evidence |
|---|---|
| **S**etting or **S**cenario | • Any occupational setting or scenario resulting in worker exposure and relevant environmental releases (includes all use and disposal indicated in Table A-3) |
| **O**utcomes | • Quantitative estimates[a] of worker exposures and of relevant environmental releases from occupational settings<br>• General information and data related and relevant to the occupational estimates[a] |
| [a] Metrics (*e.g.,* fibers/kg/day or fibers/cm$^3$ for worker exposures, kg/site/day for releases) are determined by toxicologists for worker exposures and by exposure assessors for releases; also, the Engineering, Release and Occupational Exposure Data Needs (Table_Apx A-5) provides a list of related and relevant general information. | |

**Table_Apx A-5. Engineering, Environmental Release, and Occupational Data Needed to Develop the Environmental Release and Occupational Exposure Assessments for Asbestos Part 2**

| Objective Determined during Scoping | Type of Data[a] |
|---|---|
| General Engineering Assessment (may apply to Occupational Exposures and / or Environmental Releases) | Description of the life cycle of the chemical(s) of interest, from manufacture to end-of-life (*e.g.,* each manufacturing, processing, or use step), and material flow between the industrial and commercial life cycle stages.<br>The total annual U.S. volume (lb/yr or kg/yr) of the chemical(s) of interest manufactured, imported, processed, and used; and the share of total annual manufacturing and import volume that is processed or used in each life cycle step.<br>Description of processes, equipment, and unit operations during each industrial/ commercial life cycle step.<br>Material flows, use rates, and frequencies (lb/site-day or kg/site-day and days/yr; lb/site-batch and batches/yr) of the chemical(s) of interest during each industrial/ commercial life cycle step. Note: if available, include weight fractions of the chemicals(s) of interest and material flows of all associated primary chemicals (especially water).<br>Number of sites that manufacture, process, or use the chemical(s) of interest for each industrial/ commercial life cycle step and site locations.<br>Concentration of the chemical of interest |
| Occupational Exposures | Description of worker activities with exposure potential during the manufacture, processing, or use of the chemical(s) of interest in each industrial/commercial life cycle stage.<br>Potential routes of exposure (*e.g.,* inhalation, dermal).<br>Physical form of the chemical(s) of interest for each exposure route (*e.g.,* liquid, vapor, mist) and activity.<br>Breathing zone (personal sample) measurements of occupational exposures to the chemical(s) of interest, measured as time-weighted averages (TWAs), short-term exposures, or peak exposures in each occupational life cycle stage (or in a workplace scenario similar to an occupational life cycle stage).<br>Area or stationary measurements of airborne concentrations of the chemical(s) of interest in each occupational setting and life cycle stage (or in a workplace scenario similar to the life cycle stage of interest).<br>For solids, bulk and dust particle characterization data (*e.g.,* size, shape, composition). |

| Objective Determined during Scoping | Type of Data[a] |
|---|---|
| | Dermal exposure data.<br>Exposure duration (hr/day).<br>Exposure frequency (days/yr).<br>Number of workers who potentially handle or have exposure to the chemical(s) of interest in each occupational life cycle stage.<br>Personal protective equipment (PPE) types employed by the industries within scope.<br>Engineering controls employed to reduce occupational exposures in each occupational life cycle stage (or in a workplace scenario similar to the life cycle stage of interest), and associated data or estimates of exposure reductions. |
| Environmental Releases (to relevant environmental media) | Description of sources of potential environmental releases, including cleaning of residues from process equipment and transport containers, involved during the manufacture, processing, or use of the chemical(s) of interest in each life cycle stage.<br>Estimated mass (lb or kg) of the chemical(s) of interest released from industrial and commercial sites to each environmental medium (water) and treatment and disposal methods (POTW), including releases per site and aggregated over all sites (annual release rates, daily release rates)<br>Release or emission factors.<br>Number of release days per year.<br>Waste treatment methods and pollution control devices employed by the industries within scope and associated data on release/emission reductions. |
| In addition to the data types listed above, EPA may identify additional data needs for mathematical modeling. These data needs will be determined on a case-by-case basis.<br>[a] These are the tags included in the full-text screening form. The screener makes a selection from these specific tags, which describe more specific types of data or information. | |

#### A.2.1.4 PESO for Fate and Transport

EPA developed a generic PESO statement to guide the screening of environmental fate data or information sources for the TSCA risk evaluations. Data or information sources that comply with the inclusion criteria in the PESO statement are eligible for inclusion, considered for evaluation, and possibly included in the environmental fate assessment. On the other hand, data or information sources that fail to meet the criteria in the PESO statement are excluded from further consideration.

Assessors seek information on various chemical-specific fate endpoints and associated fate processes, environmental media and exposure pathways as part of the process of developing the environmental fate assessment for each risk evaluation. EPA uses the PESO statement (Table_Apx A-6) along with the information in Table_Apx A-7 when screening the fate data or information sources to ensure complete coverage of the processes, pathways, and data or information relevant to the environmental fate and transport of the chemical substance undergoing risk evaluation.

**Table_Apx A-6. Inclusion Criteria for Data or Information Sources Reporting Environmental Fate and Transport Data for Asbestos Part 2**

| PESO Element | Evidence |
|---|---|
| **P**athways and **P**rocesses | Environmental fate, transport, partitioning and degradation behavior across environmental media to inform exposure pathways in conceptual models of the chemical substance of interest<br>Exposure pathways included in the conceptual models: air, surface water, groundwater, wastewater, soil, sediment and biosolids<br>Processes associated with the target exposure pathways<br>Bioconcentration and bioaccumulation<br>Destruction and removal by incineration<br>Please refer to the conceptual models for more information about the exposure pathways included in each TSCA risk evaluation |
| **E**xposure | Exposure to a relevant fiber:<br>• Asbestos, as defined by the following fiber types: Chrysotile, Amosite, Anthophylite, Crocidolite, Tremolite, and Actinolite (includes studies of multiple asbestos fiber types); or<br>• Winchite and/or richterite<br>Environmental exposure of environmental receptors (*i.e.,* aquatic and terrestrial organisms) to the chemical substance of interest, mixtures including the chemical substance, and/or its degradation products and metabolites<br>Environmental exposure of human receptors, including any PESS, to the chemical substance of interest, mixtures including the chemical substance, and/or its degradation products and metabolites<br>Consumer and occupational exposure pathways to Asbestos<br>(Chemical-specific population[s] of interest may be determined by toxicologists or by EPA policy decisions)<br>Please refer to the conceptual models for more information about the environmental and human receptors included in each TSCA risk evaluation |
| **S**etting or **S**cenario | Any setting or scenario resulting in releases of the chemical substance of interest into the natural or built environment (*e.g.,* buildings including homes or workplaces, or wastewater treatment facilities) that would expose environmental (*i.e.,* aquatic and terrestrial organisms) or human receptors (*i.e.,* general population, and PESS)<br>Consumer and occupational exposure scenarios to asbestos |
| **O**utcomes | Fate properties which allow assessments of exposure pathways:<br>• Abiotic and biotic degradation rates, mechanisms, pathways, and products<br>• Bioaccumulation magnitude and metabolism rates<br>• Partitioning within and between environmental media (see Pathways and Processes) |

**Table_Apx A-7. Fate Endpoints and Associated Processes, Media, and Exposure Pathways Considered in the Development of the Environmental Fate Assessment for Asbestos Part 2**

| Fate Data Endpoint | Associated Process(es) | Associated Media/Exposure Pathways | | | |
|---|---|---|---|---|---|
| | | Surface Water, Wastewater, Sediment | Soil, Biosolids | Groundwater | Air |
| Required environmental fate data | | | | | |
| Desorption information | Sorption, Mobility | X | X | X | X |
| Destruction and removal by incineration | Incineration | | | | X |
| $K_{OC}$ and other sorption information | Sorption, Mobility | X | X | X | X |
| Wastewater treatment removal information | Wastewater treatment | X | X | | |
| Abiotic transformation products | Hydrolysis, Photolysis, Incineration | | | | X |
| Atmospheric deposition information | Atmospheric deposition | | | | X |
| Coagulation information | Coagulation, Mobility | X | | | |
| Suspension/resuspension information | Suspension/resuspension, Mobility | X | | | X |
| Particle transport | Mobility | X | | | X |

### A.2.1.5 Generation of Hazard Heat Maps

As stated in Appendix A.1.3.1, SWIFT Review has pre-set literature search strategies ("filters") developed by information specialists that can be applied to identify studies that are more likely to be useful for identifying human health and ecotoxicity content. The filters function like a typical search strategy where studies are tagged as belonging to a certain filter if the terms in the filter literature search strategy appear in title, abstract, keyword, or MeSH fields content.

After the completion of full-text screening for hazard data, all references tagged as included (or "PECO-relevant) were uploaded to the SWIFT Review tool for further filtering. The SWIFT Review filters applied at this phase focused on types of health outcomes included, "ADME," "PBPK," "cancer," "cardiovascular," "developmental," "endocrine," "gastrointestinal," "hematological and immune," "hepatic," "mortality," "musculoskeletal," "neurological," "nutritional and metabolic," "ocular and sensory," "renal," "reproductive," "respiratory," and "skin and connective tissue." The details of these

health outcome search strategies that underlie the filters are available online. Studies that included one or more of the search terms in the title, abstract, keyword, or MeSH fields were exported and used to populate the Hazard Heat Map (Figure 2-10). Studies that were not retrieved using these filters were tagged as "No Tag." The evidence type listed in the heat map (*e.g.,* human, animal-human health model, animal-environmental model, and plant) was manually assigned to each reference by screeners during the full-text screening.

The health outcome tags were originally designed for vertebrate systems, and as such, did not conform well to plant evidence. Therefore, any plant studies tagged for: "cancer," "cardiovascular," "gastrointestinal," "hematological and immune," "hepatic," "musculoskeletal," "neurological," "ocular and sensory" and "renal and respiratory" were manually reviewed and re-tagged to more appropriate health outcomes.

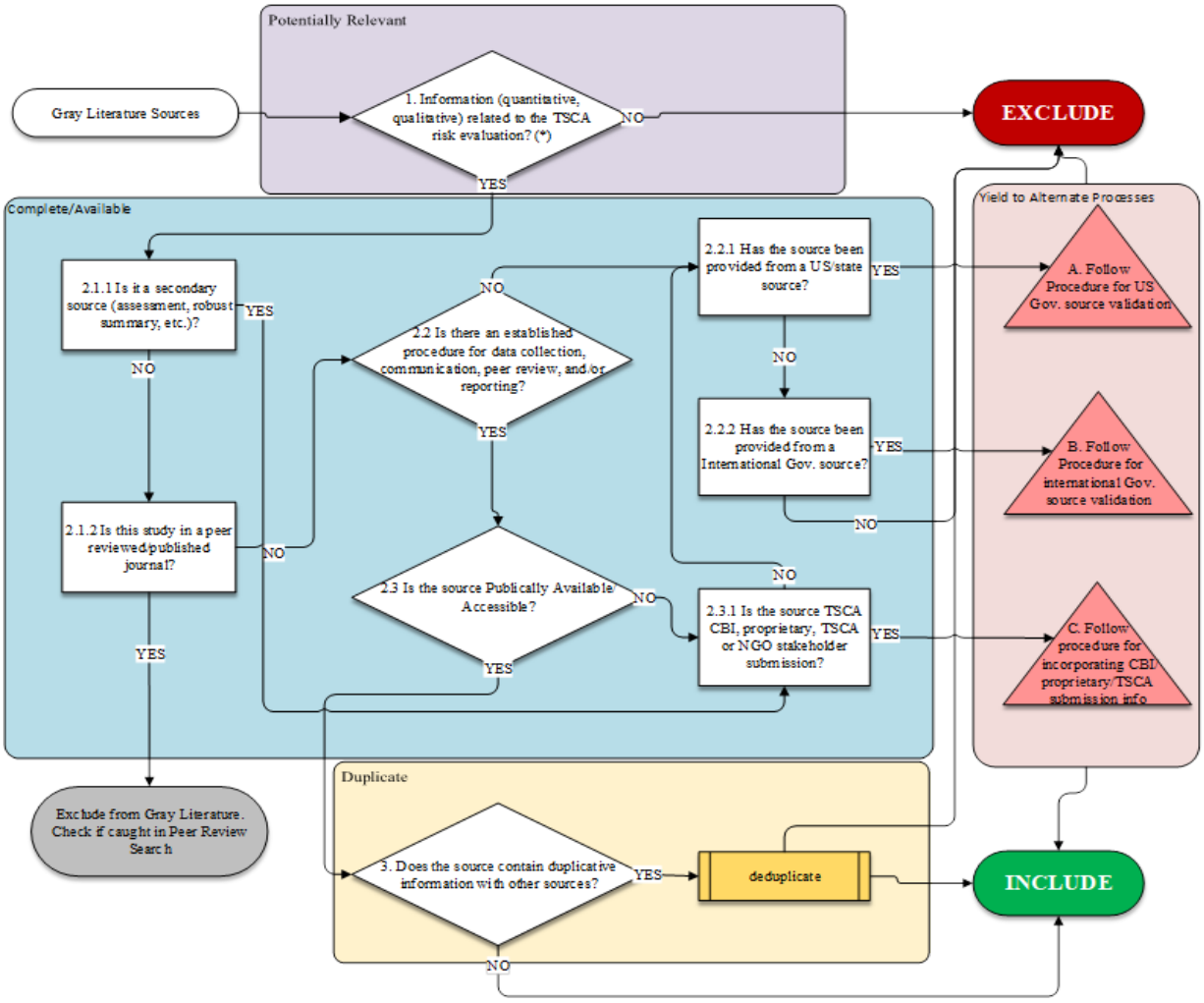
## A.3 Gray Literature Search and Screening Strategies

EPA utilized gray literature acquired during Part I and conducted a gray literature search update for reasonably available information to support the TSCA risk evaluation for Asbestos and new fiber types (*i.e.,* winchite, richterite, and LAA). Gray literature is defined as the broad category of data/information sources not found in standard, peer-reviewed literature databases (*e.g.,* PubMed and Web of Science). Gray literature includes data/information sources such as white papers, conference proceedings, technical reports, reference books, dissertations, information on various stakeholder websites, and other databases. Given the nature of how gray literature is searched and collected, results may not come with a bibliographic citation or abstract and were therefore processed using a decision tree logic described in Appendix A.3.1 for potential relevance prior to entering full text screening where a discipline-specific PECO is applied.

Search terms were variable dependent on source and based on knowledge of a given source to provide discipline-specific information. A summary of sources is provided in Appendix A.3.4. The criteria for determining the potential relevance of documents identified from gray literature sources is described in the following sections for each discipline.

### A.3.1 Screening of Gray Literature

To reduce the overall burden of processing gray literature results, EPA developed a screening process to determine the potential relevance of gray literature. This step was introduced prior to collecting the resulting documents. Figure_Apx A-1 describes the decision logic used to screen gray literature results.




**Figure_Apx A-1. Decision Logic Tree Used to Screen Gray Literature Results**

### A.3.2 Initial Screening of Sources Using Decision Logic Tree

The purpose of the inclusion/exclusion decision logic tree in Figure_Apx A-1 is to provide a broad, general screening technique to determine whether each gray literature source should be included and further screened or excluded with no additional screening necessary. The diamonds in the decision tree require analysis by the screener, whereas the rectangular boxes are used to classify the type of source. All the questions used in the decision process are provided in Table_Apx A-8**.**

**Table_Apx A-8. Decision Logic Tree Overview**

| Step | Metric | Questions to Consider |
|---|---|---|
| 1 | Potential Relevance | Does the result have information (qualitative or quantitative) related to TSCA risk evaluations?[a] |
| 2.1.1 | Complete/Available | Is it a secondary data source (assessment, robust summary, TSCA submission databases, etc.)? |
| 2.1.2 | | Is the document from a peer reviewed/published journal? |

| Step | Metric | Questions to Consider |
|---|---|---|
| 2.2 | Complete/Available | Is there an established procedure for data collection, communication, peer review, and/or reporting? |
| 2.2.1 | | Has the data been provided by a US governmental/state source? |
| 2.2.2 | | Has the data been provided by an international governmental source? |
| 2.3 | | Are these data publicly available/accessible? |
| 2.3.1 | | Is the source TSCA CBI, proprietary, TSCA, or NGO stakeholder submission? |
| 3 | Duplicate | Does the result contain any duplicative information found in other sources? |
| [a] Apply discipline relevancy metric. | | |

Results of the gray literature search and decision tree process are included in Appendix A.3.3.

### A.3.3 TSCA Submission Searching and Title Screening

EPA screens information submitted under TSCA sections 4, 5, 8(e), and 8(d), as well as FYI submissions. In the gray literature process defined in Appendix A.3.2, EPA considers the databases that contain TSCA submissions to be secondary sources (Step 1.1) because the metadata in the databases are secondary. These databases then advance to Step 2.3.1 and then to Process C. The Process C steps are described here.

EPA first screens the titles using two screeners per title. EPA conducts this step primarily to reduce the number of full studies to be obtained because some studies are available only on microfiche or in long-term storage. Screening is done using the inclusion and exclusion criteria within the relevant PECOs, PESOs, or RESOs for each topic area (Appendix A.2.1). EPA excludes interim reports (*e.g.,* interim sacrifices for toxicity studies) and only final reports are further considered. If the title is not clear regarding the document's contents, EPA obtains the full text and advances to the next steps.

After full texts are obtained, EPA will review some sources (prior to full-text screening) based on whether they have several factors; primary data, an established procedure for peer review, data collection, communication and/or reporting and are publicly available. Sources that have these factors will move on to full text screening. Other sources will go straight to full text screening using PECO-type criteria without going through this extra step.

EPA may decide to initiate a backwards search on sources that are deemed to have secondary data. In situations where parameters such as procedures for peer review and data collection are unclear, EPA may reach out to the authors to retrieve information to gauge whether the source should be included or excluded. Studies that are not publicly available (such as proprietary or CBI sources) may undergo additional screening steps.

During the full-text screening step, two individuals screen each source according to the PECOs, PESOs, and RESOs (Appendix A.2.1).

Results of the TSCA submission search and decision tree process are included in Appendix A.3.4

### A.3.4 Gray Literature Search Results for Asbestos

Table_Apx A-9 provides a list of gray literature sources that yielded results for asbestos.

**Table_Apx A-9. Gray Literature Sources that Yielded Results for Asbestos**

| Source Agency | Source Name | Source Type | Source Category | Source Website |
|---|---|---|---|---|
| ATSDR | ATSDR Miscellaneous/Other | Other US Agency Resources | Assessment or Related Document | |
| ATSDR | ATSDR Toxicological Profiles (Original Publication) | Other US Agency Resources | Assessment or Related Document | https://www.atsdr.cdc.gov/toxprofiles/index.asp |
| CAL EPA | Technical Support Documents for Regulations: Drinking Water Public Health Goals | Other US Agency Resources | Technical Report | https://oehha.ca.gov/chemicals |
| ECHA | European Chemicals Agency (ECHA) Documents | International Resources | Assessment or Related Document | https://echa.europa.eu/information-on-chemicals |
| ECHA | European Union Risk Assessment Report | International Resources | Assessment or Related Document | https://echa.europa.eu/information-on-chemicals/information-from-existing-substances-regulation |
| Environment Canada | Guidelines, Risk Management, Regulations | International Resources | Assessment or Related Document | https://www.canada.ca/en.html |
| EPA | EPA Office of Water: Ambient Water Quality Criteria documents | US EPA Resources | Assessment or Related Document | https://www.epa.gov/wqc |
| EPA | Integrated Risk Information System (IRIS) Tox Review | US EPA Resources | Assessment or Related Document | https://cfpub.epa.gov/ncea/iris2/atoz.cfm |
| EPA | Office of Water: STORET and WQX | US EPA Resources | Database | https://www.waterqualitydata.us/portal/ |
| EPA | OPPT: TSCATS Database Maintained at SRC (TSCA Submissions) | US EPA Resources | Database | http://chem.sis.nlm.nih.gov/chemidplus/chemidheavy.jsp |

| Source Agency | Source Name | Source Type | Source Category | Source Website |
|---|---|---|---|---|
| EPA | Office of Air: Air Emission Factors (AP-42) | US EPA Resources | Regulatory Document or List | https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors |
| EPA | Other EPA: Misc Sources | US EPA Resources | General Search | https://www.epa.gov/ |
| EPA | Integrated Risk Information System (IRIS) Summary | US EPA Resources | Assessment or Related Document | https://cfpub.epa.gov/ncea/iris_drafts/atoz.cfm?list_type=alpha |
| EPA | Office of Air: Code of Federal Regulations (CFRs) and Dockets | US EPA Resources | Regulatory Document or List | https://www.epa.gov/stationary-sources-air-pollution |
| EPA | EPA: Generic Scenario | US EPA Resources | Assessment or Related Document | https://www.epa.gov/tsca-screening-tools/chemsteer-chemical-screening-tool-exposures-and-environmental-releases#genericscenarios |
| EPA | Office of Water: Code of Federal Regulations (CFRs) | US EPA Resources | Regulatory Document or List | https://www.epa.gov/eg |
| IARC | International Agency for Research on Cancer (IARC) Monograph | International Resources | Assessment or Related Document | http://monographs.iarc.fr/ENG/Monographs/PDFs/index.php |
| KOECT | Kirk-Othmer Encyclopedia of Chemical Technology Journal Article | Other Resources | Encyclopedia | https://onlinelibrary.wiley.com/doi/book/10.1002/0471238961 |
| MSHA | Mine Safety and Health Administration | Other US Agency Resources | Database | https://www.msha.gov/mine-data-retrieval-system |
| NIOSH | CDC NIOSH: Pocket Guides | Other US Agency Resources | Factsheet | https://www.cdc.gov/niosh/npg/default.html |
| NIOSH | CDC NIOSH: Publications and Products | Other US Agency Resources | Assessment or Related Document | https://www2a.cdc.gov/nioshtic-2/ |
| NIOSH | CDC NIOSH: Health Hazard Evaluations (HHEs) | Other US Agency Resources | Assessment or Related Document | https://www2a.cdc.gov/hhe/search.asp |

| Source Agency | Source Name | Source Type | Source Category | Source Website |
|---|---|---|---|---|
| NIOSH | CDC NIOSH: Workplace Survey Reports | Other US Agency Resources | Assessment or Related Document | https://www.cdc.gov/niosh/surveyreports/allreports.html |
| NLM | National Library of Medicine's HazMap | Other US Agency Resources | Database | https://haz-map.com/ |
| NLM | National Library of Medicine's PubChem | Other US Agency Resources | Database | https://pubchem.ncbi.nlm.nih.gov/ |
| NLM | National Library of Medicine's Hazardous Substance Databank | Other US Agency Resources | Database | https://www.nlm.nih.gov/databases/download/hsdb.html |
| NTP | Additional NTP Reports | Other US Agency Resources | Assessment or Related Document | https://ntp.niehs.nih.gov/publications/index.html |
| NTP | Report on Carcinogens (RoC) Monographs | Other US Agency Resources | Assessment or Related Document | https://ntp.niehs.nih.gov/pubhealth/roc/listings/index.html |
| OECD | OECD: Emission Scenario Documents | International Resources | Assessment or Related Document | http://www.oecd.org/document/46/0,2340,en_2649_201185_2412462_1_1_1_1,00.html |
| OECD | OECD: General Site | International Resources | General Search | https://www.oecd.org/ |
| OSHA | OSHA Chemical Exposure Health Data | Other US Agency Resources | Database | https://www.osha.gov/opengov/healthsamples.html |
| State of North Carolina | NC Division of Environmental Assistance and Customer Service | Other US Agency Resources | General Search | http://deq.nc.gov/about/divisions/environmental-assistance-customer-service |

# Appendix B PHYSICAL AND CHEMICAL PROPERTIES OF ASBESTOS

Table_Apx B-1 to Table_Apx B-6 summarize statistics for the physical and chemical property values identified through systematic review as of September 2021. The "N" column indicates the number of unique primary sources of data for that endpoint. That is, if multiple sources presented equivalent values and cited the same primary source, only one of those was included in these statistics and included in the statistical calculations.

**Table_Apx B-1. Physical and Chemical Properties of Chrysotile**

| Property or Endpoint | N | Unit | Mean | Standard Deviation | Min | Max |
|---|---|---|---|---|---|---|
| Essential composition | 1 | – | – | – | – | – |
| Color | 6 | – | – | – | – | – |
| Luster | 2 | – | – | – | – | – |
| Surface area | 2 | $m^2/g$ | 18.0 | 6.3 | 13.5 | 22.4 |
| Hardness | 2 | Mohs | 3.3 | 1.1 | 2.5 | 4 |
| Specific gravity | 6 | – | 2.44 | 0.21 | 2.19 | 2.68 |
| Optical properties | 1 | – | – | – | – | – |
| Flexibility | 2 | – | – | – | – | – |
| Texture | 2 | – | – | – | – | – |
| Spinnability | 1 | – | – | – | – | – |
| Fiber size, median true diameter | 1 | µm | 0.06 | – | 0.06 | 0.06 |
| Fiber size, median true length | 1 | µm | 0.55 | – | 0.55 | 0.55 |
| Resistance to: Acids Bases | 1 | – | – | – | – | – |
| Zeta potential | 2 | mV | 34 | 29 | 14 | 54 |
| Decomposition temperature | 4 | °C | 700 | 146 | 500 | 850 |
| Refractive index | 2 | – | 1.656 | 0.040 | 1.627 | 1.684 |
| Dielectric constant | 1 | – | – | – | – | – |
| Tensile strength | 2 | MPa | 620 | 99 | 550 | 690 |

**Table_Apx B-2. Physical and Chemical Properties of Crocidolite**

| Property or Endpoint | N | Unit | Mean | Standard Deviation | Min | Max |
|---|---|---|---|---|---|---|
| Essential composition | 1 | – | – | – | – | – |
| Color | 3 | – | – | – | – | – |
| Luster | 1 | – | – | – | – | – |
| Surface area | 2 | $m^2/g$ | 9.7 | 7.2 | 4.62 | 14.8 |
| Hardness | 1 | Mohs | 4.0 | – | 4 | 4 |
| Specific gravity | 2 | – | 3.25 | 0.07 | 3.2 | 3.3 |
| Optical properties | 1 | – | – | – | – | – |
| Flexibility | 1 | – | – | – | – | – |
| Texture | 1 | – | – | – | – | – |
| Spinnability | 1 | – | – | – | – | – |
| Fiber size, median true diameter | 1 | µm | 0.09 | – | 0.09 | 0.09 |
| Fiber size, median true length | 1 | µm | 1.16 | – | 1.16 | 1.16 |
| Resistance to: Acids<br>Bases | 1 | – | – | – | – | – |
| Zeta potential | 1 | mV | 32 | – | 32 | 32 |
| Decomposition temperature | 1 | °C | 400 | – | 400 | 400 |
| Refractive index | 2 | – | 1.677 | 0.033 | 1.654 | 1.700 |
| Dielectric constant | – | – | – | – | – | – |
| Tensile strength | 2 | MPa | 1,395 | 997 | 690 | 2,100 |

**Table_Apx B-3. Physical and Chemical Properties of Amosite**

| Property or Endpoint | N | Unit | Mean | Standard Deviation | Min | Max |
|---|---|---|---|---|---|---|
| Essential composition | 1 | – | – | – | – | – |
| Color | 3 | – | – | – | – | – |
| Luster | 1 | – | – | – | – | – |
| Surface area | 2 | $m^2/g$ | 4.7 | 3.4 | 2.25 | 7.1 |
| Hardness | 2 | Mohs | 5.8 | 0.4 | 5.5 | 6 |

| Property or Endpoint | N | Unit | Mean | Standard Deviation | Min | Max |
|---|---|---|---|---|---|---|
| Specific gravity | 2 | – | 3.18 | 0.11 | 3.1 | 3.25 |
| Optical properties | 1 | – | – | – | – | – |
| Flexibility | 1 | – | – | – | – | – |
| Texture | 1 | – | – | – | – | – |
| Spinnability | 1 | – | – | – | – | – |
| Fiber size, median true diameter | 1 | µm | 0.26 | - | 0.26 | 0.26 |
| Fiber size, median true length | 1 | µm | 2.53 | - | 2.53 | 2.53 |
| Resistance to: Acids<br>Bases | 1 | – | – | – | – | – |
| Zeta potential | 2 | mV | −30 | 14 | −40 | −20 |
| Decomposition temperature | 1 | °C | 600 | - | 600 | 600 |
| Refractive index | 2 | – | 1.666 | 0.043 | 1.635 | 1.696 |
| Dielectric constant | – | – | – | – | – | – |
| Tensile strength | 2 | MPa | 365 | 361 | 110 | 620 |

**Table_Apx B-4. Physical and Chemical Properties of Anthophyllite**

| Property or Endpoint | N | Unit | Mean | Standard Deviation | Min | Max |
|---|---|---|---|---|---|---|
| Essential composition | 1 | – | – | – | – | – |
| Color | 3 | – | – | – | – | – |
| Luster | 1 | – | – | – | – | – |
| Surface area | – | $m^2/g$ | – | – | – | – |
| Hardness | 2 | Mohs | 5.8 | 0.4 | 5.5 | 6 |
| Specific gravity | 2 | – | 2.98 | 0.18 | 2.85 | 3.1 |
| Optical properties | 1 | – | – | – | – | – |
| Flexibility | – | – | – | – | – | – |
| Texture | – | – | – | – | – | – |
| Spinnability | – | – | – | – | – | – |
| Fiber size, median true diameter | – | µm | – | – | – | – |

| Property or Endpoint | N | Unit | Mean | Standard Deviation | Min | Max |
|---|---|---|---|---|---|---|
| Fiber size, median true length | – | µm | – | – | – | – |
| Resistance to Acids<br>Resistance to Bases | 1 | – | – | – | – | – |
| Zeta potential | – | mV | – | – | – | – |
| Decomposition temperature | 1 | °C | 1,150 | – | 1,150 | 1,150 |
| Refractive index | 2 | – | 1.624 | 0.040 | 1.596 | 1.652 |
| Dielectric constant | – | – | – | – | – | – |
| Tensile strength | 1 | MPa | 30 | – | 30 | 30 |

**Table_Apx B-5. Physical and Chemical Properties of Tremolite**

| Property or Endpoint | N | Unit | Mean | Standard Deviation | Min | Max |
|---|---|---|---|---|---|---|
| Essential composition | 1 | – | – | – | – | – |
| Color | 4 | – | – | – | – | – |
| Luster | 1 | – | – | – | – | – |
| Surface area | – | $m^2/g$ | – | – | – | – |
| Hardness | 2 | Mohs | 5.5 | 0.71 | 5 | 6 |
| Specific gravity | 2 | – | 3.05 | 0.21 | 2.9 | 3.2 |
| Optical properties | 1 | – | – | – | – | – |
| Flexibility | 1 | – | – | – | – | – |
| Texture | 1 | – | – | – | – | – |
| Spinnability | 1 | – | – | – | – | – |
| Fiber size, median true diameter | – | µm | – | – | – | – |
| Fiber size, median true length | – | µm | – | – | – | – |
| Resistance to: Acids<br>Bases | 1 | – | – | – | – | – |
| Zeta potential | – | mV | – | – | – | – |
| Decomposition temperature | 1 | °C | 950 | - | 950 | 950 |
| Refractive index | 2 | – | 1.634 | 0.049 | 1.599 | 1.668 |
| Dielectric constant | 1 | – | 7.03 | – | 7.03 | 7.03 |

| Property or Endpoint | N | Unit | Mean | Standard Deviation | Min | Max |
|---|---|---|---|---|---|---|
| Tensile strength | 2 | MPa | 34 | 37 | 7 | 60 |

**Table_Apx B-6. Physical and Chemical Properties of Actinolite**

| Property or Endpoint | N | Unit | Mean | Standard Deviation | Min | Max |
|---|---|---|---|---|---|---|
| Essential composition | 1 | – | – | – | – | – |
| Color | 2 | – | – | – | – | – |
| Luster | 1 | – | – | – | – | – |
| Surface area | – | $m^2/g$ | – | – | – | – |
| Hardness | 1 | Mohs | 6.0 | – | 6 | 6 |
| Specific gravity | 2 | – | 3.10 | 0.14 | 3 | 3.2 |
| Optical properties | 1 | – | – | – | – | – |
| Flexibility | 1 | – | – | – | – | – |
| Texture | 1 | – | – | – | – | – |
| Spinnability | 1 | – | – | – | – | – |
| Fiber size, median true diameter | 1 | µm | 0.50 | – | 0.5 | 0.5 |
| Fiber size, median true length | 1 | µm | 20.00 | – | 20 | 20 |
| Resistance to: Acids<br>Bases | 1 | – | – | – | – | – |
| Zeta potential | – | mV | – | – | – | – |
| Decomposition temperature | 1 | °C | 1,140 | - | 1,140 | 1,140 |
| Refractive index | 7 | – | 1.638 | 0.022 | 1.599 | 1.668 |
| Dielectric constant | – | – | – | – | – | – |
| Tensile strength | 1 | MPa | 7 | – | 7 | 7 |

# Appendix C ENVIRONMENTAL FATE AND TRANSPORT PROPERTIES OF ASBESTOS

Table_Apx C-1 to Table_Apx C-3 provide the environmental fate characteristics that EPA identified and considered in developing the scope for asbestos. This table may be updated as EPA collects additional information through systematic review methods.

**Table_Apx C-1. Aquatic Bioconcentration Study Summary for Asbestos**

| Study Type | Initial Concentration | Species | Duration | Result | Comments | Reference | Data Quality Evaluation Results of Full Study Report |
|---|---|---|---|---|---|---|---|
| Asbestos | | | | | | | |
| Non-guideline; experimental study; uptake monitoring of chrysotile asbestos in Coho and juvenile green sunfish | $1.5\times10^{6}$ and $3.0\times10^{6}$ fibers/L | Coho salmon (*Oncorhynchus kisutch*) and juvenile green sunfish (*Lepomis cyanellus*) | Coho salmon: 86 and 40 days; Green sunfish: 67 and 52 days | Asbestos fibers were found in the asbestos-treated fish by transmission electron microscopy (TEM); however total body burdens were not calculated. Sunfish lost scales and had epidermal tissue erosion. Asbestos fibers were not identified in control or blank samples. | The reviewer agreed with this study's overall quality level. | (Belanger et al., 1986c) | High |
| Non-guideline; experimental study; uptake monitoring of chrysotile by Asiatic clams | $2.5\times10^{8}$ to $8.8\times10^{9}$ fibers/L | Asiatic clams (*Corbicula* sp.) | 96 hours and 30 days | Chrysotile asbestos was detected in clams at 69.1±17.1 fibers/mg whole body homogenate after 96 hours of exposure to $10^{8}$ fibers/L and food.<br><br>Chrysotile asbestos was detected in clams after 30 days of exposure to $10^{8}$ fibers/L at 147.3±52.6 fibers/mg dry weight gill tissue and 903.7±122.9 fibers/mg dry weight visceral tissue. Chrysotile | The reviewer agreed with this study's overall quality level. | (Belanger et al., 1986b) | High |

| Study Type | Initial Concentration | Species | Duration | Result | Comments | Reference | Data Quality Evaluation Results of Full Study Report |
|---|---|---|---|---|---|---|---|
| | | | | asbestos was not detected in clams after 96 hours at all asbestos exposure concentrations tested with no food. | | | |
| Non-guideline; experimental study; measuring uptake of chrysotile asbestos by Asiatic clams | 0, $10^4$, and $10^8$ fibers/L | Asiatic clams (*Corbicula* sp., collected in winter and summer) | 30 days | Fibers were not detected in clams from blank control groups and after exposure to $10^4$ fiber/L groups for 30 days.<br><br>Asbestos concentration in tissue after exposure to $10^8$ fiber/L for 30 days (fibers/mg dry weight tissue) in winter samples: Gills: 132.1 ± 36.4; Viscera: 1055.1 ± 235.9 and summer samples: Gills: 147.5 ± 30.9; Viscera: 1127.4 ± 190.2. | The reviewer agreed with this study's overall quality level. | (Belanger et al., 1986a) | High |
| Non-guideline; experimental study; BCF determination of asbestos in the Asiatic clam | 0, $10^4$, and $10^8$ fibers/L | Asiatic clam (*corbicula* sp.) | 30 day and field exposed | BCF = 0.308 in gill tissue, 1.89 in viscera tissue, and 1.91 in whole clam homogenates after 30-days exposure to $10^8$ fibers/L.<br><br>Field exposed BCFs = 0.16–0.19 in gills, 64.9–102 in viscera, 1,442–5,222 in whole clams. | The reviewer agreed with this study's overall quality level. | (Belanger et al., 1987) | High |
| Non-guideline; experimental study; chrysotile | $5.1 \pm 2.8 \times 10^6$ and $7.6 \pm 8.1 \times 10^{10}$ fibers/L | Japanese Medaka (*Oryzias latipes*) | 28 days and 13 weeks | After 28 days of exposure to chrysotile asbestos at $10^{10}$ fibers/L | The reviewer agreed with this study's | (Belanger et al., 1990) | High |

| Study Type | Initial Concentration | Species | Duration | Result | Comments | Reference | Data Quality Evaluation Results of Full Study Report |
|---|---|---|---|---|---|---|---|
| asbestos uptake study in Japanese Medaka | | | | concentrations, fish total body burden was 375.7 fibers/mg. After 3 months of exposure to chrysotile asbestos at $10^8$ fibers/L concentrations, fish total body burden was 486.4 ± 47.9 fibers/mg. | overall quality level. | | |

**Table_Apx C-2. Hydrolysis Study Summary for Asbestos**

| Study Type | pH | Temperature (°C) | Duration | Results | Comments | Reference | Data Quality Evaluation Results of Full Study Report |
|---|---|---|---|---|---|---|---|
| Asbestos | | | | | | | |
| Non-guideline, experimental study; dissolution of asbestos in water at various pH and temperatures | 7, 7, 7, 9, and 4 for experiments 1–5, respectively | 44, 6, 25, 25, and 25 for experiments 1–5, respectively | 170 or 1,024 hours | 170-hour study results (proportion of 1 surface layer in ppm/layer) evaluating Mg removal from Chrysotile:<br>Experiments 1–4: 0.32–0.89<br>Experiment 5: (pH 4, 25 °C): 8.84.<br><br>170-hour study results (proportion of 1 surface layer in ppm/layer) evaluating Si removal from Chrysotile:<br>Experiments 1–4: 0.5–0.25<br>Experiment 5: 5.05.<br><br>170-hour study results | The reviewer agreed with this study's overall quality level. | (Gronow, 1987) | High |

| Study Type | pH | Temperature (°C) | Duration | Results | Comments | Reference | Data Quality Evaluation Results of Full Study Report |
|---|---|---|---|---|---|---|---|
| | | | | (proportion of 1 surface layer in ppm/layer) evaluating Mg removal from Crocidolite: Experiments 1–5: 0.42–1.80.<br><br>170-hour study results (proportion of 1 surface layer in ppm/layer) evaluating Si removal from Crocidolite: 0.03–0.56.<br><br>1,024-hour results (proportion of 1 surface layer in ppm/layer) for experiment 3 only: Chrysolite, Mg: 0.94; Si: 0.36 Crocidolite, Mg: 1.42; Si: 0.37. | | | |
| Non-guideline; dissolution study; sample size, temperature and pH evaluated; pH change over time compared for asbestos minerals, amosite, crocidolite and chrysotile | 5.9–6.1 (initial) | 5 to 45 | 20 minutes; 1,000 hours | Rate of dissolution is a function of surface area and temperature. $Mg^{2+}$ may be continuously liberated from fibers leaving a silica skeleton. The rate-controlling step was determined to be removal of brucite layer. Smaller particles liberated more magnesium. | The reviewer agreed with this study's overall quality level. | (Choi and Smith, 1972) | High |
| Non guideline; experimental study; a particle | Not reported but held constant | Not reported but held constant | 3–5 days | Chrysotile in natural water acquires a negative surface charge by rapid | The reviewer agreed with this study's | (Bales and Morgan, 1985) | High |

| Study Type | pH | Temperature (°C) | Duration | Results | Comments | Reference | Data Quality Evaluation Results of Full Study Report |
|---|---|---|---|---|---|---|---|
| electrophoresis apparatus was used to monitor absorption properties of chrysotile asbestos aging in water | | | | adsorption of natural organic matter (<1 day). Positively charged >Mg-$OH^{2+}$ sites are removed by dissolution in the outer brucite sheet resulting in exposure of underlying >$SiO^{-}$ sites. | overall quality level. | | |
| Chrysotile | | | | | | | |
| Non-guideline; dissolution study under natural, acidic, and basic conditions | NR in water or NaOH, 1.5–2.4 in 0.1N HCl | 25, 37, and 90 | 70 days | 1.7 and <0.2 mg/100 mL MgO and SiO2 detected at 70 days at 25 °C in water.<br><br>100 and 20 mg/100 mL MgO and $SiO_2$ detected at 132 days at 37 °C in 0.1 N HCl.<br><br>0 and 0.1 mg/100 mL MgO and $SiO_2$ detected at 49 days at 37°C in 0.1 N NaOH. | The reviewer agreed with this study's overall quality level. | (Clark and Holt, 1961) | Medium |
| Steady-state dissolution rate study | 2 to 8 | 22 | 187-659 hours | During the progress of each experiment, solution acidity decreased and chrysotile dissolved, releasing Mg and Si into solution. | The reviewer agreed with this study's overall quality level. | (Thom et al., 2013) | High |
| Mg and Si dissolution from Chrysotile over the pH range 3.0–8.5 | 3.0, 4.5, 6.0, 7.5, and 8.5 | 20 ± 2 | 336 hours | Mg = 552, 585 and 448 µmol/L at pH 3.0. 7.5 and 8.5 and 0.5, 336 and 336 hours, respectively.<br><br>Si = 11.6, 15.4 and 8.5 | The reviewer agreed with this study's overall quality level. | (Walter et al., 2019) | High |

| Study Type | pH | Temperature (°C) | Duration | Results | Comments | Reference | Data Quality Evaluation Results of Full Study Report |
|---|---|---|---|---|---|---|---|
| | | | | µmol/L at pH 3.0. 7.5 and 8.5 and 0.5, 336 and 336 hours, respectively. | | | |

**Table_Apx C-3. Other Fate Endpoints Study Summary for Asbestos**

| Study Type | System | Results | Comments | Reference | Data Quality Evaluation Results of Full Study Report |
|---|---|---|---|---|---|
| Asbestos | | | | | |
| Non-guideline, experimental study; the effect of lichen colonization on chrysotile structure is investigated by analyzing the composition of both colonized and uncolonized field samples. The effect of oxalic acid exposure on chrysotile structure is also investigated at various concentrations. | Chrysotile fibers were incubated in oxalic acid solutions for 35 days to observe its effect on MgO content. Chrysotile (both uncolonized or colonized by lichens) from 3 serpentinite outcrops and one asbestos cement roof were collected. | In the three asbestos outcrops and asbestos-cement roof, MgO content (wt %) was lower by 15–20% in lichen colonized chrysotile than in uncolonized chrysotile. Incubation in 50 mM oxalic acid transformed chrysotile fibers into "an amorphous powdery material, consisting mainly of pure silica," and without fibrous nature. | The reviewer agreed with this study's overall quality level. | (Favero-Longo et al., 2005) | High |
| Non-guideline, experimental study; oxalic acid and citric acid leaching of asbestos rich sediment | Asbestos rich sediment and a serpentine bedrock sample underwent leaching in 0.025 M oxalic acid and 0.017 M citric acid. Total elemental analysis was performed using inductively coupled plasma spectrometry (ICPS), individual fiber analysis was done using energy dispersive x-ray | ICPS results showed citric acid was slightly more effective at removing most metals from the sediment samples than oxalic acid; however, EDX analysis of individual fibers showed Mg/Si ratios were reduced from 0.68–0.69 to 0.07 by oxalic acid and only to 0.38 by citric acid. | The reviewer agreed with this study's overall quality level. | (Schreier et al., 1987) | High |

| Study Type | System | Results | Comments | Reference | Data Quality Evaluation Results of Full Study Report |
|---|---|---|---|---|---|
| | analysis (EDX) and a scanning and transmission electron microscope (STEM). | | | | |
| Non-guideline, experimental study; decomposition study of asbestos in 25% acid or caustic solutions | Chrysotile, crocidolite, amosite, anthophyllite, actinolite, and tremolite asbestos fibers were dissolved in 25% acid or NaOH solution | Degradation in 25% HCl, acetic acid, $H_3PO_4$, $H_2SO_4$ and NaOH, respectively was reported for:<br>• Chrysotile (55.69, 23.42, 55.18, 55.75 and 0.99%)<br>• Crocidolite (4.38, 0.91, 4.37, 3.69 and 1.35%)<br>• Amosite (12.84, 2.63, 11.67, 11.35 and 6.97%)<br>• Anthophyllite (2.66, 0.60, 3.16, 2.73 and 1.22%)<br>• Actinolite (20.31, 12.28, 20.19, 20.38 and 9.25%)<br>• Tremolite (4.77, 1.99, 4.99, 4.58 and 1.80%) | Due to limited information assessing the results were challenging. | (Speil and Leineweber, 1969) | Unacceptable |
| Non-guideline, U.S. Army Water Purification Equipment (ERDLator Unit) was used to remove asbestos fibers from Lake Superior water. | The optimized system operation was coagulation with addition of 2 ppm cationic polyelectrolyte (added in ERDLator water well), followed by filtration with 0.4 lbs of celite 535 precoat (Johns Manville) and 28 ppm body feed (Hyflo, Johns Manville Co.) with a 4.75 hour time. Analysis by Transmission Electron Microscopy (TEM) | Fiber concentration ($10^6$ fibers/L): Analysis 1: Raw Influent: 2.0; Effluent: 0; Analysis 2: Raw Influent: 0.3; Effluent: 0. | The reviewer agreed with this study's overall quality level. | (Schmitt et al., 1977) | Medium |

| Study Type | System | Results | Comments | Reference | Data Quality Evaluation Results of Full Study Report |
|---|---|---|---|---|---|
| Non-guideline, Water Treatment Pilot Plant Study | Ultracentrifugation of samples followed by ultrasonic resuspension of the residue in 1 mL of water and placing a 1 uL drop of this suspension on a 3-mm carbon-coated electron microscope grid. | Asbestos fiber in the finished waters were $<0.05\times10^6$ to $1.6\times10^6$ fibers/L after dual media filter #1; $<0.05\times10^6$ to $0.8\times10^6$ fibers/L after dual media filter #2 and, $0.05\times10^6$ to $1.9\times10^6$ fibers/L after the sand filter; fiber concentrations in all but two runs and $<5\times10^5$ fibers/L in 76% of the cases. | This overall score was downgraded: Evaluation of the reasonableness of the study results was not possible since a lack of a specific relationship between initial and final concentrations could not be determined. | (Hunsinger et al., 1980) | Low |
| Non-guideline, Asbestos fiber removal in a pilot plant | Well agitated suspension 10L tank, 8L flocculation tank (20 mg/L alum, pH 6.5), 35L sedimentation tank (120 min retention time), sand and MgO filter columns. Operation flow rate 240 mL/min. | Asbestos removal: from the feed water = $3\times10^9$ to $4\times10^9$ f/L, post sediment = $1.9\times10^6$ to $2.0\times10^6$ f/L, sand filter = $0.5\times10^6$ to $0.6\times10^6$ f/L, MgO filter = $0.2\times10^6$ to $0.3\times10^6$ f/L | Based on metric 7, 11, 15 and 17: Initial concentrations, mass balance and overall removal efficiencies were not reported. | (Ottaviani et al., 1986) | Unacceptable |
| Non-guideline, Laboratory settling experiment with bed sediment samples | Two bed-sediment samples were collected in the Sumas River at Nooksack and Swift Creek; samples (32.5 g Nooksack; 19.5 g Swift Creek) were suspended in 1 L asbestos free distilled water and mixed. | # of fibers at time 0 = ca. $1\times10^{12}$ f/L and after 144 hours = $1.75\times10^7$ to $1.75\times10^8$ f/L (Nooksack), # of fibers at time 0 = ca. $1.5\times10^{12}$ f/L and after 144 hours = $1.5\times10^8$ f/L (Swift Creek); suspended fiber size at time = 0 was ca. 16–45 µm and 8–9 µm at 144 hours (Nooksack # of fibers at time 0 = ca. $1.5\times10^{12}$ f/L and after 144 hours = $1.5\times10^8$ f/L (Swift Creek); suspended fiber size at time = 0 was ca. 16–45 µm and | Based on metric 15: Initial target chemical concentrations were not specified; mass balance not reported. | (Schreier and Taylor, 1981) | Unacceptable |

| Study Type | System | Results | Comments | Reference | Data Quality Evaluation Results of Full Study Report |
|---|---|---|---|---|---|
| | | 8–9 µm at 144 hours (Nooksack), at time = 0 was ca. 21 µm and 10 µm at 144 hours (Swift Creek); general observations: asbestos fibers settle in the absence of turbulence and water movement; rate of settling decreases over time; smaller fibers remain suspended longer than larger fibers. | | | |
| Non-guideline, Wastewater treatment removal efficiency: Denver Potable Water Reuse Demonstration Project in which a facility remediated secondary treated wastewater to meet potable water standards. | Rapid mix basin, flocculation basin, chemical clarifier, recarbonation basin, ballast pond, filters, first-stage carbon, ozone basin, second-stage carbon, reverse osmosis, and disinfection stages | Influent: 12.2 M fibers/L.<br><br>Effluent: Below detection limit or more than 50% of data was below the detection limit. | The reviewer agreed with this study's overall quality level. | (Lauer and Convery, 1988) | High |
| Chrysotile | | | | | |
| Non-guideline, Destructive treatment of asbestos-containing wastes (ACW) | Shaft furnace test facility: gasification and melting furnace with combustion chamber (CC), boiler, temperature reduction tower, bag filter (BF), and catalyst reaction tower; a HEPA filter was used to prevent discharge of fibers into the atmosphere. Melting temperature target 1500 °C (exceeded target 1568–696 °C), combustion chamber target 850–900 | Asbestos was not detected in solid product or in exhaust gas; TEM analysis detected no asbestos fibers in slag and fly ash (0 f/3,000 particles; <0.1% asbestos concentration); low levels were detected in BF outlet comparable to the surrounding ambient environment (<0.13–0.19 f/L); Measured asbestos concentration in the treated waste: slate material (n = 2) | The reviewer agreed with this study's overall quality level. | (Osada et al., 2013) | High |

| Study Type | System | Results | Comments | Reference | Data Quality Evaluation Results of Full Study Report |
|---|---|---|---|---|---|
| | °C, exhaust gas measured in the combustion chamber = 899–906 °C and exhaust gas measured in the HEPA filter inlet = 183–186 °C | chrysotile 7.3%, amosite <0.1%, crocidolite <0.1%; preformed insulation:chrysotile <0.1%, amosite 2.7%, crocidolite <0.1%. | | | |
| Non-guideline, Partitioning in the environment | 4 pond water and sediment samples collected (north, south, east, west), near an asbestos cement factory | 282–304 fibers/L in pond water, 360-420 fibers/g dw in pond sediment, plants (range includes root, pedicel, and leaves): 24–41 fiber/g dw in *Nelumbo nucifera*, 38–47 fiber/g dw in *Nymphaea nouchali*, 23-44 fiber/g dw in *Ranunculus scleratus* and 21 fiber/g dw in *Lemna gibba*. | The reviewer agreed with this study's overall quality level. | (Trivedi et al., 2004) | High |
| Non-guideline, Treatment of asbestos-containing material (ACM) wastes containing about 85 wt% chrysotile with ferric oxide and magnesium | Thermochemical method based on self-propagating high-temperature thermite reactions; reactions initiated using a tungsten coil connected to the power supply programmed to produce an energy pulse at 20V for ca. 4 seconds and turn off as soon as reaction began. Stainless steel reaction chamber filled with argon; temperature during reaction and average velocity of the combustion wave measured using thermocouples in the reaction mixture | Results for 50% ACM indicate the chrysotile reflections observed in the XRD pattern related to the initial material disappear after treatment; maintenance of self-propagating character of the system was optimal when ACM content was equal to or below 60 wt%. | The reviewer agreed with this study's overall quality level. | (Porcu et al., 2005) | High |

| Study Type | System | Results | Comments | Reference | Data Quality Evaluation Results of Full Study Report |
|---|---|---|---|---|---|
| Non-guideline, Fiber removal from water treatment plants in Southern California | Fiber concentrations were measured in influent and effluent at 5 water treatment plants. | Removal of fibers by coagulation and filtration during water treatment (%): Jensen: >97.7; Weymouth: 99.0; Diemer: 99.2; Mills: 99.8; Skinner: >86. Mean fiber concentrations in effluent from water plants were all $<5.4\times10^6$ fibers/L. | The reviewer agreed with this study's overall quality level. | (Bales et al., 1984) | Medium |
| Non-guideline, Removal of fibers in downstream source-water reservoirs | Fiber concentrations were measured in the influent and effluent of downstream source-water reservoirs. | Removal of fibers (%): Lake Pyramid-Castaic: 99.8; Lake Silverwood: 27; Lake Perris: 96; Lake Skinner: 88. Mean fiber concentrations ($10^6$ fibers/L) in effluents ranged from 2.2 (Lake Pyramid-Castaic) to 720 (Lake Silverwood). | The reviewer agreed with this study's overall quality level. | (Bales et al., 1984) | Medium |
| Non-guideline, Thermal decomposition study of the dehydroxylation of chrysotile, and subsequent recrystallization into non-hazardous minerals | A FEI Quanta 200 ESEM equipped with a thermal tungsten gun, a gaseous secondary electron detector (GSED), and a 1,500 °C hot stage for in situ electron imaging. 1.9–3.5 Torr for He and 2.5–3.4 Torr for water vapor atm. | He atm: newly formed crystals on the fiber surface appear up to 1,000 °C and crystallization continues up to 1,150 °C. Water vapor atmosphere: complete recrystallization is not accomplished during the non-isothermal experiment up to 1,300 °C. | The overall score was downgraded: this study evaluated thermal treatment processes but did not quantify all results. | (Gualtieri et al., 2008) | Low |
| Non-guideline, Asbestos fiber removal efficiency in direct filtration water treatment plants | Water treatment process: rapid mixing, flocculation, sedimentation, filtration, clear well; chemical treatment included pre-, intermediate, and post chlorination, coagulation | Mean removal: Weymouth 99.89%, Diemer 94.74%, Jensen NR, Skinner NR, Mills 99.33%; under optimized conditions >90% removal was observed in Weymouth; less effective | The reviewer agreed with this study's overall quality level. | (McGuire et al., 1983) | High |

| Study Type | System | Results | Comments | Reference | Data Quality Evaluation Results of Full Study Report |
|---|---|---|---|---|---|
| | with alum and cationic polymer and pH stabilization with caustic soda. | and more variable removals observed in Diemer; removal efficiency was not quantifiable in Jensen due to effluent values below detection levels; poor performance observed in Skinner; removal rates were among highest recorded in Mills. | | | |
| Non-guideline, Removal via coagulation | Open system; two reactors: 1L Pyrex beaker (mixed via stirred) and 0.9L Pyrex settling column (mixed via inversions). | 5 to 50-fold reduction in fiber concentration observed; total fiber count ($10^8$ fibers/L) = 0.05 ± 0.08 after 120 hours in beaker experiment and 1.7 ± 0.6 and 0.5 ± 0.2 after 68 and 120 hr, respectively, in the column experiment. | The reviewer agreed with this study's overall quality level. | (Kebler et al., 1989) | Medium |
| Non-guideline, Sedimentation of asbestos fibers | Asbestos suspensions allowed to settle and sedimentation rates were determined by visible settling rate or by measuring turbidity as a function of depth. Suspensions allowed to settle in graduated cylinders. | Fibers flocculate and settle rapidly (< 0 minutes) until volume reduced to 20% of initial volume, further reduction proceeded more slowly: 19% remaining /24hr; Fiber concentration: $5\times10^{11}$ fibers/L after 1 hr, $1\times10^{11}$ fibers/L after 24 hr. | The reviewer agreed with this study's overall quality level. | (Lawrence and Zimmermann, 1977) | High |

# Appendix D REGULATORY HISTORY

The chemical substance, asbestos, is subject to federal and state laws and regulations in the United States (Table_Apx D-1 and Table_Apx D-2). Regulatory actions by other governments, tribes, and international agreements applicable to asbestos are listed in Table_Apx D-3.

## D.1 Federal Laws and Regulations

**Table_Apx D-1. Federal Laws and Regulations**

| Statutes/Regulations | Description of Authority/Regulation | Description of Regulation |
|---|---|---|
| EPA statues/regulations | | |
| Asbestos Hazard Emergency Response Act (AHERA), 1986<br><br>TSCA Subchapter II: Asbestos Hazard Emergency Response 15 U.S.C. §2641–2656 | Defines asbestos as the asbestiform varieties of chrysotile (serpentine), crocidolite (riebeckite), amosite (cummingtonite-grunerite), anthophyllite, tremolite or actinolite.<br><br>Requires local education agencies (*i.e.,* school districts) to inspect school buildings for asbestos and submit asbestos management plans to appropriate state; management plans must be publicly available, and inspectors must be trained and accredited.<br><br>Tasked EPA to develop an asbestos Model Accreditation Plan (MAP) for states to establish training requirements for asbestos professionals who do work in school buildings and also public and commercial buildings. | Asbestos-Containing Materials in Schools Rule (per AHERA), 1987<br>40 CFR Part 763, Subpart E<br>Requires local education agencies to use trained and accredited asbestos professionals to identify and manage asbestos-containing building material and perform asbestos response actions (abatements) in school buildings. |
| Asbestos: Manufacture, Importation, Processing, and Distribution in Commerce Prohibitions; Final Rule (1989)<br>40 CFR Part 763, Subpart I | | EPA issued a final rule under section 6 of TSCA banning most asbestos-containing products.<br><br>In 1991, this rule was vacated and remanded by the Fifth Circuit Court of Appeals. As a result, most of the original ban on the manufacture, importation, processing, or distribution in commerce for the majority of the asbestos-containing products originally covered in the 1989 final rule was overturned. The following products remain banned by rule under TSCA:<br>• Corrugated paper |

| Statutes/Regulations | Description of Authority/Regulation | Description of Regulation |
|---|---|---|
| | | • Rollboard<br>• Commercial paper<br>• Specialty paper<br>• Flooring felt<br>In addition, the regulation continues to ban the use of asbestos in products that have not historically contained asbestos, otherwise referred to as "new uses" of asbestos (Defined by 40 CFR 763.163 as "commercial uses of asbestos not identified in §763.165 the manufacture, importation or processing of which would be initiated for the first time after August 25, 1989."). |
| Restrictions on Discontinued Uses of Asbestos; Significant New Use Rule (SNUR), 2019<br>40 CFR Parts 9 and 721 – Restrictions on Discontinued Uses of Asbestos | | This final rule strengthens the Agency's ability to rigorously review an expansive list of asbestos products that are no longer on the market before they could be sold again in the United States. Persons subject to the rule are required to notify EPA at least 90 days before commencing any manufacturing, importing, or processing of asbestos or asbestos-containing products covered under the rule. These uses are prohibited until EPA conducts a thorough review of the notice and puts in place any necessary restrictions or prohibits use. |
| Asbestos Worker Protection Rule, 2000<br>40 CFR Part 763, Subpart G | | Extends OSHA standards to public employees in states that do not have an OSHA approved worker protection plan. |
| Asbestos Information Act, 1988<br>15 U.S.C. §2607(f) | | Helped to provide transparency and identify the companies making certain types of asbestos-containing products by requiring manufacturers to report production to the EPA. |
| Asbestos School Hazard Abatement Act (ASHAA), 1984 and Asbestos School Hazard Abatement Reauthorization Act (ASHARA), 1990 | | Provided funding for and established an asbestos abatement loan and grant program for school districts and ASHARA further tasked EPA to update the MAP asbestos worker training requirements. |

| Statutes/Regulations | Description of Authority/Regulation | Description of Regulation |
|---|---|---|
| 20 U.S.C. 4011 et seq. | | |
| Emergency Planning and Community Right-to-Know Act (EPCRA) – section 313 | Requires annual reporting from facilities in specific industry sectors that employ 10 or more full-time equivalent employees and that manufacture, process or otherwise use a TRI-listed chemical in quantities above threshold levels. A facility that meets reporting requirements must submit a reporting form for each chemical for which it triggered reporting, providing data across a variety of categories, including activities and uses of the chemical, releases and other waste management (*e.g.,* quantities recycled, treated, combusted) and pollution prevention activities (under section 6607 of the Pollution Prevention Act). These data include on- and off-site data as well as multimedia data (*i.e.,* air, land, and water). | Under section 313, Toxics Release Inventory (TRI), requires reporting of environmental releases of friable asbestos at a concentration level of 0.1%.<br><br>Friable asbestos is designated as a hazardous substance subject to an Emergency Release Notification at 40 CFR §355.40 with a reportable quantity of 1 lb. |
| Clean Air Act, 1970<br>42 U.S.C. §7401 et seq.<br><br>Asbestos National Emission Standard for Hazardous Air Pollutants (NESHAP), 1973 | 40 CFR Part 61, Subpart M | Specifies demolition and renovation work practices involving asbestos in buildings and other facilities (but excluding residences with 4 or fewer dwelling units single family homes).<br><br>Requires building owner/operator notify appropriate state agency of potential asbestos hazard prior to demolition/renovation.<br><br>Banned spray-applied surfacing asbestos-containing material for fireproofing/insulating purposes in certain applications.<br><br>Requires that asbestos-containing waste material from regulated activities be sealed in a leak-tight container while wet, labeled, and disposed of properly in a landfill qualified to receive asbestos waste. |
| Clean Water Act (CWA), 1972 33 U.S.C. §1251 et seq | | Toxic pollutant subject to effluent limitations per section 1317. Asbestos is a Priority Pollutant. |

| Statutes/Regulations | Description of Authority/Regulation | Description of Regulation |
|---|---|---|
| Safe Drinking Water Act (SDWA), 1974 42 U.S.C. §300f et seq | | Asbestos Maximum Contaminant Level (MCL) 7 million fibers/L (longer than 10 µm). |
| Resource Conservation and Recovery Act (RCRA), 1976 42 U.S.C. §6901 et seq. | 40 CFR 239–282 | Asbestos is subject to solid waste regulation when discarded; NOT considered a hazardous waste. |
| Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), 1980 42 U.S.C. §9601 et seq. | 40 CFR Part 302.4 – Designation of Hazardous Substances and Reportable Quantities | 13 Superfund sites containing asbestos, 9 of which are on the National Priorities List (NPL) Reportable quantity of friable asbestos is 1 lb. |
| Other federal statutes/regulations | | |
| Occupational Safety and Health Administration (OSHA): Public Law 91-596 Occupational Safety and Health Act, 1970 | Asbestos General Standard 29 CFR 1910 Asbestos Shipyard Standard 29 CFR 1915 Asbestos Construction Standard 29 CFR 1926 | Employee permissible exposure limit (PEL) is 0.1 fibers per cubic centimeter (f/cc) as an 8-hour, time-weighted average (TWA) and/or the excursion limit (1.0 f/cc as a 30-minute TWA). |
| Consumer Product Safety Act<br><br>Federal Hazardous Substances Act (FHSA) 16 CFR 1500 | The CPSA provides the Consumer Product Safety Commission with authority to recall and ban products under certain circumstances.<br><br>The FHSA requires certain hazardous household products to have warning labels. It also gives CPSC the authority to regulate or ban a hazardous substance, and toys or other articles intended for use by children, under certain circumstances. | Consumer patching compounds and artificial ash and embers containing respirable freeform asbestos are banned as hazardous products under the CPSA. (16 CFR 1304 & 1305)<br><br>General-use garments containing asbestos are banned as a hazardous substance under the FHSA (16 CFR 1500.17(a)) |
| Federal Food and Cosmetics Act (FFDCA) | Provides the FDA with authority to oversee the safety of food, drugs and cosmetics. | Prohibits the use of asbestos-containing filters in pharmaceutical manufacturing, processing and packing. 21 CFR 211.72 |
| Mine Safety and Health Administration (MSHA) | | Surface Mines 30 CFR part 56, subpart D Underground Mines 30 CFR part 57, subpart D |
| Federal Hazardous Materials Transportation Act (HMTA) | Section 5103 of the Act directs the Secretary of Transportation to: | Asbestos is listed as a hazardous material with regard to transportation and is subject to regulations prescribing requirements |

| Statutes/Regulations | Description of Authority/Regulation | Description of Regulation |
|---|---|---|
| | • Designate material (including an explosive, radioactive material, infectious substance, flammable or combustible liquid, solid or gas, toxic, oxidizing or corrosive material, and compressed gas) as hazardous when the Secretary determines that transporting the material in commerce may pose an unreasonable risk to health and safety or property.<br>• Issue regulations for the safe transportation, including security, of hazardous material in intrastate, interstate. and foreign commerce. | applicable to the shipment and transportation of listed hazardous materials. 49 CFR part 172.101Appendix A. |

## D.2 State Laws and Regulations

Pursuant to AHERA, states have adopted through state regulation the EPA's Model Accreditation Plan (MAP) for asbestos abatement professionals who do work in schools and public and commercial buildings. Thirty-nine states have EPA-approved MAP programs and 12 states have also applied to and received a waiver from EPA to oversee implementation of the Asbestos-Containing Materials in Schools Rule pursuant to AHERA. States also implement regulations pursuant to the Asbestos NESHAP regulations or further delegate those oversight responsibilities to local municipal governments. While federal regulations set national asbestos safety standards, states have the authority to impose stricter regulations. As an example, many states extend asbestos federal regulations—such as asbestos remediation by trained and accredited professionals, demolition notification, and asbestos disposal—to ensure safety in single-family homes. Thirty states require firms hired to abate asbestos in single family homes to be licensed by the state. Nine states mandate a combination of notifications to the state, asbestos inspections, or proper removal of asbestos in single family homes. Some states have regulations completely independent of the federal regulations. For example, California and Washington regulate products containing asbestos. Both prohibit use of more than 0.1 percent of asbestos in brake pads and require laboratory testing and labeling.

Table_Apx D-2 includes a non-exhaustive list of state regulations that are independent of the federal AHERA and NESHAP requirements that states implement.

**Table_Apx D-2. State Laws and Regulations**

| State Actions | Description of Action |
|---|---|
| California | Asbestos is listed on California's Candidate Chemical List as a carcinogen. Under California's Propositions 65, businesses are required to warn Californians of the presence and danger of asbestos in products, home, workplace and environment. |
| California Brake Friction Material Requirements (Effective 2017) | *Division 4.5, California Code of Regulations, Title 22 Chapter 30*<br>Sale of any motor vehicle brake friction materials containing more than 0.1% asbestiform fibers by weight is prohibited. All brake pads for sale in the state of California must be laboratory tested, certified and labeled by the manufacturer. |

| State Actions | Description of Action |
|---|---|
| Massachusetts | *Massachusetts Toxics Use Reduction Act (TURA)*<br><br>Requires companies in Massachusetts to provide annual pollution reports and to evaluate and implement pollution prevention plans. Asbestos is included on the Complete List of TURA Chemicals – March 2016. |
| Minnesota | *Toxic Free Kids Act Minn. Stat. 2010 116.9401 – 116.9407*<br><br>Asbestos is included on the 2016 Minnesota Chemicals of High Concern List as a known carcinogen. |
| New Jersey | New Jersey *Right to Know Hazardous Substances*<br><br>The state of New Jersey identifies hazardous chemicals and products. Asbestos is listed as a known carcinogen and talc containing asbestos is identified on the Right to Know Hazardous Substances list. |
| Rhode Island | *Rhode Island Air Resources – Air Toxics Air Pollution Control Regulation No. 22*<br><br>Establishes acceptable ambient air levels for asbestos. |
| Washington | *Better Brakes Law (Effective 2015) Chapter 70.285 RCW Brake Friction Material*<br><br>Prohibits the sale of brake pads containing more than 0.1% asbestiform fibers (by weight) in the state of Washington and requires manufacturer certification and package/product labeling.<br><br>*Requirement to Label Building Materials that Contain Asbestos Chapter 70.310 RCW*<br><br>Building materials that contain asbestos must be clearly labeled as such by manufacturers, wholesalers, and distributors. |

## D.3 International Laws and Regulations

**Table_Apx D-3. Regulatory Actions by Other Governments, Tribes, and International Agreements**

| Country/ Organization | Requirements and Restrictions |
|---|---|
| European Union | The European Union (EU) will prohibit the use of asbestos in the chlor-alkali industry by 2025 (Regulation(EC) No 1907/2006 of the European Parliament and of the Council, 18 December 2006).<br><br>Otherwise, under EU regulations, the placing on the market and use of chrysotile fibers and products containing these fibers added intentionally are already prohibited pursuant to Directive 1999/77/ |

| Country/ Organization | Requirements and Restrictions |
|---|---|
| | E.C. of 26.7.1999. The use of products containing asbestos fibers that were already installed and/or in service before the implementation date of Directive 1999/77/ EC continues to be authorized until such products are disposed of or reach the end of their service life. However, Member States may prohibit the use of such products before they are disposed of or reach the end of their service life (Regulatory Status of chrysotile asbestos in the EU).<br><br>The emissions and release of asbestos is regulated, and construction materials containing asbestos are classified as hazardous waste. Concerning the safety of workers, EU regulations stipulate that employers shall ensure that no worker is exposed to an airborne concentration of asbestos (including chrysotile) in excess of 0.1 fibers per $cm^3$ as an 8-hour time-weighted average (Regulatory Status of chrysotile asbestos in the EU). |
| Canada | Canada banned asbestos in 2018.<br><br>*Prohibition of Asbestos and Products Containing Asbestos Regulations: SOR/2018-196* (Canada Gazette, Part II, Volume 152, Number 21). |
| UNEP Rotterdam Convention | The Conference of Parties is considering a recommendation from the Chemical Review Committee to list chrysotile asbestos in Annex III to the Rotterdam Convention. Annex III chemicals require prior informed consent for importation. |
| UNEP Basel Convention | Under the Basel Convention, Asbestos (dust and fibres) is designated a hazardous waste. Listed codes Y36 (Annex 1) and A2050 (Annex VIII). Among its provisions, the Convention restricts the import and export of hazardous waste and requires parties to the convention to appropriate measures to ensure the environmentally sound management of hazardous waste. |
| World Health Organization (WHO) | The World Health Assembly resolution 60.26 requests WHO to carry out a global campaign for the elimination of asbestos-related diseases "…bearing in mind a differentiated approach to regulating its various forms - in line with the relevant international legal instruments and the latest evidence for effective interventions…." |
| Algeria, Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Chile, Croatia, Cyprus, Czech Republic, Denmark, Egypt, Estonia, Finland, France, Germany, Greece, Honduras, Hungary, Iceland, Ireland, Israel, Italy, Japan, Kuwait, Latvia, Lithuania, Luxembourg, Mozambique, Netherlands, New Zealand, North Macedonia, Norway, Oman, Poland, Portugal, Romania, Saudi Arabia, Serbia, Slovakia, Slovenia, South Afrika, | National bans of asbestos are reported in these countries (IARC 2012 Lin R-T, Lancet 2019). |

| Country/ Organization | Requirements and Restrictions |
|---|---|
| South Korea, Spain, Sweden, Taiwan, Turkey, United Kingdom, Uruguay | |

# Appendix E PROCESS, RELEASE, AND OCCUPATIONAL EXPOSURE INFORMATION

This appendix provides information and data found in preliminary data gathering for asbestos.

## E.1 Process Information

Process-related information potentially relevant to the risk evaluation may include process diagrams, descriptions, and equipment. Such information may inform potential release sources and worker exposure activities.

## E.2 Uses

### E.2.1 Chemical Substances in Construction, Paint, Electrical, and Metal Products

Asbestos has several unique properties, including low electrical conductivity, high tensile strength, high friction coefficient and high heat resistance (Virta, 2011). These properties are one reason why asbestos was previously incorporated in various products, like insulation (sound, heat and electrical) and building materials (cement pipes, roofing compounds, adhesives, flooring). Due to health concerns and consumer preference, manufacturers no longer incorporate asbestos in these products. However, ongoing exposures to asbestos in these and other products continue to occur, particularly when buildings are renovated or demolished. It is also possible that imported asbestos-containing products could go into aftermarket sales and be used commercially.

Previously, asbestos was found in various construction materials such as cement sheets used in corrugated cement, siding and roofing shingles used in residential and commercial buildings, and various other construction applications (U.S. EPA, 1982). Asbestos-cement (A/C) products typically contained 30 to 40 percent chrysotile asbestos, by weight. At locations where these legacy products are still found, asbestos can be released when the products are disturbed or removed.

In 1982, EPA reported that asbestos was used at the time in various adhesive, sealant, paint, and coating products, including spackling compounds, drywall patching and taping compounds, and textured paints (U.S. EPA, 1982). EPA's 1982 analysis also concluded that asbestos was found in consumer and commercial asphalt and tar-based sealants at concentrations ranging from 5 to 10 percent wetted chrysotile fibers and in water-soluble latex or gypsum-based sealants at between 3 to 5 percent non-wetted asbestos. These sealings and coatings were likely used by various contractors or tradesmen, and were commercially spread on the roofing of level-top buildings using large brushes or trowels, but certain sealant formulations were likely applied by brush or spray coating (U.S. EPA, 1982). Some of the previously installed asbestos-containing products may still be found in buildings and other settings today and represent a source of potential exposure during renovations, demolitions, fires, and other scenarios.

### E.2.2 Chemical Substances in Furnishing, Cleaning, and Treatment Care Products

An analysis by EPA conducted in 1982 identified numerous different textiles that contained asbestos, some with concentrations between 75 to 100 percent. Examples of these products included: lap, roving, yarn, cord, thread, cloth, tape, tubing, wick, rope, and felt. These intermediate textile forms were used to manufacture fire resistant clothing, thermal and electrical insulation, packaging and gaskets, friction materials, and specialty textiles (U.S. EPA, 1982).

### E.2.3 Chemical Substances in Packaging, Paper, Plastic, Toys, and Hobby Products

EPA's 1982 analysis noted that asbestos fibers were incorporated into various forms of plastics available at the time, when the asbestos was used to increase impact resistance, heat resistance, and dimensional stability (U.S. EPA, 1982). These plastic articles typically contained asbestos at low concentrations and were used in many applications. In the early 20th century, amosite asbestos was used as decorative "artificial snow" that was sprinkled onto trees, wreaths, and ornaments in homes (Povtak, 2011). EPA plans to further investigate these asbestos-containing products during risk evaluation, to the extent that the products may be encountered today.

### E.2.4 Chemical Substances in Products Not Described by Other Codes

More recent literature has reported that asbestos has been found in artifacts in museum collections, which presents a risk of exposure for curators and conservators that handle the items (Holzer, 2012). As previously stated, asbestos has been incorporated into plastic products in order to increase their physical properties. Some current specialty uses of these products include aerospace applications, such as thermal isolator blocks for the RS-25 engine and high-performance plastics including heat shields, rocket motor casings, and rocket motor liners (NASA, 2015). EPA plans to further investigate these uses of asbestos during risk evaluation.

### E.2.5 Disposal

Each of the conditions of use of asbestos may generate asbestos-containing waste streams that are collected and transported to third-party sites for disposal or treatment. Industrial sites that treat or dispose onsite wastes that they themselves generate are assessed in each condition of use assessment. Similarly, point source discharges of asbestos to surface water are assessed in each condition of use assessment (point source discharges are exempt as solid wastes under the Resource Conservation and Recovery Act [RCRA]). Asbestos-containing wastes that are generated during a condition of use and sent to a third-party site for treatment or disposal include

- Wastewater: Asbestos may be contained in wastewater discharged to POTW or to other, non-public treatment works for treatment. Industrial wastewater containing asbestos discharged to a POTW may be subject to EPA or authorized NPDES state pretreatment programs. The assessment of wastewater discharges to POTWs and non-public treatment works of asbestos is included in each of the condition of use assessments.
- Solid Wastes: Solid wastes are defined under RCRA as any material that is discarded by being: abandoned; inherently waste-like; a discarded military munition; or recycled in certain ways (certain instances of the generation and legitimate reclamation of secondary materials are exempted as solid wastes under RCRA).
- Wastes Exempted as Solid Wastes under RCRA: Certain conditions of use of asbestos may generate wastes of asbestos that are exempted as solid wastes under 40 CFR 261.4(a).

The asbestos NESHAP minimizes asbestos release during renovation/demolition by requiring NESHAP regulated asbestos-containing waste material be sealed in a leak-tight container while wet, labeled and disposed of properly in a landfill qualified to receive asbestos waste.

Landfills have special requirements for handling and securing the asbestos-containing waste regulated under NESHAP to prevent releases of asbestos into the air. Transportation vehicles that move the waste from the point of generation to the asbestos landfill have special labeling requirements and waste shipment recordkeeping requirements (U.S. EPA, 2016). Specific waste management practices are controlled at the state level.

Asbestos has no vapor pressure at 25 °C (77 °F). Because of this and due to asbestos' fibrous form, releases of asbestos "vapors" are not expected to occur. However, EPA anticipates dust releases of asbestos to air because asbestos fibers are in solid form.

## E.3 Preliminary Occupational Exposure Data

EPA presents below an example of occupational exposure-related information obtained from preliminary data gathering. EPA plans to consider this information and data in combination with other data and methods for use in the risk evaluation.

Table_Apx E-1 summarizes NIOSH Health Hazard Evaluations identified during EPA's preliminary data gathering. HHEs can be found at https://www.cdc.gov/niosh/hhe/.

**Table_Apx E-1. Summary of NIOSH HHEs with Monitoring for Asbestos**

| Year of Publication | Report Number | Facility Description |
|---|---|---|
| 2019 | HETA-2018-0094-3355 | Cleanup and debris removal companies (Northern California) |
| 2019 | HETA-2017-0076-3352 | Federal forest management agency (Kootenai National Forest, MT) |
| 2014 | HETA-2012-0077-3223 | Federal forest management agency (Kootenai National Forest, MT) |
| 2009 | HETA-2007-0201-3086 | Electronics manufacturing plant (Sanmina-SCI Corporation, Huntsville, AL) |
| 2006 | HETA-2005-0329-2995 | Youth development center (Swannanoa, North Carolina) |
| 2003 | HETA-2002-0157-2887 | Municipal waste transfer station (Dominic Tomaro Public Works Garage Complex, Cleveland Heights, OH) |
| 2003 | HETA-2001-0461-2889 | Counter top design and installation firm (The Concrete Revolution, Denver, CO) |
| 2002 | HETA-2002-0038-2870 | Federal office building (New York City, NY) |
| 2002 | HETA-98-0237-2872 | Iron Foundry (Mueller Company, Chattanooga, TN) |
| 1997 | HETA-94-0078-2660 | Office building (Washington, D.C.) and apartment complex (Buffalo, NY) |
| 1994 | HETA-93-0696-2395 | Landfill (Hardy Road Landfill, Akron, OH) |
| 1994 | HETA-93-0562-2464 | University building (Copeland Hall, Ohio University) |
| 1994 | HETA-92-0319-2459 | University building (L.K. Downing Hall, Howard University) |
| 1993 | HETA-91-0215-2293 | Office building (IRS Appeals Office, Omaha, NE) |
| 1992 | HETA-92-0216-2239 | Office building (Kenton County Department for Social Insurance, Covington, KY) |
| 1992 | HETA-91-0338-2187 | Nitroparaffin plant (IMC Corporation, Sterlington, LA) |
| 1992 | HETA-89-0252-2178 | Power plant (Albright Power Station, Albright, WV) |
| 1990 | HETA-90-0151-L2067 | Residential homes (Westside Energy Co-Op, Denver, CO) |

| Year of Publication | Report Number | Facility Description |
|---|---|---|
| 1990 | HETA-89-0270-2080 | Steam power plant (Harrisburg Steam Generation Facility, Harrisburg, PA) |
| 1990 | HETA-88-0348-2081 | Wastewater treatment plant (A.E. Staley Manufacturing Company, Decatur, IL) |
| 1989 | HETA-89-0262-1994 | Power plant (Albright Power Station, Albright, WV) |
| 1989 | HETA-88-0372-1953 | Government building, hospital, sugar factory, public school, and vehicle maintenance shop (Bridgetown, Barbados) |
| 1988 | HETA-86-0422-1891 | Power plant (City of Ames Municipal Power Plant, Ames, IA) |
| 1987 | HETA-87-0162-1864 | Office buildings, garage, carpenter shop, kennels, plumbing shop, apartments, storage buildings, houses, powerhouse (Denali National Park and Preserve, Denali, AK) |
| 1986 | HETA-84-0257-1650 | Municipal water distribution company (Denver Water Department, Denver, CO) |
| 1985 | HETA-85-0226-1839 | Vitamin manufacturing facility (Freshlabs, Warren, MI) |
| 1985 | HETA-84-0321-1590 | Residential building (Rockford, IL) |
| 1984 | HETA-84-043-1429 | Office building (Pennsylvania Department of Transportation and Safety, Harrisburg, PA) |
| 1984 | HETA-84-029-1427 | Office building (Jewish Family and Childrens Agency, Ardmore, PA) |
| 1984 | HETA-83-0450-1468 | Monument (George Rogers Clark National Historical Park, Vincennes, IN) |
| 1984 | HETA-83-0418-1449 | Office buildings (Randolph County Register of Deeds Office, Asheboro, NC) |
| 1984 | HETA-82-0305-1541 | Landfill (Fountain Avenue Landfill, Brooklyn, NY) |
| 1984 | HETA-82-0102-1464 | University laboratory (University of Cincinnati, OH) |
| 1983 | HETA-83-358-1362 | Federal office building (Baltimore, MD) |
| 1983 | HETA-83-189-1368 | Aerospace product manufacturing plant (Goodyear Aerospace Corporation, Akron, OH) |
| 1983 | HETA-83-134-1327 | Visitor center (Mound City Group National Monument Visitors Service Center, Chillicothe, OH) |
| 1983 | HETA-83-0112-1309 | High school (Saint Francis High School, Morgantown, WV) |
| 1983 | HETA-83-0106-1311 | Office building (West Virginia Geological and Economic Survey, Morgantown, WV) |
| 1983 | HETA-83-0073-1293 | Petrified wood storage facility (Russell-Zuhl, Inc., New York City, NY) |

| Year of Publication | Report Number | Facility Description |
|---|---|---|
| 1983 | HETA-83-040-1356 | Motor vehicle part manufacturing plant (Drive Train Industries, Casper, WY) |
| 1983 | HETA-83-039-1305 | Motor vehicle part manufacturing plant (Drive Train Industries, Grand Junction, CO) |
| 1983 | HETA-82-0373-1363 | Office building (Transamerica Occidental Life Insurance Company, Atlanta, GA) |
| 1983 | HETA-82-096-1259 | Aluminum manufacturing plant (Kaiser Aluminum and Chemical Corporation, Ravenswood, WV) |
| 1983 | HETA-82-067-1253 | Roofing application sites (Anchor Hocking Glass Company, Lancaster, OH) |
| 1983 | HETA-79-129-1350 | Newspaper printing press (San Francisco Newspaper Agency, San Francisco, CA) |
| 1982 | HETA-82-0131-1098 | Office building (U.S. Department of Justice, Washington, D.C.) |
| 1982 | HETA-82-086-1126 | Office building (Pennsylvania Department of Transportation, Montoursville, PA) |
| 1981 | HETA-82-004-1006 | Elementary school (Guilford School, Cincinnati, OH) |
| 1981 | HETA-81-038-801 | Hotel (Hensel Phelps Construction Company, Greeley, CO) |
| 1981 | HETA-81-0028-1059 | Freight car shop (Consolidated Railroad Corporation, Reading, PA) |
| 1981 | HETA-80-0176-0955 | Office building (New England Telephone Company, Manchester, NH) |
| 1980 | HETA-80-0114-0737 | Retail location (Potomac Photo Supply, Washington, D.C.) |
| 1980 | HETA-79-141-711 | Electronics manufacturing site (Fischer & Porter Company, Warminster, PA) |
| 1979 | HETA-79-28 | Warehouse (Smithsonian Institution, Washington, D.C.) |
| 1979 | HETA-78-119-637 | Petroleum product compounding site (Texaco, Bayonne, NJ) |
| 1979 | HETA-78-71-633 | Flooring manufacturing plant (Kentile Floors, Brooklyn, NY) |
| 1977 | HETA-77-102-434 | Airport Terminal (Trans World Airlines, Kansas City International Airport, Kansas City, MO) |
| 1976 | HETA-76-63 | Museums (Smithsonian Institution, Washington, D.C.) |
| 1976 | HETA-76-000-040 | Office building (National Science Foundation, Washington, D.C) |

Data that inform occupational exposure assessment and which EPA expects to consider as part of the occupational exposure assessment is the OSHA Chemical Exposure Health Data (CEHD), which are monitoring data collected during OSHA inspections. According to OSHA asbestos standards, the employee PEL is 0.1 fibers per cubic centimeter (f/cc) as an 8-hour, TWA and an excursion limit of 1.0 f/cc as a 30-minute TWA (Asbestos General Standard 29 CFR 1910).

A preliminary summary of OSHA's monitoring data from 2010 to 2020 is presented in Table_Apx E-2. These data represent actual exposure levels of asbestos at specific workplaces encompassing several industry sectors and conditions of use.

**Table_Apx E-2. Summary of Industry Sectors with Asbestos Monitoring Samples Available from OSHA Inspections Conducted between 2010 and 2020**

| North American Industrial Classification System (NAICS) | NAICS Description | Number of Data Points |
|---|---|---|
| 11 | Agriculture, Forestry, Fishing and Hunting | 9 |
| 21 | Mining, Quarrying, and Oil and Gas Extraction | 4 |
| 22 | Utilities | 145 |
| 23 | Construction | 3,433 |
| 31–33 | Manufacturing | 892 |
| 42 | Wholesale Trade | 214 |
| 44–45 | Retail Trade | 228 |
| 48–49 | Transportation and Warehousing | 1,019 |
| 51 | Information | 114 |
| 52 | Finance and Insurance | 67 |
| 53 | Real Estate and Rental and Leasing | 536 |
| 54 | Professional, Scientific, and Technical Services | 103 |
| 55 | Management of Companies and Enterprises | 5 |
| 56 | Administrative and Support and Waste Management and Remediation Services | 1,102 |
| 61 | Educational Services | 389 |
| 62 | Health Care and Social Assistance | 498 |
| 71 | Arts, Entertainment, and Recreation | 55 |
| 72 | Accommodation and Food Services | 129 |
| 81 | Other Services (except Public Administration) | 228 |
| 92 | Public Administration | 805 |

# Appendix F SUPPORTING INFORMATION – CONCEPTUAL MODEL FOR INDUSTRIAL AND COMMERCIAL ACTIVITIES AND USES

**Table_Apx F-1. Worker and Occupational Non-user Exposure Conceptual Model Supporting Table**

| Life Cycle Stage | Category | Subcategory | Release/ Exposure Scenario | Exposure Pathway | Exposure Route | Receptor/ Population | Proposed for Further Risk Evaluation | Rationale for Further Evaluation / No Further Evaluation |
|---|---|---|---|---|---|---|---|---|
| Industrial/ Commercial Use | Chemical Substances in Construction, Paint, Electrical, and Metal Products | Construction and building materials covering large surface areas, including paper articles; metal articles; stone, plaster, cement, glass, and ceramic articles | Used in construction and building materials covering large surface areas, including paper articles; metal articles; stone, plaster, cement, glass, and ceramic articles | Solid Contact | Dermal, Oral | Workers | Yes | The potential for worker exposure exists during this use, since in-place asbestos-containing materials can be disturbed during activities involving demolition or renovation. |
| | | | | Liquid Contact | Dermal, Oral | Workers, ONU | Yes | Liquid exposure is possible during this use, as workers and ONUs may contact asbestos-contaminated stormwater, and workers may contact dust suppression water, and other wastewater found at construction and demolition sites. |
| | | | | Vapor | Inhalation | Workers, ONU | No | Asbestos is a fibrous substance, thus would not exist as a vapor. |
| | | | | Mist | Inhalation, Dermal, Oral | Workers, ONU | No | Mist generation is not expected during use in construction/building materials. |
| | | | | Dust | Inhalation, Dermal, Oral | Workers, ONU | Yes | Dust generation is possible during activities involving demolition or renovation when in-place asbestos-containing materials are disturbed. |
| | | | | Solid Contact | Dermal, Oral | ONU | No | Exposures are expected to be primarily restricted to workers who are working at locations where in-place asbestos-containing materials are disturbed. ONUs are not expected to come in direct contact with asbestos. |
| | | Machinery, mechanical appliances, | Used in machinery, mechanical | Solid Contact | Inhalation, Dermal, Oral | Workers | Yes | The potential for worker exposure exists during this use, as solid asbestos could be incorporated into machinery and mechanical appliances. |

| Life Cycle Stage | Category | Subcategory | Release/ Exposure Scenario | Exposure Pathway | Exposure Route | Receptor/ Population | Proposed for Further Risk Evaluation | Rationale for Further Evaluation / No Further Evaluation |
|---|---|---|---|---|---|---|---|---|
| Industrial/ Commercial Use | Chemical Substances in Construction, Paint, Electrical, and Metal Products | electrical/electronic articles | appliances, and electronic articles | Liquid Contact | Dermal, Oral | Workers, ONU | No | Liquid generation is not expected during use in machinery. |
| | | | | Vapor | Inhalation | Workers, ONU | No | Asbestos is a fibrous substance, thus would not exist as a vapor. |
| | | | | Mist | Inhalation, Dermal, Oral | Workers, ONU | No | Mist generation is not expected during use in machinery. |
| | | | | Dust | Inhalation, Dermal, Oral | Workers, ONU | Yes | Dust generation is possible during use in machinery. |
| | | | | Solid Contact | Dermal, Oral | ONU | No | Exposures are expected to be primarily restricted to workers who are working at locations where in-place asbestos-containing materials are disturbed. ONUs are not expected to come in direct contact with asbestos. |
| | | Other machinery, mechanical appliances, electronic/electronic articles | Used in other machinery, mechanical appliances, and electronic articles | Solid Contact | Inhalation, Dermal, Oral | Workers | Yes | The potential for worker exposure exists during this use, as solid asbestos could be incorporated into other mechanical appliances. |
| | | | | Liquid Contact | Dermal, Oral | Workers, ONU | No | Liquid generation is not expected during use in other machinery. |
| | | | | Vapor | Inhalation | Workers, ONU | No | Asbestos is a fibrous substance, thus would not exist as a vapor. |
| | | | | Mist | Inhalation, Dermal, Oral | Workers, ONU | No | Mist generation is not expected during use in other machinery. |
| | | | | Dust | Inhalation, Dermal, Oral | Workers, ONU | Yes | Dust generation is possible during use in other machinery. |
| | | | | Solid Contact | Dermal, Oral | ONU | No | Exposures are expected to be primarily restricted to workers who are working at locations where in-place asbestos-containing materials are disturbed. ONUs are not expected to come in direct contact with asbestos. |
| | | Fillers and putties | Used in fillers and putties | Solid Contact | Inhalation, Dermal, Oral | Workers | Yes | The potential for worker exposure exists during this use, as dried fillers and putties containing asbestos could chip away from the intended surfaces. |

| Life Cycle Stage | Category | Subcategory | Release/ Exposure Scenario | Exposure Pathway | Exposure Route | Receptor/ Population | Proposed for Further Risk Evaluation | Rationale for Further Evaluation / No Further Evaluation |
|---|---|---|---|---|---|---|---|---|
| Industrial/ Commercial Use | Chemical Substances in Construction, Paint, Electrical, and Metal Products | | | Liquid Contact | Dermal, Oral | Workers, ONU | Yes | Liquid exposure is possible during this use, as workers and ONUs may contact asbestos-contaminated wastewater from surfaces treated with fillers and putties. |
| | | | | Vapor | Inhalation | Workers, ONU | No | Asbestos is a fibrous substance, thus would not exist as a vapor. |
| | | | | Mist | Inhalation, Dermal, Oral | Workers, ONU | No | Mist generation is not expected during use of fillers and putties. |
| | | | | Dust | Inhalation, Dermal, Oral | Workers, ONU | Yes | Dust generation is possible during use of fillers and putties, especially after drying. |
| | | | | Solid Contact | Dermal, Oral | ONU | Yes | The potential for exposures to ONUs exists during this use, as dried fillers and putties containing asbestos could chip away from the intended surfaces after application. |
| | | Solvent-based/water-based paint | Used in solvent-based and water-based paints | Solid Contact | Inhalation, Dermal, Oral | Workers | Yes | The potential for worker exposure exists during this use, as dried paints containing asbestos could chip away from the intended surfaces after application. |
| | | | | Liquid Contact | Dermal, Oral | Workers, ONU | Yes | Liquid exposure is possible during this use, as workers and ONUs may contact asbestos-contaminated wastewater from surfaces coated with solvent and water-based paints. |
| | | | | Vapor | Inhalation | Workers, ONU | No | Asbestos is a fibrous substance, thus would not exist as a vapor. |
| | | | | Mist | Inhalation, Dermal, Oral | Workers, ONU | Yes | Mist generation is plausible if the paint application method is via spraying. |
| | | | | Dust | Inhalation, Dermal, Oral | Workers, ONU | Yes | Dust generation is possible during use of solvent and water-based paints, especially after drying. |
| | | | | Solid Contact | Dermal, Oral | ONU | Yes | The potential for exposures to ONUs exists during this use, as dried paints containing asbestos could chip away from the intended surfaces after application. |

| Life Cycle Stage | Category | Subcategory | Release/ Exposure Scenario | Exposure Pathway | Exposure Route | Receptor/ Population | Proposed for Further Risk Evaluation | Rationale for Further Evaluation / No Further Evaluation |
|---|---|---|---|---|---|---|---|---|
| Industrial/ Commercial Use | Chemical Substances in Construction, Paint, Electrical, and Metal Products | Electrical batteries and accumulators | Used in electrical batteries and accumulators | Solid Contact | Inhalation, Dermal, Oral | Workers | Yes | The potential for worker exposure exists during this use, as solid asbestos could be incorporated into electrical batteries and accumulators. |
| | | | | Liquid Contact | Dermal, Oral | Workers, ONU | No | Liquid generation is not expected during use in batteries and accumulators. |
| | | | | Vapor | Inhalation | Workers, ONU | No | Asbestos is a fibrous substance, thus would not exist as a vapor. |
| | | | | Mist | Inhalation, Dermal, Oral | Workers, ONU | No | Mist generation is not expected during use in batteries and accumulators. |
| | | | | Dust | Inhalation, Dermal, Oral | Workers, ONU | Yes | Dust generation is possible during use in batteries and accumulators. |
| | | | | Solid Contact | Dermal, Oral | ONU | No | Exposures are expected to be primarily restricted to workers who are working at locations where in-place asbestos-containing materials are disturbed. ONUs are not expected to come in direct contact with asbestos. |
| | Chemical Substances in Furnishing, Cleaning, Treatment Care Products | Construction and building materials covering large surface areas, including fabrics, textiles, and apparel | Used in construction and building materials covering large surface areas, including fabrics, Textiles, and apparel | Solid Contact | Inhalation, Dermal, Oral | Workers | Yes | The potential for worker exposure exists during this use, since in-place asbestos-containing materials can be disturbed during activities involving demolition or renovation. |
| | | | | Liquid Contact | Dermal, Oral | Workers, ONU | No | Liquid generation is not expected during use in construction and building materials including fabrics and textiles. |
| | | | | Vapor | Inhalation | Workers, ONU | No | Asbestos is a fibrous substance, thus would not exist as a vapor. |
| | | | | Mist | Inhalation, Dermal, Oral | Workers, ONU | No | Mist generation is not expected during use in construction and building materials. |
| | | | | Dust | Inhalation, Dermal, Oral | Workers, ONU | Yes | Dust generation is possible during activities involving demolition or renovation when in-place asbestos-containing materials are disturbed. |

| Life Cycle Stage | Category | Subcategory | Release/ Exposure Scenario | Exposure Pathway | Exposure Route | Receptor/ Population | Proposed for Further Risk Evaluation | Rationale for Further Evaluation / No Further Evaluation |
|---|---|---|---|---|---|---|---|---|
| Industrial/ Commercial Use | Chemical Substances in Furnishing, Cleaning, Treatment Care Products | | | Solid Contact | Dermal, Oral | ONU | No | Exposures are expected to be primarily restricted to workers who are working at locations where in-place asbestos-containing materials are disturbed. ONUs are not expected to come in direct contact with asbestos. |
| | | Furniture & furnishings including stone, plaster, cement, glass add ceramic articles; metal articles; or rubber articles | Used in furniture & furnishings including stone, plaster, cement, glass a nd ceramic articles; metal articles; or rubber articles | Solid Contact | Inhalation, Dermal, Oral | Workers | Yes | The potential for worker exposure exists during this use, as solid asbestos could be incorporated into furniture and furnishings. |
| | | | | Liquid Contact | Dermal, Oral | Workers, ONU | No | Liquid generation is not expected during use of furniture and furnishings. |
| | | | | Vapor | Inhalation | Workers, ONU | No | Asbestos is a fibrous substance, thus would not exist as a vapor. |
| | | | | Mist | Inhalation, Dermal, Oral | Workers, ONU | No | Mist generation is not expected during use of furniture and furnishings. |
| | | | | Dust | Inhalation, Dermal, Oral | Workers, ONU | Yes | Dust generation is possible during use of furniture and furnishings. |
| | | | | Solid Contact | Dermal, Oral | ONU | No | Exposures are expected to be primarily restricted to workers who are working at locations where in-place asbestos-containing materials are disturbed. ONUs are not expected to come in direct contact with asbestos. |
| | Chemical Substances in Packaging, Paper, Plastic, Toys, Hobby Products | Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft) | Used in packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft) | Solid Contact | Inhalation, Dermal, Oral | Workers | Yes | The potential for worker exposure exists during this use, as solid asbestos could be incorporated into packaging. |
| | | | | Liquid Contact | Dermal, Oral | Workers, ONU | No | Liquid generation is not expected during use of packaging. |
| | | | | Vapor | Inhalation | Workers, ONU | No | Asbestos is a fibrous substance, thus would not exist as a vapor. |
| | | | | Mist | Inhalation, Dermal, Oral | Workers, ONU | No | Mist generation is not expected during use of packaging. |
| | | | | Dust | Inhalation, Dermal, Oral | Workers, ONU | Yes | Dust generation is possible during use of packaging |

| Life Cycle Stage | Category | Subcategory | Release/ Exposure Scenario | Exposure Pathway | Exposure Route | Receptor/ Population | Proposed for Further Risk Evaluation | Rationale for Further Evaluation / No Further Evaluation |
|---|---|---|---|---|---|---|---|---|
| Industrial/ Commercial Use | | | | Solid Contact | Dermal, Oral | ONU | No | Exposures are expected to be primarily restricted to workers who are working at locations where in-place asbestos-containing materials are disturbed. ONUs are not expected to come in direct contact with asbestos. |
| | | Toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard) | Used in toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard) | Solid Contact | Inhalation, Dermal, Oral | Workers | Yes | The potential for worker exposure exists during this use, as solid asbestos could be incorporated into children's toys. |
| | | | | Liquid Contact | Dermal, Oral | Workers, ONU | No | Liquid generation is not expected during use of children's toys. |
| | | | | Vapor | Inhalation | Workers, ONU | No | Asbestos is a fibrous substance, thus would not exist as a vapor. |
| | | | | Mist | Inhalation, Dermal, Oral | Workers, ONU | No | Mist generation is not expected during use of children's toys. |
| | | | | Dust | Inhalation, Dermal, Oral | Workers, ONU | Yes | Dust generation is possible during use of children's toys. |
| | | | | Solid Contact | Dermal, Oral | ONU | No | Exposures are expected to be primarily restricted to workers who are working at locations where in-place asbestos-containing materials are disturbed. ONUs are not expected to come in direct contact with asbestos. |
| | Chemical Substances in Products not Described by Other Codes | Other (artifacts) | Used in artifacts in museums and collections | Solid Contact | Inhalation, Dermal, Oral | Workers | Yes | The potential for worker exposure exists during this use, as solid asbestos could be incorporated into artifacts. |
| | | | | Liquid Contact | Dermal, Oral | Workers, ONU | No | Liquid generation is not expected during use of artifacts. |
| | | | | Vapor | Inhalation | Workers, ONU | No | Asbestos is a fibrous substance, thus would not exist as a vapor. |
| | | | | Mist | Inhalation, Dermal, Oral | Workers, ONU | No | Mist generation is not expected during use of artifacts. |
| | | | | Dust | Inhalation, Dermal, Oral | Workers, ONU | Yes | Dust generation is possible during use of artifacts. |

| Life Cycle Stage | Category | Subcategory | Release/ Exposure Scenario | Exposure Pathway | Exposure Route | Receptor/ Population | Proposed for Further Risk Evaluation | Rationale for Further Evaluation / No Further Evaluation |
|---|---|---|---|---|---|---|---|---|
| Industrial/ Commercial Use | Chemical Substances in Products not Described by Other Codes | | | Solid Contact | Dermal, Oral | ONU | No | Exposures are expected to be primarily restricted to workers who are working at locations where in-place asbestos-containing materials are disturbed. ONUs are not expected to come in direct contact with asbestos. |
| | | Other (aerospace applications) | Used in aerospace applications | Solid Contact | Inhalation, Dermal, Oral | Workers | Yes | The potential for worker exposure exists during this use, as solid asbestos could be present during aerospace applications |
| | | | | Liquid Contact | Dermal, Oral | Workers, ONU | No | Liquid generation is not expected during use of aerospace applications. |
| | | | | Vapor | Inhalation | Workers, ONU | No | Asbestos is a fibrous substance, thus would not exist as a vapor. |
| | | | | Mist | Inhalation, Dermal, Oral | Workers, ONU | No | Mist generation is not expected during use of aerospace applications. |
| | | | | Dust | Inhalation, Dermal, Oral | Workers, ONU | Yes | Dust generation is possible during use of aerospace applications. |
| | | | | Solid Contact | Dermal, Oral | ONU | No | Exposures are expected to be primarily restricted to workers who are working at locations where in-place asbestos-containing materials are disturbed. ONUs are not expected to come in direct contact with asbestos. |
| Disposal | Disposal | Disposal | Worker handling of asbestos-containing wastes, demolition debris | Solid Contact | Inhalation, Dermal, Oral | Workers | Yes | The potential for worker exposure exists during this use, as demolition debris and wastes are often in solid form. |
| | | | | Liquid Contact | Dermal, Oral | Workers, ONU | Yes | Liquid exposure is possible during this use, as workers and ONUs may contact asbestos-contaminated stormwater, and workers may contact dust suppression water, and other wastewater found at demolition sites. |
| | | | | Vapor | Inhalation | Workers, ONU | No | Asbestos is a fibrous substance, thus would not exist as a vapor. |

| Life Cycle Stage | Category | Subcategory | Release/ Exposure Scenario | Exposure Pathway | Exposure Route | Receptor/ Population | Proposed for Further Risk Evaluation | Rationale for Further Evaluation / No Further Evaluation |
|---|---|---|---|---|---|---|---|---|
| | | | | Mist | Inhalation, Dermal, Oral | Workers, ONU | No | Mist generation is not expected during handling of wastes and demolition debris. |
| | | | | Dust | Inhalation, Dermal, Oral | Workers, ONU | Yes | Dust generation is possible during disposal of wastes and demolition. |
| | | | | Solid Contact | Dermal, Oral | ONU | No | Exposures are expected to be primarily restricted to workers who are working at locations where in-place asbestos-containing materials are disturbed. ONUs are not expected to come in direct contact with asbestos. |

# Appendix G SUPPORTING INFORMATION – CONCEPTUAL MODEL FOR CONSUMER ACTIVITIES AND USES

**Table_Apx G-1. Consumer Exposure Conceptual Model Supporting Table**

| Life Cycle Stage | Category | Subcategory | Release from Source | Exposure Pathway | Route | Receptor | Plans to Evaluate | Rationale |
|---|---|---|---|---|---|---|---|---|
| Consumer Use | Chemical Substances in Construction, Paint, Electrical, and Metal Articles | Construction and building materials covering large surface areas, including paper articles; metal articles; stone, plaster, cement, glass and ceramic articles | Direct contact through handling of articles containing chemical | Direct Contact | Dermal | Consumers | Yes | Dermal exposure may occur for this condition of use |
| | | | Direct contact through mouthing of articles containing chemical | Mouthing | Oral | Consumers | Yes | Oral exposure may occur for this condition of use |
| | | | Long-term emission/mass-transfer, Abrasion, Transfer to Dust | Dust | Dermal, Inhalation, Oral | Consumers, Bystanders | Yes | Dermal, oral, and inhalation exposure from this condition of use may occur |
| Consumer Use | Chemical Substances in Construction, Paint, Electrical, and Metal Articles | Machinery, mechanical appliances, electrical/ electronic articles | Direct contact through handling of articles containing chemical | Direct Contact | Dermal | Consumers | Yes | Dermal exposure may occur for this condition of use |
| | | | Direct contact through mouthing of articles containing chemical | Mouthing | Oral | Consumers | Yes | Oral exposure may occur for this condition of use |
| | | | Long-term emission/mass-transfer, Abrasion, Transfer to Dust | Dust | Dermal, Inhalation, Oral | Consumers, Bystanders | Yes | Dermal, oral, and inhalation exposure from this condition of use may occur |

| Life Cycle Stage | Category | Subcategory | Release from Source | Exposure Pathway | Route | Receptor | Plans to Evaluate | Rationale |
|---|---|---|---|---|---|---|---|---|
| Consumer Use | Chemical Substances in Construction, Paint, Electrical, and Metal Articles | Fillers and putties | Direct contact through handling of articles containing chemical | Direct Contact | Dermal | Consumers | Yes | Dermal exposure may occur for this condition of use |
| | | | Direct contact through mouthing of articles containing chemical | Mouthing | Oral | Consumers | Yes | Oral exposure may occur for this condition of use |
| | | | Long-term emission/mass-transfer, Abrasion, Transfer to Dust | Dust | Dermal, Inhalation, Oral | Consumers, Bystanders | Yes | Dermal, oral, and inhalation exposure from this condition of use may occur |
| Consumer Use | Chemical Substances in Construction, Paint, Electrical, and Metal Articles | Solvent-based/water-based paint | Direct contact through application or use of products | Liquid Contact | Dermal | Consumers | Yes | Exposure is expected to be primarily restricted to consumer who are directly involved in using the chemical. |
| | | | Long-term emission/mass-transfer, Abrasion, Transfer to Dust | Dust | Dermal, Inhalation, Oral | Consumers, Bystanders | Yes | Dermal, oral, and inhalation exposure from this condition of use may occur |
| Consumer Use | Chemical Substances in Furnishing, Cleaning, Treatment Care Articles | Construction and building materials covering large surface areas, including fabrics, textiles, and apparel | Direct contact through handling of articles containing chemical | Direct Contact | Dermal | Consumers | Yes | Dermal exposure may occur for this condition of use |
| | | | Direct contact through mouthing of articles containing chemical | Mouthing | Oral | Consumers | Yes | Oral exposure may occur for this condition of use |

| Life Cycle Stage | Category | Subcategory | Release from Source | Exposure Pathway | Route | Receptor | Plans to Evaluate | Rationale |
|---|---|---|---|---|---|---|---|---|
| | | | Long-term emission/mass-transfer, Abrasion, Transfer to Dust | Dust | Dermal, Inhalation, Oral | Consumers, Bystanders | Yes | Dermal, oral, and inhalation exposure from this condition of use may occur |
| Consumer Use | Chemical Substances in Furnishing, Cleaning, Treatment Care Articles | Furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles | Direct contact through handling of articles containing chemical | Direct Contact | Dermal | Consumers | Yes | Dermal exposure may occur for this condition of use |
| | | | Direct contact through mouthing of articles containing chemical | Mouthing | Oral | Consumers | Yes | Oral exposure may occur for this condition of use |
| | | | Long-term emission/mass-transfer, Abrasion, Transfer to Dust | Dust | Dermal, Inhalation, Oral | Consumers, Bystanders | Yes | Dermal, oral, and inhalation exposure from this condition of use may occur |
| Consumer Use | Chemical Substances in Packaging, Paper, Plastic, Toys, Hobby Articles | Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft) | Direct contact through handling of articles containing chemical | Direct Contact | Dermal | Consumers | Yes | Dermal exposure may occur for this condition of use |
| | | | Direct contact through mouthing of articles containing chemical | Mouthing | Oral | Consumers | Yes | Oral exposure may occur for this condition of use |
| | | | Long-term emission/mass-transfer, Abrasion, Transfer to Dust | Dust | Dermal, Inhalation, Oral | Consumers, Bystanders | Yes | Dermal, oral, and inhalation exposure from this condition of use may occur |

| Life Cycle Stage | Category | Subcategory | Release from Source | Exposure Pathway | Route | Receptor | Plans to Evaluate | Rationale |
|---|---|---|---|---|---|---|---|---|
| Consumer Use | Chemical Substances in Packaging, Paper, Plastic, Toys, Hobby Articles | Toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard) | Direct contact through handling of articles containing chemical | Direct Contact | Dermal | Consumers | Yes | Dermal exposure may occur for this condition of use |
| | | | Direct contact through mouthing of articles containing chemical | Mouthing | Oral | Consumers | Yes | Oral exposure may occur for this condition of use |
| | | | Long-term emission/mass-transfer, Abrasion, Transfer to Dust | Dust | Dermal, Inhalation, Oral | Consumers, Bystanders | Yes | Dermal, oral, and inhalation exposure from this condition of use may occur |
| Consumer Use | Chemical Substances in Automotive, Fuel, Agriculture, Outdoor Use Articles | Lawn and Garden Care Products | Direct contact through handling of articles containing chemical | Direct Contact | Dermal | Consumers | Yes | Dermal exposure may occur for this condition of use |
| | | | Direct contact through mouthing of articles containing chemical | Mouthing | Oral | Consumers | Yes | Oral exposure may occur for this condition of use |
| | | | Long-term emission/mass-transfer, Abrasion, Transfer to Dust | Dust | Dermal, Inhalation, Oral | Consumers, Bystanders | Yes | Dermal, oral, and inhalation exposure from this condition of use may occur |
| Consumer Use | Chemical Substances in Products not Described by Other Codes | Other (artifacts) | Direct contact through handling of articles containing chemical | Direct Contact | Dermal | Consumers | Yes | Dermal exposure may occur for this condition of use |

| Life Cycle Stage | Category | Subcategory | Release from Source | Exposure Pathway | Route | Receptor | Plans to Evaluate | Rationale |
|---|---|---|---|---|---|---|---|---|
| | | | Direct contact through application or use of products | Liquid Contact | Dermal | Consumers | Yes | Exposure is expected to be primarily restricted to consumer who are directly involved in using the chemical. |
| | | | Direct contact through mouthing of articles containing chemical | Mouthing | Oral | Consumers | Yes | Oral exposure may occur for this condition of use |
| | | | Long-term emission/mass-transfer, Abrasion, Transfer to Dust | Dust | Dermal, Inhalation, Oral | Consumers, Bystanders | Yes | Dermal, oral, and inhalation exposure from this condition of use may occur. |
| Consumer Use | Chemical Substances in Construction, Paint, Electrical, and Metal Products | Construction and building materials covering large surface areas, including paper articles; metal articles; stone, plaster, cement, glass and ceramic articles | Direct contact through handling of products containing chemical | Direct Contact | Dermal | Consumers | Yes | Dermal exposure may occur for this condition of use |
| | | | Direct contact through mouthing of products containing chemical | Mouthing | Oral | Consumers | Yes | Oral exposure may occur for this condition of use |
| | | | Long-term emission/mass-transfer, Abrasion, Transfer to Dust | Dust | Dermal, Inhalation, Oral | Consumers, Bystanders | Yes | Dermal, oral, and inhalation exposure from this condition of use may occur |
| Consumer Use | Chemical Substances in Construction, Paint, | Machinery, mechanical appliances, electrical/ | Direct contact through handling of products containing chemical | Direct Contact | Dermal | Consumers | Yes | Dermal exposure may occur for this condition of use |

| Life Cycle Stage | Category | Subcategory | Release from Source | Exposure Pathway | Route | Receptor | Plans to Evaluate | Rationale |
|---|---|---|---|---|---|---|---|---|
| | Electrical, and Metal Products | electronic articles | Direct contact through mouthing of products containing chemical | Mouthing | Oral | Consumers | Yes | Oral exposure may occur for this condition of use |
| | | | Long-term emission/mass-transfer, Abrasion, Transfer to Dust | Dust | Dermal, Inhalation, Oral | Consumers, Bystanders | Yes | Dermal, oral, and inhalation exposure from this condition of use may occur |
| Consumer Use | Chemical Substances in Construction, Paint, Electrical, and Metal Products | Fillers and putties | Direct contact through handling of products containing chemical | Direct Contact | Dermal | Consumers | Yes | Dermal exposure may occur for this condition of use |
| | | | Direct contact through mouthing of products containing chemical | Mouthing | Oral | Consumers | Yes | Oral exposure may occur for this condition of use |
| | | | Long-term emission/mass-transfer, Abrasion, Transfer to Dust | Dust | Dermal, Inhalation, Oral | Consumers, Bystanders | Yes | Dermal, oral, and inhalation exposure from this condition of use may occur |
| Consumer Use | Chemical Substances in Construction, Paint, Electrical, and Metal Products | Solvent-based/water-based paint | Direct contact through application or use of products | Liquid Contact | Dermal | Consumers | Yes | Exposure is expected to be primarily restricted to consumer who are directly involved in using the chemical. |
| | | | Long-term emission/mass-transfer, Abrasion, Transfer to Dust | Dust | Dermal, Inhalation, Oral | Consumers, Bystanders | Yes | Dermal, oral, and inhalation exposure from this condition of use may occur |

| Life Cycle Stage | Category | Subcategory | Release from Source | Exposure Pathway | Route | Receptor | Plans to Evaluate | Rationale |
|---|---|---|---|---|---|---|---|---|
| Consumer Use | Chemical Substances in Furnishing, Cleaning, Treatment Care Products | Construction and building materials covering large surface areas, including fabrics, textiles, and apparel | Direct contact through handling of products containing chemical | Direct Contact | Dermal | Consumers | Yes | Dermal exposure may occur for this condition of use |
| | | | Direct contact through mouthing of products containing chemical | Mouthing | Oral | Consumers | Yes | Oral exposure may occur for this condition of use |
| | | | Long-term emission/mass-transfer, Abrasion, Transfer to Dust | Dust | Dermal, Inhalation, Oral | Consumers, Bystanders | Yes | Dermal, oral, and inhalation exposure from this condition of use may occur |
| Consumer Use | Chemical Substances in Furnishing, Cleaning, Treatment Care Products | Furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles | Direct contact through handling of products containing chemical | Direct Contact | Dermal | Consumers | Yes | Dermal exposure may occur for this condition of use |
| | | | Direct contact through mouthing of products containing chemical | Mouthing | Oral | Consumers | Yes | Oral exposure may occur for this condition of use |
| | | | Long-term emission/mass-transfer, Abrasion, Transfer to Dust | Dust | Dermal, Inhalation, Oral | Consumers, Bystanders | Yes | Dermal, oral, and inhalation exposure from this condition of use may occur |
| Consumer Use | Chemical Substances in Packaging, Paper, Plastic, | Packaging (excluding food packaging), including rubber articles; | Direct contact through handling of products containing chemical | Direct Contact | Dermal | Consumers | Yes | Dermal exposure may occur for this condition of use |

| Life Cycle Stage | Category | Subcategory | Release from Source | Exposure Pathway | Route | Receptor | Plans to Evaluate | Rationale |
|---|---|---|---|---|---|---|---|---|
| | Toys, Hobby Products | plastic articles (hard); plastic articles (soft) | Direct contact through mouthing of products containing chemical | Mouthing | Oral | Consumers | Yes | Oral exposure may occur for this condition of use |
| | | | Long-term emission/mass-transfer, Abrasion, Transfer to Dust | Dust | Dermal, Inhalation, Oral | Consumers, Bystanders | Yes | Dermal, oral, and inhalation exposure from this condition of use may occur |
| Consumer Use | Chemical Substances in Packaging, Paper, Plastic, Toys, Hobby Products | Toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard) | Direct contact through handling of products containing chemical | Direct Contact | Dermal | Consumers | Yes | Dermal exposure may occur for this condition of use |
| | | | Direct contact through mouthing of products containing chemical | Mouthing | Oral | Consumers | Yes | Oral exposure may occur for this condition of use |
| | | | Long-term emission/mass-transfer, Abrasion, Transfer to Dust | Dust | Dermal, Inhalation, Oral | Consumers, Bystanders | Yes | Dermal, oral, and inhalation exposure from this condition of use may occur |
| Consumer Use | Chemical Substances in Automotive, Fuel, Agriculture, Outdoor Use Products | Lawn and Garden Care Products | Direct contact through handling of products containing chemical | Direct Contact | Dermal | Consumers | Yes | Dermal exposure may occur for this condition of use |
| | | | Direct contact through mouthing of products containing chemical | Mouthing | Oral | Consumers | Yes | Oral exposure may occur for this condition of use |

| Life Cycle Stage | Category | Subcategory | Release from Source | Exposure Pathway | Route | Receptor | Plans to Evaluate | Rationale |
|---|---|---|---|---|---|---|---|---|
| | | | Long-term emission/mass-transfer, Abrasion, Transfer to Dust | Dust | Dermal, Inhalation, Oral | Consumers, Bystanders | Yes | Dermal, oral, and inhalation exposure from this condition of use may occur |
| Consumer Use | Chemical Substances in Products not Described by Other Codes | Other (artifacts) | Direct contact through handling of products containing chemical | Direct Contact | Dermal | Consumers | Yes | Dermal exposure may occur for this condition of use |
| | | | Direct contact through application or use of products | Liquid Contact | Dermal | Consumers | Yes | Exposure is expected to be primarily restricted to consumer who are directly involved in using the chemical. |
| | | | Direct contact through mouthing of products containing chemical | Mouthing | Oral | Consumers | Yes | Oral exposure may occur for this condition of use |
| | | | Long-term emission/mass-transfer, Abrasion, Transfer to Dust | Dust | Dermal, Inhalation, Oral | Consumers, Bystanders | Yes | Dermal, oral, and inhalation exposure from this condition of use may occur. |
| Consumer Handling of Disposal and Waste | Wastewater, liquid, wastes, and solid wastes | Wastewater, liquid, wastes, and solid wastes | Long-term emission/mass-transfer, Abrasion, Transfer to Dust | Dust | Dermal, Inhalation, Oral | Consumers, Bystanders | Yes | Dust generation is possible during the handling of solid waste. |
| | | | Direct contact through handling or disposal of products | Liquid Contact | Dermal | Consumers | Yes | Exposure is expected to be primarily restricted to consumers who are directly involved in handling and disposal of the chemical. |

| Life Cycle Stage | Category | Subcategory | Release from Source | Exposure Pathway | Route | Receptor | Plans to Evaluate | Rationale |
|---|---|---|---|---|---|---|---|---|
| | | | Direct contact through handling of products containing chemical | Direct Contact | Dermal | Consumers | Yes | Dermal exposure may occur for this condition of use |

# Appendix H SUPPORTING INFORMATION – CONCEPTUAL MODEL FOR ENVIRONMENTAL RELEASES AND WASTES

**Table_Apx H-1. General Population and Environmental Exposure Conceptual Model Supporting Table**

| Life Cycle Stage | Category | Release | Exposure Pathway/ Media | Exposure Routes | Receptor/ Population | Plans to Evaluate | Rationale |
|---|---|---|---|---|---|---|---|
| All | Emissions to Air | Emissions to Air | Near source ambient air concentrations | Inhalation | General Population | Yes | Asbestos fibers emissions and releases from landfills and waste management facilities is expected. Deposition to nearby bodies of water and soil are expected |
| | | | Indirect deposition to nearby bodies of water and soil catchments | Oral Dermal | General Population | Yes | |
| | | | | Inhalation | Aquatic and Terrestrial Receptors | Yes | |
| | Wastewater or Liquid Wastes | Wastewater treatment, or POTW | Direct release into surface water and indirect partitioning to sediment | Oral Dermal | Aquatic and Terrestrial Receptors | Yes | Release of Asbestos fibers into surface water and indirect partitioning to sediment exposure pathways to aquatic and terrestrial receptors will be evaluated |
| | | | | Oral Dermal | General Population | Yes | Release of Asbestos fibers into surface water and indirect partitioning to sediment and exposure pathways to the general population will be evaluated. |
| | | | Drinking Water via Surface or Ground Water | Oral Dermal and Inhalation (*e.g.,* showering) | General Population | Yes | Release of Asbestos fibers into surface water and indirect partitioning to drinking water is an expected exposure pathway. |
| | | | Biosolids: application to soil and/or migration to | Oral (*e.g.,* ingestion of soil) Dermal | General Population | Yes | EPA plans to analyze the pathway from biosolids to the general |

| Life Cycle Stage | Category | Release | Exposure Pathway/ Media | Exposure Routes | Receptor/ Population | Plans to Evaluate | Rationale |
|---|---|---|---|---|---|---|---|
| | | | groundwater and/or surface water | Inhalation | | | population, aquatic and terrestrial species. |
| | | | | Oral<br>Dermal<br>Inhalation | Aquatic and Terrestrial Receptors | Yes | |
| Disposal | Solid and Liquid Wastes | Municipal landfill and other land disposal | Leachate to soil, ground water and/or mitigation to surface water | Oral<br>Dermal<br>Inhalation (*e.g.,* inhalation of soil containing asbestos fibers) | General Population | Yes | EPA plans to analyze the pathway from municipal landfills and other land disposal to the general population, aquatic and terrestrial receptors. |
| | | | | Oral<br>Dermal Inhalation (*e.g.,* inhalation of soil containing asbestos fibers) | Aquatic and Terrestrial Receptors | | |

# Appendix I CHARACTERIZATION OF LITERATURE INCLUDING ASBESTOS AND TALC

This Appendix presents heatmaps for each disciplines characterizing the number and types of the data and information sources included thus far in the screening of the literature obtained from the asbestos literature search that also includes talc. Note, the studies included in these heatmaps (see Figure_Apx I-1 and Figure_Apx I-2) are not presented in the heatmaps presented in Section 2.1.2.

**Fate Heat Map of Asbestos (Talc- or Magnesium-Silicate-Contaminated Asbestos)**

| | Media | | | | | |
|---|---|---|---|---|---|---|
| **Endpoint** | **Air** | **Soil, Sediment** | **Wastewater, Biosolids** | **Water** | **Other** | **Grand Total** |
| **Bioconcentration** | | | | | | |
| **Biodegradation** | | | | | | |
| **Hydrolysis** | | | | | | |
| **Photolysis** | | | | | | |
| **Sorption** | | | | | | |
| **Volatilization** | | | | | | |
| **Wastewater Treatment** | | | 2 | 2 | | 2 |
| **Other** | | | 2 | 3 | 1 | 4 |
| **Grand Total** | | | 2 | 3 | 1 | 4 |

**Figure_Apx I-1. Peer-Reviewed Literature Inventory Heat Map for Talc- or Magnesium-Silicate-Contaminated Asbestos – Fate and Transport Search Results for Asbestos**

View the interactive version in HAWC for additional study details. The column totals, row totals, and grand totals indicate total numbers of unique references, as some references may be included in multiple cells. The various shades of color visually represent the number of relevant references identified by exposure media or data type. The darker the color, the more references are available for a given exposure media or data type. Data in this figure represent references obtained from the publicly available databases search (see Appendix A.1.3) that were included during full-text screening as of May 12, 2022. Additional data may be added to the interactive version as they become available.

| Engineering Heat Map of Asbestos (Talc- or Magnesium-Silicate-Contaminated Asbestos) | | |
|---|---|---|
| Data Type | Evidence Tags | |
| Environmental Releases | Description of release source | 13 |
| | Release or emission factors | 2 |
| | Release quantity | 4 |
| | Waste treatment methods and pollution control | 17 |
| | Total | 23 |
| General Engineering Assessment | Chemical concentration | 68 |
| | Exposure route | |
| | Life cycle description | 12 |
| | Number of sites | 12 |
| | Physical form | |
| | Process description | 22 |
| | Production, import, or use volume | 28 |
| | Throughput | 2 |
| | Total | 87 |
| Occupational Exposures | Area sampling data | 100 |
| | Dermal exposure data | 1 |
| | Engineering control | 47 |
| | Exposure duration | 39 |
| | Exposure frequency | 3 |
| | Exposure route | 69 |
| | Number of workers | 34 |
| | Particle size characterization | 44 |
| | Personal protective equipment | 37 |
| | Personal sampling data | 47 |
| | Physical form | 101 |
| | Worker activity description | 110 |
| | Total | 126 |
| Grand Total | | 138 |

**Figure_Apx I-2. Peer-Reviewed Literature Inventory Heat Map for Talc- or Magnesium-Silicate-Contaminated Asbestos – Engineering Search Results for Asbestos**

View the interactive version in HAWC for additional study details. Data in this figure represent references obtained from the publicly available databases search (see Appendix A.1.3) that were included during full-text screening as of May 6, 2022. Additional data may be added to the interactive version as they become available.

Exposure Heat Map of Asbestos (Talc- or Magnesium-Silicate-Contaminated Asbestos)

| Media (group) | Data Type: Monitoring Study | Modeling Study | Completed Assessment | Experimental Study | Epidemiological Study | Database | Survey | Grand Total |
|---|---|---|---|---|---|---|---|---|
| Ambient Air | 2 | | 1 | | | | | 3 |
| Biosolids/Sludge | | | | | | | | |
| Drinking Water | 1 | | | | | | | 1 |
| Groundwater | | | | | | | | |
| Sediment | 1 | | | | | | | 1 |
| Soil | | | 1 | | | | | 1 |
| Surface Water | 3 | | | | | | | 3 |
| Wastewater | 1 | | | | | | | 1 |
| Aquatic Species | | | | | | | | |
| Terrestrial Species | | | | | | | | |
| Consumer | 1 | | 1 | | 1 | | | 2 |
| Dietary | | | | | | | | |
| Dust | | | | | | | | |
| Exposure Factors | | | | | | | | |
| Exposure Pathway | 1 | | 1 | | | | | 2 |
| Human Biomonitoring | 4 | | | | 2 | | | 4 |
| Indoor Air | | | | | | | | |
| Isomers | | | | | | | | |
| Use Information | 2 | | 1 | | | | | 3 |
| Land Disposal/Landfill | | | | | | | | |
| Geology/Geochemistry | | | | | | | | |
| Grand Total | 8 | | 2 | | 2 | | | 10 |

**Figure_Apx I-3. Peer-Reviewed Literature Inventory Heat Map for Talc- or Magnesium-Silicate-Contaminated Asbestos – Exposure Search Results for Asbestos**

View the interactive version in HAWC for additional study details. The column totals, row totals, and grand totals indicate total numbers of unique references only, as some references may be included in multiple cells. The various shades of color visually represent the number of relevant references identified by exposure media or data type. The darker the color, the more references are available for a given exposure media or data type. Data in this figure represent all references obtained from the publicly available databases search (see Appendix A.1.3), and gray literature references search (see Appendix A.3) that were included during full-text screening as of May 17, 2022. Additional data may be added to the interactive version as they become available.

Heat Map

| Health Outcomes | Evidence Type: Human | Animal - Environmental Model | Plant | Grand Total |
|---|---|---|---|---|
| ADME | 2 | | | 2 |
| Cancer | 8 | | | 8 |
| Cardiovascular | 1 | | | 1 |
| Developmental | 3 | | | 3 |
| Endocrine | | | | |
| Gastrointestinal | 2 | | | 2 |
| Hematological and Immune | | | | |
| Hepatic | | | | |
| Mortality | 2 | | | 2 |
| Musculoskeletal | | | | |
| Neurological | 1 | | | 1 |
| Nutritional and Metabolic | 1 | | | 1 |
| Ocular and Sensory | 1 | | | 1 |
| PBPK | | | | |
| Renal | | | | |
| Reproductive | | | | |
| Respiratory | 13 | | | 13 |
| Skin and Connective Tissue | | | | |
| No Tag | 2 | | | 2 |
| Grand Total | 15 | | | 15 |

**Figure_Apx I-4. Peer-Reviewed Literature Inventory Heat Map for Talc- or Magnesium-Silicate-Contaminated Asbestos – Human Health and Environmental Hazards Search Results for Asbestos**
View the interactive version in HAWC for additional study details. The numbers indicate the number of studies with TIAB keywords related to a particular health outcome, not the number of studies that observed an association with asbestos. Evidence types were manually extracted, and Health Systems were determined via machine learning. Therefore, the studies examining multiple Health Outcomes and Evidence types, connections between health outcome, and evidence type may not be accurately represented. If a study evaluated multiple health outcomes or included multiple populations or study designs, it is shown here multiple times. Data in this figure represents references obtained from the publicly available databases search (see Appendix A.1.3) that were included during full-text screening as of May 11, 2022. Additional data may be added to the interactive version as they become available.