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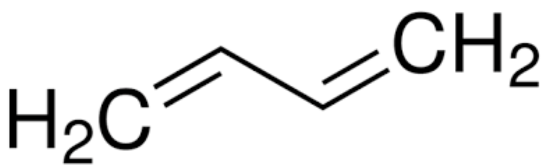
Office of Chemical Safety and
Pollution Prevention

United States
Environmental Protection Agency

Draft Risk Evaluation for 1,3-Butadiene

CASRN: 106-99-0



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ACKNOWLEDGEMENTS

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Docket

Supporting information can be found in the public docket, Docket ID: EPA-HQ-OPPT-2024-0425.

Disclaimer

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This draft risk evaluation was reviewed and cleared for release by OPPT and OCSPP leadership.

EXECUTIVE SUMMARY

Background and Preliminary Risk Determination

The U.S. Environmental Protection Agency (EPA or the Agency) has evaluated the health and environmental risks of the chemical 1,3-butadiene under section 6 of the Toxic Substances Control Act (TSCA). EPA designated 1,3-butadiene as a high priority substance for risk evaluation in December 2019 and followed with the *Final Scope of the Risk Evaluation for 1,3-Butadiene; CASRN 106-99-0* (U.S. EPA, 2020c). In alignment with the Final Scope's Analysis Plan, the Agency evaluated all reasonably available physical and chemical properties, environmental fate, and environmental release data and determined that air is the major exposure pathway. Following public comment and independent peer review, EPA will issue a risk evaluation that includes its determination as to whether 1,3-butadiene presents unreasonable risk of injury to health or the environment under its conditions of use (COUs; also called TSCA COUs).

1,3-Butadiene is used primarily as a chemical intermediate and monomer in the manufacture of polymers such as synthetic rubbers and elastomers. Domestic manufacturers report 1,3-butadiene production volumes through the TSCA Chemical Data Reporting (CDR) rule under CAS Registry Number (CASRN) 106-99-0. The U.S. production volume for 1,3-butadiene in 2016 ranged from 1 to 5 billion pounds (lb) and remained unchanged in 2019, based on the latest 2020 CDR data. EPA describes production volumes as a range to protect confidential business information. 1,3-Butadiene has been assessed by multiple national and international governmental organizations and is broadly regulated by EPA, various states, and other countries (Appendix B).

The Agency chose to evaluate 1,3-butadiene because both laboratory animal and human data show that it may be harmful to people if they are exposed to enough of it over a long enough period of time. The kinds of health effects that 1,3-butadiene is associated with include harm to pregnant women and their fetuses, blood and immune system disease, and cancer. In particular, lymphomas seen in laboratory mice were consistent with human epidemiology studies linking workers' exposure to 1,3-butadiene to increases in lymphatic and hematopoietic cancers.

EPA evaluated the risks to people from being exposed to 1-3-butadiene at work and outdoors. Given the environmental fate properties of 1,3-butadiene, an in-depth analysis of releases to water or land and associated environmental exposures was not conducted. When it is manufactured or used to make products, 1,3-butadiene is mainly released into the air due to its volatility, with relatively small releases to land or water. If released into water or land, 1,3-butadiene will quickly volatilize from water and land surfaces. 1,3-Butadiene breaks down in the air within a few hours by reacting with hydroxyl or nitrate radicals in the atmosphere. Additional sources of 1,3-butadiene exposure come from vehicle exhaust, tobacco smoke, burning wood, and forest fires. Consistent with these properties, the Agency for Toxic Substances and Disease Registry (ATSDR (2012)) concluded that inhalation is the predominant route for human exposures and 1,3-butadiene has not been quantified by any other routes.

Workers may be exposed to 1,3-butadiene when using 1,3-butadiene in the workplace. The general population—specifically, people who reside near facilities that manufacture or process 1,3-butadiene—may be exposed when those facilities release 1,3-butadiene into the air. In determining whether 1,3-butadiene presents an unreasonable risk of injury to human health, EPA incorporated the following potentially exposed and susceptible subpopulations (PESS) into its assessment: females of reproductive age, males of reproductive age, pregnant females, infants, children and adolescents, people exposed to 1,3-butadiene in the workplace, and populations who reside near 1,3-butadiene-releasing facilities. These subpopulations are PESS because some have greater exposure to 1,3-butadiene or exhibit greater biological susceptibility than the general population.

Appendix BIn this draft risk evaluation, EPA only evaluated risks resulting from exposure to 1,3-butadiene from facilities that use, manufacture, or process 1,3-butadiene under industrial and/or commercial COUs subject to TSCA and the products that result from such manufacture and processing. Human or environmental exposure to 1,3-butadiene from other sources (*e.g.*, vehicle exhaust, tobacco smoke, woodburning) were *not* quantitatively evaluated for risk characterization by EPA in reaching its preliminary determination of unreasonable risk to injury of human health.

EPA's assessment preliminarily determined that 1,3-butadiene presents an unreasonable risk of injury to human health because of risks to workers and the general population (including fenceline communities) from inhalation exposure. The risks are highest in areas along the Gulf Coast region from Texas to Louisiana, near 1,3-butadiene-releasing facilities.

Based on the assessment of consumer risk and related risk factors, the Agency preliminarily determined that consumer COUs do not significantly contribute to the unreasonable risk of 1,3-butadiene.

Based on the pathways evaluated in this draft risk evaluation, EPA preliminarily determines that risk to the environment does not significantly contribute to the unreasonable risk determination for 1,3-butadiene.

Summary, Considerations, and Next Steps

EPA evaluated a total of 28 TSCA COUs for 1,3-butadiene detailed in Section 2.2 with subsequent exposures and risk characterizations for human health and to environmental species in Sections 5 and 6, respectively.

The Agency preliminarily determines that the following COUs, considered singularly or in combination with other exposures, significantly contribute to the unreasonable risk to human health:

- Manufacturing – domestic manufacturing;
- Manufacturing – import;
- Processing – processing as a reactant – intermediate (adhesive manufacturing; all other basic organic chemical manufacturing; fuel binder for solid rocket fuels; organic fiber manufacturing; petrochemical manufacturing; petroleum refineries; plastic material and resin manufacturing; propellant manufacturing; synthetic rubber manufacturing; paint and coating manufacturing; wholesale and retail trade);
- Processing – processing as a reactant – monomer used in polymerization process (synthetic rubber manufacturing; plastic material and resin manufacturing);
- Processing – incorporation into formulation, mixture, or reaction product – processing aids, not otherwise listed (petrochemical manufacturing; monomers used in: plastic product manufacturing; synthetic rubber manufacturing);
- Processing – incorporation into formulation, mixture, or reaction product – other (adhesive manufacturing, paint and coating manufacturing, petroleum lubricating oil and grease manufacturing, and all other chemical product and preparation manufacturing);
- Processing – incorporation into article – other (polymer in: rubber and plastic product manufacturing);
- Processing – repackaging – intermediate (wholesale and retail trade; monomer in: synthetic rubber manufacturing);
- Processing – recycling;
- Commercial use – other use – laboratory chemicals; and
- Disposal

EPA preliminarily determines that the following COUs do not contribute significantly to the unreasonable risk:

- Industrial use – adhesives and sealants, including epoxy resins;
- Commercial use – fuels and related products;
- Commercial use – other articles with routine direct contact during normal use including rubber articles; plastic articles (hard);
- Commercial use – toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard);
- Commercial use – synthetic rubber (*e.g.*, rubber tires);
- Commercial use – furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles;
- Commercial use – packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft);
- Commercial use – automotive care products;
- Commercial use – lubricants and lubricant additives, including viscosity modifier;
- Commercial use – paints and coatings, including aerosol spray paint;
- Commercial use – adhesives and sealants, including epoxy resins;
- Consumer use – other articles with routine direct contact during normal use including rubber articles; plastic articles (hard);
- Consumer use – toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard);
- Consumer use – synthetic rubber (*e.g.*, rubber tires);
- Consumer use – furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles;
- Consumer use – packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft); and
- Distribution in commerce.

This draft risk evaluation has been released for public comment and will be peer reviewed by the Science Advisory Committee on Chemicals (SACC) in February 2025. EPA will issue a finalized 1,3-butadiene risk evaluation after considering input from the public and recommendations received from the SACC. If the Agency determines that 1,3-butadiene presents unreasonable risk to human health or the environment in the finalized risk evaluation, EPA will initiate regulatory action to mitigate those risks.

1 INTRODUCTION

EPA has evaluated 1,3-butadiene (CASRN 106-99-0) under the Toxic Substances Control Act (TSCA). 1,3-Butadiene is a colorless gas with a total production volume (PV) in the United States between 1 and 5 billion pounds (lb). 1,3-Butadiene is produced from petrochemical processing and is also used to aid in petrochemical manufacturing, but is primarily used as a monomer to produce plastic and rubber products. This involves polymerization of 1,3-butadiene with itself or with other monomers, which are then incorporated into various rubber and plastic articles. These synthetic rubbers, resins, and latex are used to manufacture tires, other rubber components and plastic materials. 1,3-Butadiene polymers are also used as viscosity agents in several formulations for adhesives, lubricants, and paints and coatings. These polymerization products which are a polymer form of 1,3-butadiene are also referred to as 1,3-butadiene by some chemical safety data sheets (SDSs). This draft risk assessment covers only the monomer form of 1,3-butadiene.

Figure 1-1 describes the major inputs, phases, and outputs/components of the TSCA risk evaluation process, from scoping to releasing the final risk evaluation. Sections 2, 2.1, and 2.2 provide the scope of the risk evaluation, including PV, life cycle diagram (LCD), conditions of use (COUs; also called TSCA COUs), and conceptual models used for 1,3-butadiene; Section 2.3 includes an overview of the systematic review process; and Section 2.4 presents the organization of this draft risk evaluation.

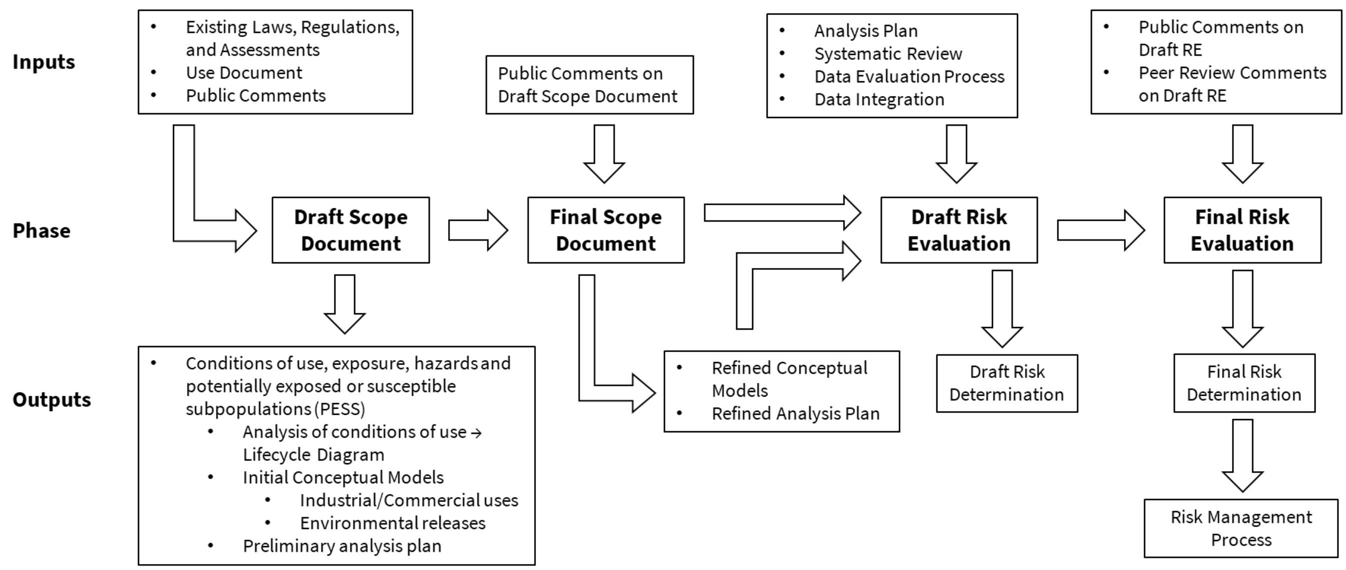


Figure 1-1. TSCA Existing Chemical Risk Evaluation Process

2 SCOPE OF THE RISK EVALUATION

EPA designated 1,3-butadiene as a high priority substance for risk evaluation in December 2019 and followed with the *Final Scope of Risk Evaluation for 1,3-Butadiene; CASRN 106-99-0* (also called "final scope document") (U.S. EPA, 2020c). In alignment with the Scope's Analysis Plan, EPA evaluated all reasonably available physical and chemical properties, environmental fate, and environmental release data and determined that air is the major exposure pathway. The Agency evaluated risk to human and environmental populations for 1,3-butadiene. Specifically for human populations, EPA quantitatively evaluated risk to (1) workers and occupational non-users (ONUs) via the inhalation route described in Section 5.3.2, and (2) the general population via inhalation route in Section 5.3.4. Additionally, EPA considered PESS in Section 5.3.5. For environmental populations, the Agency qualitatively assessed risks via water, sediment, and air to aquatic and terrestrial species in Sections 6.2.2 and 6.2.3, respectively.

EPA identified literature with human health hazards via the inhalation route of exposure. Furthermore, as expected based on the determination of air as the major pathway of exposure, the Agency did not identify literature on human health hazards via the oral or dermal routes of exposure. EPA also did not find literature reporting hazards to aquatic or terrestrial organisms. OPPT identified several inhalation epidemiological studies describing a single cohort of styrene-butadiene rubber occupational workers. Some of the studies that used this occupational cohort study were included in the 2002 EPA Integrated Risk Information System (IRIS) *Health Assessment of 1,3-Butadiene* (U.S. EPA, 2002b). Using the occupational cohort data, OPPT re-evaluated and revised the inhalation unit risk for cancer which was published by IRIS in 2002.

EPA used reasonably available information, defined in 40 CFR 702.33, in a fit-for purpose approach to develop a risk evaluation that relies on the best available science and is based in the weight of scientific evidence. EPA evaluated the quality of methods and reporting or results of the individual studies using the evaluations strategies described in the *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances* (U.S. EPA, 2021a) and *Draft Systematic Review Protocol for 1,3-Butadiene* (U.S. EPA, 2024ac), or as otherwise noted in the relevant technical support documents (TSDs; see also Appendix C).

2.1 Life Cycle and Production Volume

The life cycle diagram (LCD) in Figure 2-1 depicts the COUs that are within the scope of this draft risk evaluation during various life cycle stages, including manufacture and import, processing, distribution, use industrial, commercial, consumer), and disposal. The LCD has been updated since its original inclusion in the final scope document. A complete list of updates and explanations of the updates made to COUs for 1,3-butadiene from the final scope document to this draft risk evaluation is provided in Appendix D.

The LCD is a graphical representation of the various life stages of the industrial, commercial, and consumer use categories included within the scope of this draft risk evaluation. The information in the life cycle diagram is grouped according to the Chemical Data Reporting (CDR) processing codes and use categories (including functional use codes for industrial uses and product categories for industrial, commercial, and consumer uses). The CDR Rule under TSCA section 8(a) (see 40 CFR part 711) requires U.S. manufacturers (including importers) who manufactured/imported 25,000 lb or more of a relevant chemical for commercial purposes during any calendar year, to provide EPA with information on the chemicals they manufacture or import into the United States. The Agency collects CDR data approximately every 4 years with the latest collections occurring in 2020. The *Risk Evaluation for 1,3-*

Butadiene CASRN: 106-99-0, Supplemental Information on Environmental Releases and Occupational Exposure Assessment (U.S. EPA, 2024y) contains additional descriptions (*e.g.*, process descriptions, worker activities, process flow diagrams) for each manufacturing, processing, use, and disposal category.

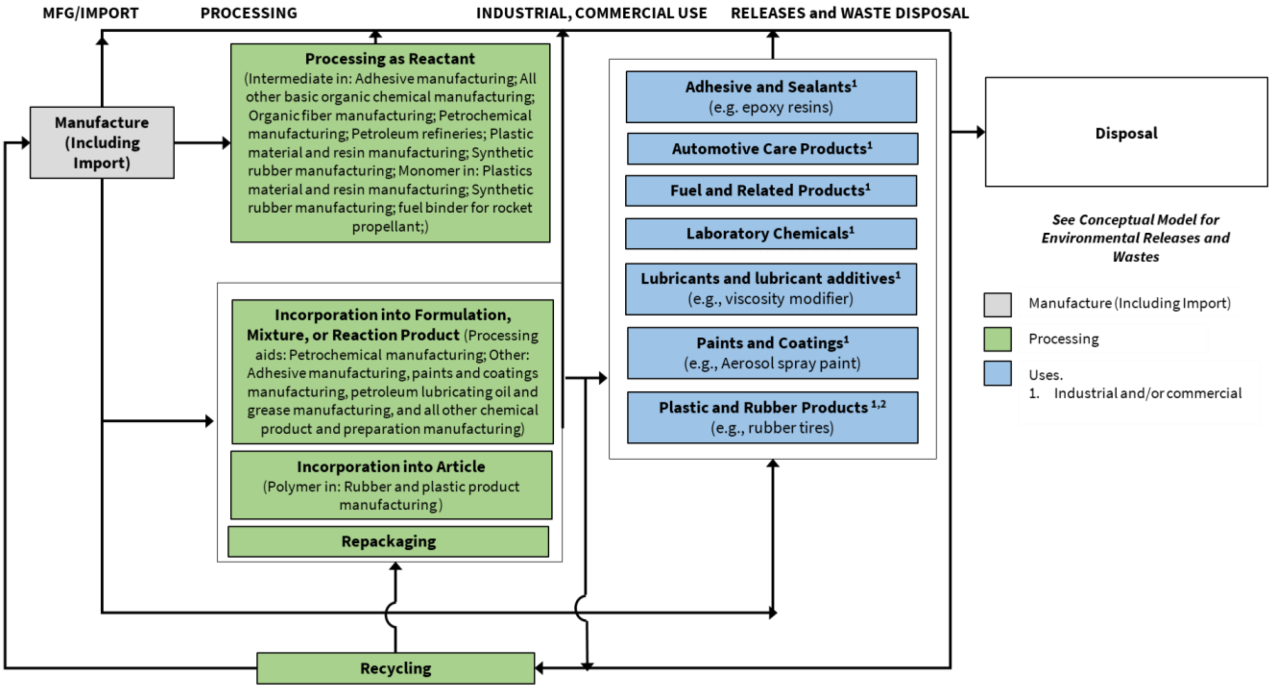
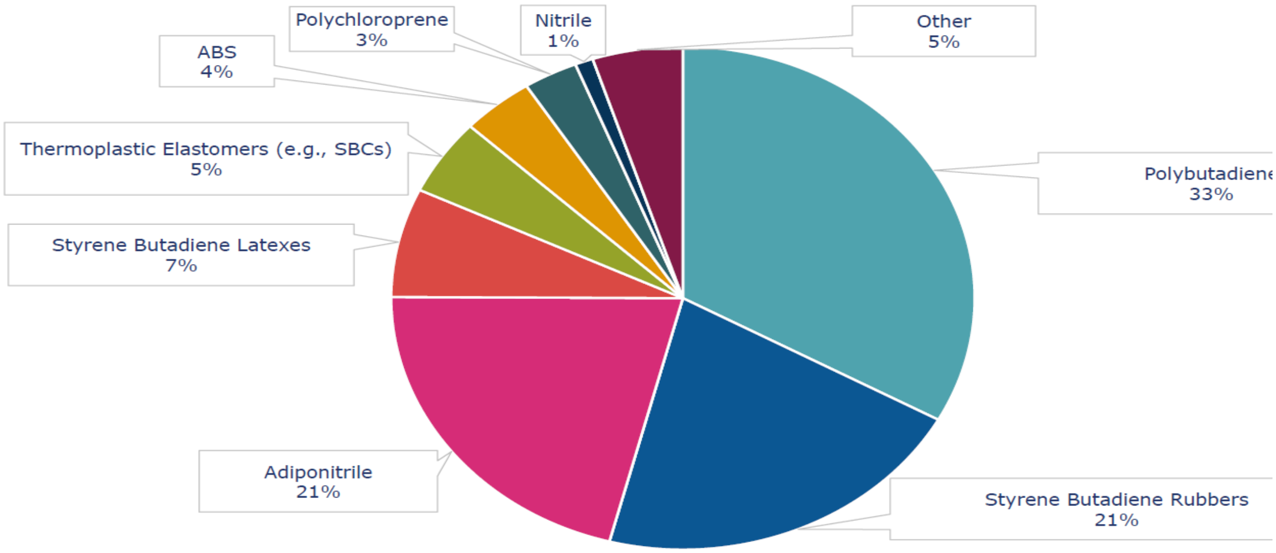


Figure 2-1. 1,3-Butadiene Life Cycle Diagram

Activities related to distribution were assessed as part of each relevant use; for example, loading and unloading that occurs at a manufacturing site will be addressed with the manufacturing use. For any distribution in commerce activities not associated with another use, EPA assessed releases and exposures by reviewing incident reports related to 1,3-butadiene distribution within the U.S. Department of Transportation (DOT) and National Response Center (NRC) databases.

The PV for 1,3-butadiene in 2016 ranged between 1 billion and 5 billion lb (U.S. EPA, 2020a) and remained unchanged in 2019 based on the latest 2020 CDR data. EPA described PV as a range to protect data claimed as confidential business information (CBI). For the 2016 and 2020 CDR cycles, collected data included the company name, volume of each chemical manufactured/imported, the number of workers at each site, and information on whether the chemical was used in the commercial, industrial, and/or consumer sector(s).

1,3-Butadiene is a monomer that is primarily used in the production of a wide range of polymers and copolymers. It is also used as an intermediate in the production of several chemicals. Due to a large majority of the total manufacturing and import volume being indicated as CBI by reporting sites, EPA did not have the ability to specify the percent of PV for each occupational exposure scenario (OES) based on CDR but instead relied on industry submitted data from the American Chemistry Council (ACC) to estimate relative percentages of use for 1,3-butadiene. ACC reported in 2022 (Figure 2-2) that roughly 63 to 69 percent of 1,3-butadiene PV goes toward the production of polymers and copolymers, such as polybutadiene and styrene-butadiene rubber, and roughly 26 to 32 percent of 1,3-butadiene PV goes toward the production of intermediate chemicals, such as adiponitrile and chloroprene. The "Other" category comprised all remaining uses of 1,3-butadiene, which may include use in formulations or as a laboratory chemical. Due to the limitations in reporting, these estimates may not fully reflect actual use and each OES may make up a smaller or larger percentage of the overall PV of 1,3-butadiene.



Source: American Chemistry Council analysis, S&P Global (formerly IHS Markit)

Figure 2-2. Percentage of 1,3-Butadiene Production Volume by Use

2.2 Conditions of Use Included in the Risk Evaluation

The *Final Scope of the Risk Evaluation for 1,3-Butadiene; CASRN 106-99-0* (U.S. EPA, 2020b) identified and described the life cycle stages, categories, and subcategories that comprise TSCA COUs that EPA planned to consider in the draft risk evaluation. TSCA section 3(4) defines COUs as "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." EPA identifies COUs for chemicals during the scoping phase and presents them in the Scoping Document, though the COUs presented may change between the scope document and the risk evaluation itself as the assessment is conducted and more information about the chemical is gathered.

EPA only evaluated risks resulting from exposure to 1,3-butadiene from facilities that use, manufacture, or process 1,3-butadiene under industrial and/or commercial COUs subject to TSCA and the products resulting from such manufacture and processing. Human or environmental exposure to 1,3-butadiene from other sources (*e.g.*, vehicle exhaust, tobacco smoke, woodburning) were not evaluated or taken into account by EPA in reaching its preliminary determination of unreasonable risk to injury of human health (see Section 7 for further information). Each COU has a unique combination of lifestyle stage, category, and subcategory that describes the chemical's use. EPA has identified a total of 28 TSCA COUs for 1,3-butadiene. All COUs for 1,3-butadiene included in this draft risk evaluation are presented in Table 2-1 below.

526 **Table 2-1. Categories and Subcategories of Conditions of Use Included in the Draft Risk**
527 **Evaluation**

Life Cycle Stage[a]	Category[b]	Subcategory[c]	Reference(s)
Manufacture	Domestic manufacturing	Domestic manufacturing	U.S. EPA (2019a)
	Importing	Importing	U.S. EPA (2019a)
Processing	Processing as a reactant	Intermediate in: adhesive manufacturing; all other basic organic chemical manufacturing; fuel binder for solid rocket fuels; organic fiber manufacturing; petrochemical manufacturing; petroleum refineries; plastic material and resin manufacturing; propellant manufacturing; synthetic rubber manufacturing; paint and coating manufacturing; wholesale and retail trade	U.S. EPA (2022a, 2019a)
		Monomer used in polymerization process in: synthetic rubber manufacturing; plastic material and resin manufacturing	U.S. EPA (2019a);EPA-HQ-OPPT-2018-0451-0004
	Processing – incorporation into formulation, mixture, or reaction product	Processing aids, not otherwise listed in: petrochemical manufacturing; monomers used in: plastic product manufacturing; synthetic rubber manufacturing	U.S. EPA (2022a)
		Other: adhesive manufacturing, paint and coating manufacturing, petroleum lubricating oil and grease manufacturing, and all other chemical product and preparation manufacturing	EPA-HQ-OPPT-2018-0451-0003; EPA-HQ-OPPT-2018-0451-0005; EPA-HQ-OPPT-2018-0451-0009; EPA-HQ-OPPT-2019-0131-0022
	Processing – incorporation into article	Other: polymer in: rubber and plastic product manufacturing	U.S. EPA (2019a)
	Repackaging	Intermediate in: wholesale and retail trade; monomer in: synthetic rubber manufacturing	U.S. EPA (2022a)
	Recycling	Recycling	U.S. EPA (2019a, 2019e)
Distribution in Commerce[d]	Distribution in commerce	Distribution in commerce (*e.g.*, sold to a trader; sold to re-sellers for petroleum fuel and petrochemical industry in: petrochemical manufacturing)	U.S. EPA (2019a)
Industrial Use	Adhesives and sealants	Adhesives and sealants, including epoxy resins	EPA-HQ-OPPT-2018-0451-0003; EPA-HQ-OPPT-2018-0451-0005; EPA-HQ-OPPT-2018-0451-0009; EPA-HQ-OPPT-2019-0131-0022
Commercial Use	Fuels and related products	Fuels and related products	U.S. EPA (2019a)
	Other articles with routine direct contact during	Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	U.S. EPA (2022a)

Life Cycle Stage[a]	**Category**[b]	**Subcategory**[c]	**Reference(s)**
Commercial Use	normal use including rubber articles; plastic articles (hard)		
	Toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard)	Toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard)	U.S. EPA (2022a)
	Synthetic rubber	Synthetic rubber (*e.g.*, rubber tires)	U.S. EPA (2022a)
	Furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles	Furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles	U.S. EPA (2022a)
	Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft)	Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft)	U.S. EPA (2022a)
	Automotive care products	Automotive care products	U.S. EPA (2019a)
	Other use	Laboratory chemicals	Sigma-Aldrich (2024)
	Lubricants and lubricant additives	Lubricant additives, including viscosity modifier	EPA-HQ-OPPT-2018-0451-0003; EPA-HQ-OPPT-2019-0131-0022
	Paints and coatings	Paints and coatings, including aerosol spray paint	EPA-HQ-OPPT-2018-0451-0005; EPA-HQ-OPPT-2019-0131-0022
	Adhesives and sealants	Adhesives and sealants, including epoxy resins	EPA-HQ-OPPT-2018-0451-0003; EPA-HQ-OPPT-2018-0451-0009; EPA-HQ-OPPT- 2019-0131-0022
Consumer Use	Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	U.S. EPA (2022a)

Life Cycle Stage[a]	Category[b]	Subcategory[c]	Reference(s)
Consumer Use	Toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard)	Toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard)	U.S. EPA (2022a)
	Synthetic rubber	Synthetic Rubber (*e.g.*, rubber tires)	U.S. EPA (2022a)
	Furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles	Furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles	U.S. EPA (2022a)
	Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft)	Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft)	U.S. EPA (2022a)
Disposal	Disposal	Disposal	

In this draft risk evaluation, EPA made updates to the COUs listed in the final scope document. These updates reflect EPA's improved understanding of the COUs based on further outreach, public comments, and updated industry code names under the CDR for 2020. Updates included (1) additions and clarification of COUs based on new reporting in the CDR for 2020 or information received from stakeholders, and (2) correction of typos or edits for consistency. A complete list of updates and explanations of the updates made to COUs for 1,3-butadiene from the final scope document to this draft risk evaluation is provided in Appendix D. EPA may further refine the COU descriptions for 1,3-butadiene included in the draft risk evaluation when the completed risk evaluation for 1,3-butadiene is published, based upon further outreach, peer-review comments, and public comments. Table 2-1 presents the revised COUs that were included and evaluated in this draft risk evaluation and Appendix E contains descriptions of each COU.

2.2.1 Occupational Scenarios

EPA assessed environmental releases and occupational exposures for the COUs described in Table 2-1. Each COU for 1,3-butadiene was assigned an OES that characterizes its release and exposure potential. Although named for their utility when assessing occupational exposure, these scenarios are also used when assessing environmental releases from industrial and commercial facilities. OES is a term that is intended to describe the grouping or segmenting of COUs for assessment of releases and exposures. For example, EPA may assess a group of multiple COUs together as one OES due to similarities in release and exposure sources, worker activities, and use patterns. Alternatively, EPA may assess multiple OESs for one COU because there are different release and exposure potentials within a given COU. OES determinations are largely driven by the availability of data and modeling approaches to assess occupational releases and exposures. For example, even if there are similarities between multiple COUs, if there is sufficient data to separately assess releases and exposures for each COU, EPA would not group them into the same OES. For each OES, environmental releases and occupational exposure results are provided and are expected to be representative of the entire population of workers and sites involved for the given OES in the United States. These results can be found in the *Draft Environmental Release and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2024y).

Table 2-2 shows the mapping between the COUs from Table 2-1 and the OESs assessed. For 1,3-butadiene, EPA mapped OESs to COUs based on data and information gathered during systematic review, industry outreach, and public comments. Several of the condition of use categories and subcategories were grouped and assessed together in a single OES due to similarities in the processes or lack of data to differentiate between them, for example Importing and Intermediate in wholesale and retail trade were both assessed under the Repackaging OES. This grouping minimized repetitive assessments. In one case, the condition of use subcategory was further delineated into multiple OESs based on expected differences in process equipment and associated releases or exposure potentials between facilities. This case was Disposal, which was delineated into Waste handling, treatment, and disposal and Recycling. Fifteen unique OESs were identified.

Table 2-2. Crosswalk of Conditions of Use to Occupational Exposure Scenarios Assessed

Life Cycle Stage[a]	Category[b]	Subcategory[c]	Occupational Exposure Scenario
Manufacture	Domestic manufacturing	Domestic manufacturing	Domestic manufacturing
	Importing	Importing	Repackaging
Processing	Processing as a reactant	Intermediate in: adhesive manufacturing; all other basic organic chemical manufacturing; fuel binder for solid rocket fuels; organic fiber manufacturing; petrochemical manufacturing; petroleum refineries; plastic material and resin manufacturing; propellant manufacturing; synthetic rubber manufacturing; paint and coating manufacturing; wholesale and retail trade	Processing as a reactant
		Monomer used in polymerization process in: synthetic rubber manufacturing; plastic material and resin manufacturing	Plastics and rubber compounding
	Processing – incorporation into formulation, mixture, or reaction product	Processing aids, not otherwise listed in: petrochemical manufacturing; monomers used in: plastic product manufacturing; synthetic rubber manufacturing	Processing – incorporation into formulation, mixture, or reaction product
		Other: adhesive manufacturing, paint and coating manufacturing, petroleum lubricating oil and grease manufacturing, and all other chemical product and preparation manufacturing	Processing – incorporation into formulation, mixture, or reaction product

Life Cycle Stage[a]	Category[b]	Subcategory[c]	Occupational Exposure Scenario
Processing	Processing – incorporation into article	Other: polymer in: rubber and plastic product manufacturing	Plastics and rubber converting
	Repackaging	Intermediate in: wholesale and retail trade; monomer in: synthetic rubber manufacturing	Repackaging
	Recycling	Recycling	Processing as a reactant
			Use of plastics and rubber products[e]
Distribution in Commerce	Distribution in commerce	Distribution in commerce (*e.g.*, sold to a trader; sold to re-sellers for petroleum fuel and petrochemical industry in: petrochemical manufacturing)	Distribution in commerce[d]
Industrial Use	Adhesives and sealants	Adhesives and sealants, including epoxy resins	Application of adhesives and sealants
Commercial Use	Fuels and related products	Fuels and related products	Fuels and related products
	Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	Use of plastics and rubber products[e]
	Toys intended for children’s use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard)	Toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard)	
	Synthetic rubber	Synthetic Rubber (*e.g.*, rubber tires)	
	Furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles	Furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles	
	Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft)	Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft)	

Life Cycle Stage[a]	Category[b]	Subcategory[c]	Occupational Exposure Scenario
Commercial Use	Automotive care products	Automotive care products	Use of plastics and rubber products[e]
	Other use	Laboratory chemicals	Use of laboratory chemicals
	Lubricants and lubricant additives	Lubricant additives, including viscosity modifier	Use of lubricants and greases[e]
	Paints and coatings	Paints and coatings, including aerosol spray paint	Application of paints and coatings
	Adhesives and sealants	Adhesives and sealants, including epoxy resins	Application of adhesives and sealants
Consumer Use	Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	N/A[f]
	Toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard)	Toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard)	
	Synthetic rubber	Synthetic rubber (*e.g.*, rubber tires)	
	Furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles	Furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles	
	Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft)	Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft)	
Disposal	Disposal	Disposal	Waste handling, treatment, and disposal
			Recycling

[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.

Life Cycle Stage[a]	Category[b]	Subcategory[c]	Occupational Exposure Scenario

- "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.

[b] These categories of conditions of use appear in the Life Cycle Diagram, reflect CDR codes, and broadly represent conditions of use of 1,3-butadiene in industrial and/or commercial settings.

[c] These subcategories reflect more specific conditions of use of 1,3-butadiene.

- "Incorporation into article – polymer in rubber product manufacturing," as reported to the 2016 CDR, is a condition of use that EPA considered as manufacturing of articles involving butadiene-derived polymers, including plastics such as acrylonitrile butadiene styrene made using polybutadiene rubber.
- "Monomer used in polymerization process," as reported to the 2016 CDR under commercial use, indicates processing of 1,3-butadiene for a polymerization reaction. This reported use was evaluated under processing as a reactant.

[d] EPA considers the activities of loading and unloading of chemical product part of distribution in commerce, however these activities were assessed as part of each use's OES. EPA's current approach for quantitively assessing releases and exposures for the remaining aspects of distribution in commerce consists of searching Department of Transportation (DOT) and National Response Center (NRC) data for incident reports pertaining to 1,3-butadiene distribution.

[e] Though these uses were identified during scoping, upon further investigation EPA made the decision to not quantitatively assess these uses of 1,3-butadiene. For a description of the rationale for not performing a quantitative assessment, and details for each decision, see Section 5.14 of the *Draft Environmental Release and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2024y).

[f] Consumer uses are not assigned to an OES as they are not part of the occupational assessment. See Section 5.1.2 for information on the consumer exposure assessment.

After identifying those OESs that will be assessed, the next step was to describe the function of 1,3-butadiene within each OES (Table 2-3). This would be utilized in mapping release and exposure data to an OES as well as applying release modeling approaches. The table below is a summary; for more information on each OES, see the corresponding process description in the *Draft Environmental Release and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2024y).

Table 2-3. Description of the Function of 1,3-Butadiene for each OES

OES	Role/Function of 1,3-Butadiene
Manufacturing	This OES captures the Domestic manufacture COU category. 1,3-Butadiene can be produced by three processes: steam cracking of paraffinic hydrocarbons (the ethylene coproduct process), catalytic dehydrogenation of n-butane and n-butene (the Houndry process), and oxidative dehydrogenation of n-butene (the Oxo-D or O-X-D process). The predominant method of the three processes is the steam cracking process, which accounts for greater than 91% of the world's butadiene supply
Repackaging	This OES captures the Importing and Repackaging COU categories. Import and repackaging sites are expected to distribute 1,3-butadiene to various downstream uses. Liquefied butadiene is shipped by pipelines, ships, barges, rail tank cars, tank trucks and bulk liquid containers. A portion of the 1,3-butadiene manufactured is also expected to be repackaged into smaller containers for commercial laboratory use.
Processing as a reactant	This OES captures the Processing as an Intermediate COU subcategory and part of the Recycling COU category.

OES	Role/Function of 1,3-Butadiene
	Processing as a reactant or intermediate is the use of 1,3-butadiene as a feedstock in the production of another chemical via a chemical reaction in which 1,3-butadiene is consumed to form the product. 1,3-Butadiene is used in the production of intermediate chemicals which are then used to make nylon and neoprene rubber among other products. 1,3-Butadiene is also processed as a reactant in propellant manufacturing by the United States Department of Defense. Also included in this OES is when ethylene manufacturers have excess butadiene supply, they can recycle the butadiene as a feedstock to produce ethylene.
Processing – incorporation into formulation, mixture, or reaction product	This OES captures the Processing –incorporation into formulation, mixture, or reaction product COU category. Incorporation into a formulation, mixture or reaction product refers to the process of mixing or blending of several raw materials to obtain a single product or preparation. 1,3-Butadiene may be used during lubricant manufacturing as a viscosity improver, as well as in paints, coatings, and adhesive manufacturing as a binder.
Plastic and rubber compounding	This OES captures the Processing as a Monomer COU subcategory. 1,3-Butadiene is used as a monomer in polymerization processes, often to produce rubbers and plastics such as styrene-butadiene, polybutadiene, acrylonitrile-butadiene-styrene, and nitrile rubber. This is the most common use of 1,3-butadiene.
Plastics and rubber converting	This OES captures the Processing –incorporation into article COU category. After the compounding process that occurs during the plastic and rubber compounding OES briefly described above, compounded plastic and rubber resins are converted into solid articles.
Distribution in commerce	This OES captures the Distribution in Commerce COU category. 1,3-Butadiene is expected to be distributed in commerce for the purposes of each processing, industrial, and commercial use of 1,3-butadiene. EPA expects 1,3-butadiene to be transported from manufacturing sites to downstream processing and repackaging sites.
Use of laboratory chemicals	This OES captures the Laboratory chemicals COU subcategory. 1,3-Butadiene uses as a laboratory chemical may include demonstration of Diels Alder reactions, synthesis of thermoplastic resins, and synthesis of disilylated dimers by reacting with chlorosilanes.
Application of paints and coatings	This OES captures the Paints and coatings COU category. 1,3-Butadiene was identified as possibly being present in multiple paint and coating products, including aerosol propellants, architectural paints and coatings, latex paints, electro-dipping coatings, and automotive primers. The application procedure depends on the type of paint or coating formulation and the type of substrate, but may involve application via brush, spray, roll, dip, curtain, or syringe or bead.
Application of adhesives and sealants	This OES captures the Industrial use of adhesives and sealants, as well as the Commercial use of adhesives and sealants COU categories.

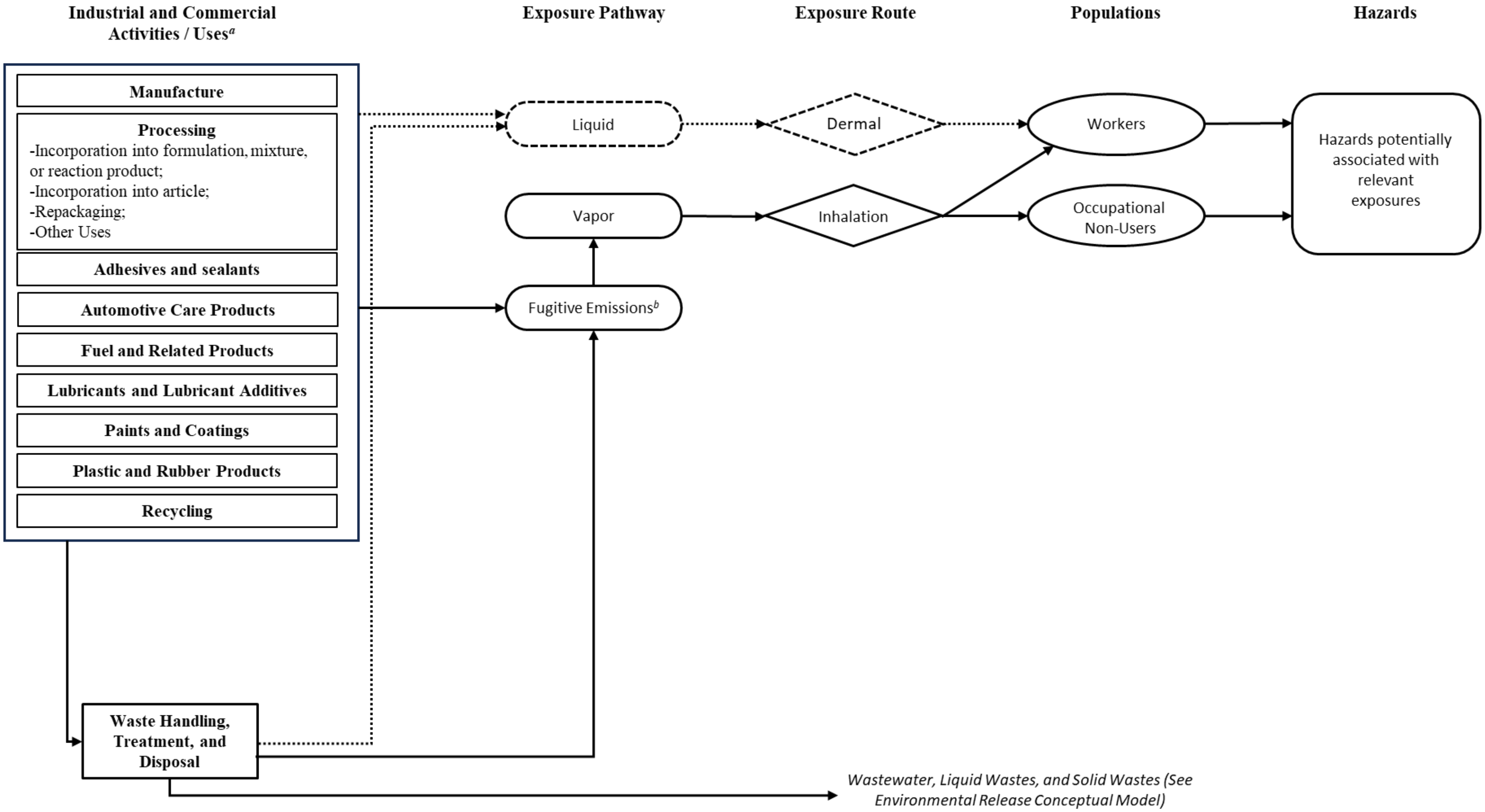
OES	Role/Function of 1,3-Butadiene
	1,3-Butadiene was identified in multiple adhesive and sealant products, including aerosol propellants, epoxy resins (incorporated for their tensile and elastomeric properties), and adhesives for electrical and circuit boards. The application procedure depends on the type of adhesive or sealant formulation and the type of substrate but may involve application via brush, spray, roll, dip, curtain, or syringe or bead.
Fuels and related products	This OES captures the Fuels and related products COU category. 1,3-Butadiene may be used at industrial sites for fueling purposes. This use of 1,3-butadiene is addressed in the Recycling OES. EPA did not find evidence that 1,3-butadiene in its monomer form is used as an additive to fuel, however it was found that 1,3-butadiene is present in butane. This use is discussed, but no release or exposure estimates provided.
Recycling	This OES captures part of the Disposal COU categories. There are multiple ways 1,3-butadiene can be recycled during its life cycle. When finished 1,3-butadiene does not meet commercial specifications, it is often combined with crude streams for energy recovery. This is examined in this OES.
Waste handling, treatment, and disposal	This OES captures part of the Disposal COU category. Each of the OESs may generate waste streams of 1,3-butadiene that are collected and transported to third-party sites for disposal or treatment, and these cases are assessed under this OES. Also handled under this OES are cases of 1,3-butadiene produced as a byproduct or impurity in an industrial setting and burned.
Use of plastics and rubber products	This OES captures the five plastic and rubber COU categories detailed in the Commercial use life cycle stage as well as the automative care products and part of the Recycling COU categories. 1,3-Butadiene may be present within rubber tires and articles produced with synthetic rubber. In addition, plastics containing 1,3-butadiene were identified in electronic appliances, furniture and furnishings, toys and recreational products, housewares, packaging, automotive parts, building materials, and 3D-printing filament. Plastic and rubber products may be recycled mechanically (injection molding, extrusion, rotational molding, and compression molding) into newly shaped products. Tires may also be recycled into tire crumbs for use on synthetic turf fields. Most automotive applications of 1,3-butadiene pertain to tires, tire products, and coatings and thus falls under plastic and rubber products described above. It was determined that butadiene is present in rubber products at no greater amounts that 6.6 ppm, and after polymerization occurs it is nearly impossible to break the polymer chain back into individual units of 1,3-butadiene. No release or exposure numbers are provided for this OES.
Use of lubricants and greases	This OES captures the Lubricants and lubricant additive COU category. 1,3-Butadiene has been identified in automotive lubricants and aircraft lubricants. 1,3-Butadiene monomer is present at very low levels within the finished styrene-butadiene copolymer product. Further, due to lack of evidence otherwise, it was determined that 1,3-

OES	Role/Function of 1,3-Butadiene
	butadiene is not present within lubricants and greases for any purpose other than the amount that may be residual within the styrene-butadiene copolymer. No release or exposure numbers are provided for this OES.

2.2.2 Conceptual Models

Figure 2-3 presents the conceptual model for exposure pathways, exposure routes, and hazards to human populations from industrial and commercial activities and uses of 1,3-butadiene. There is potential for exposures to workers and/or ONUs via inhalation. EPA evaluated activities resulting in exposures associated with distribution in commerce (*e.g.*, loading, unloading) throughout the various life cycle stages and COUs (*e.g.*, Manufacturing, Processing, Industrial use, Commercial use, Disposal), as well as qualitatively through a single distribution scenario.

Figure 2-4 presents the conceptual model for general population exposure pathways and hazards from environmental releases and wastes, and ecological exposures and hazards from environmental releases and wastes.



589

590 **Figure 2-3. 1,3-Butadiene Conceptual Model for Industrial and Commercial Activities and Uses: Potential Exposure and Hazards**
591 [a] Some products are used in both industrial and commercial applications. See Table 2-1 for categories and subcategories of COUs.
592 [b] Fugitive air emissions are emissions that are not routed through a stack and include fugitive equipment leaks from valves, pump seals, flanges,
593 compressors, sampling connections and open-ended lines; evaporative losses from surface impoundment and spills; and releases from building ventilation
594 systems.
595 Solid lines represent a quantitative assessment while broken lines represent a qualitative assessment.

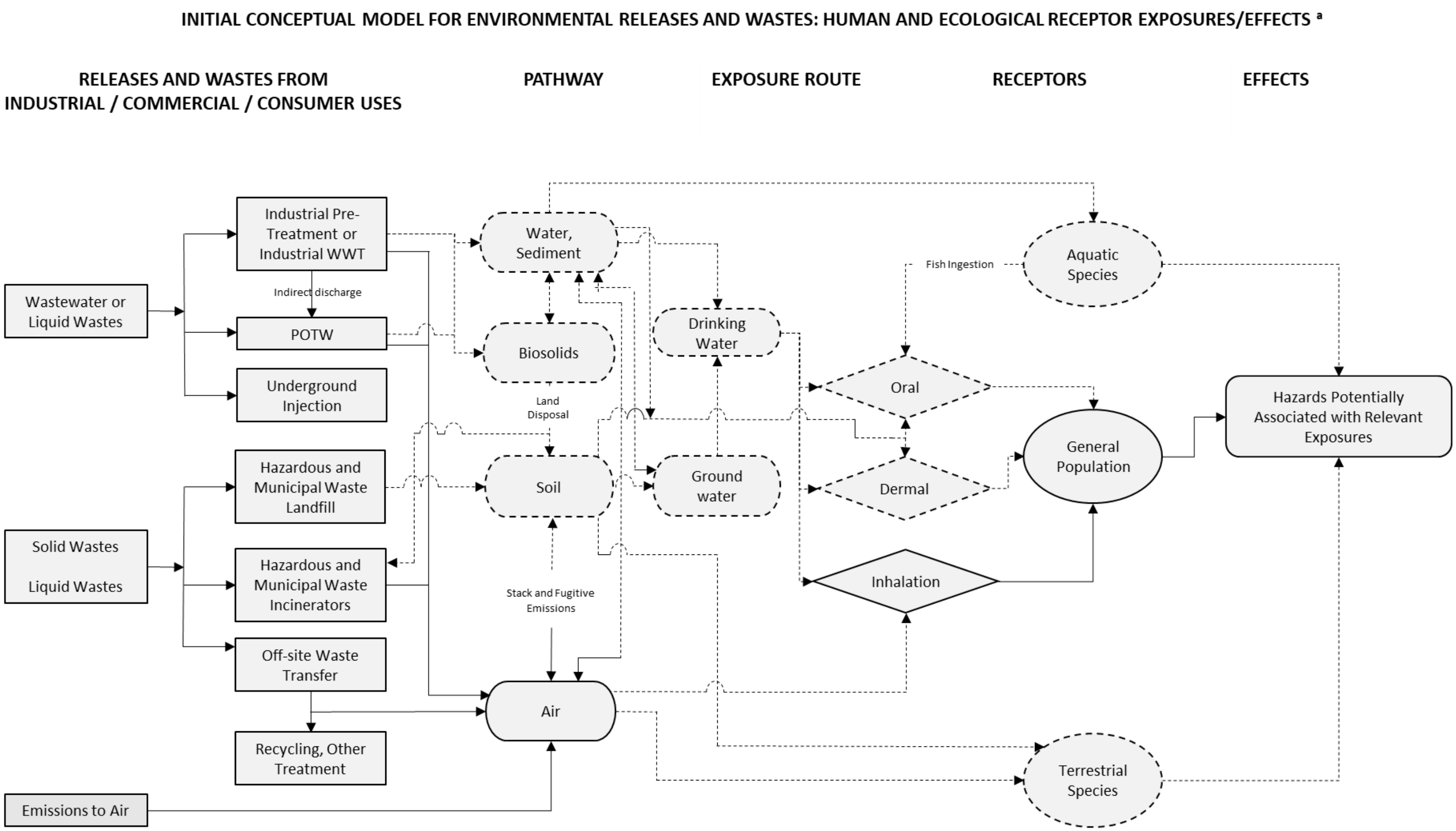


Figure 2-4. 1,3-Butadiene Conceptual Model for Environmental Releases and Wastes: Environmental and General Population Hazards

The conceptual model presents the exposure pathways, exposure routes, and hazards to human and ecological populations from releases and wastes from industrial and commercial uses of 1,3-butadiene.

Solid lines represent a quantitative assessment while broken lines represent a qualitative assessment.

2.2.3 Populations

Based on the conceptual models presented in Section 2.2.2, EPA evaluated risk to environmental and human populations. Environmental exposure and risks were qualitatively evaluated for aquatic and terrestrial species in Section 6. Human health risks were evaluated for all exposure scenarios, as applicable based on reasonably available exposure and hazard data as well as the relevant populations for each. Human populations assessed included

- workers and ONUs, including average adults and women of reproductive age; and
- general population exposed to environmental releases, including infants, children, youth, and adults.

2.2.4 Potentially Exposed or Susceptible Subpopulations

TSCA section 6(b)(4)(A) requires that risk evaluations "determine whether a chemical substance presents an unreasonable risk of injury to health or the environment, without consideration of costs or other non-risk 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." TSCA section 3(12) states that "the term 'potentially exposed or susceptible subpopulation' (PESS) 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 of adverse health effects from exposure to a chemical substance or mixture, such as infants, children, pregnant women, workers, or the elderly."

This draft risk evaluation considers PESS throughout the human health risk assessment (Section 5.3.5)—including throughout the exposure assessment, hazard identification, and dose-response analysis supporting this assessment. In addition, see Section 9.2 in the *Draft Human Health Hazard Assessment for 1,3-Butadiene* (U.S. EPA, 2024t) for more details on how EPA considered evidence of greater susceptibility among subpopulations.

2.3 Systematic Review

EPA/OPPT applies systematic review principles in the development of risk evaluations under the amended TSCA. TSCA section 26(h) requires EPA to use scientific information, technical procedures, measures, methods, protocols, methodologies, and models consistent with the best available science and base decisions under section 6 on the weight of scientific evidence.

To meet the TSCA section 26(h) science standards, EPA used the TSCA systematic review process described in the *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances, Version 1.0: A Generic TSCA Systematic Review Protocol with Chemical-Specific Methodologies* (also called the "Draft Systematic Review Protocol") (U.S. EPA, 2021a) and in the *Draft Systematic Review Protocol for 1,3-Butadiene* (U.S. EPA, 2024ac). Systematic review supports the risk evaluation in that data searching, screening, evaluation, extraction, and evidence integration are used to develop the exposure and hazard assessments based on reasonably available information. EPA defines "reasonably available information" to mean information that the Agency possesses or can reasonably obtain and synthesize for use in risk evaluations, considering the deadlines for completing the evaluation (40 CFR 702.33).

The systematic review process is briefly described in Figure 2-5 below. Additional information regarding these steps is provided in the Draft Systematic Review Protocol (U.S. EPA, 2021a) and the *Draft Systematic Review Protocol for 1,3-Butadiene* (U.S. EPA, 2024ac). The latter provides additional information on the steps in the systematic review process—including literature inventory trees and evidence maps for each discipline (*e.g.*, human health hazard) containing results of the literature search and screening, as well as sections summarizing data evaluation, extraction, and evidence integration.

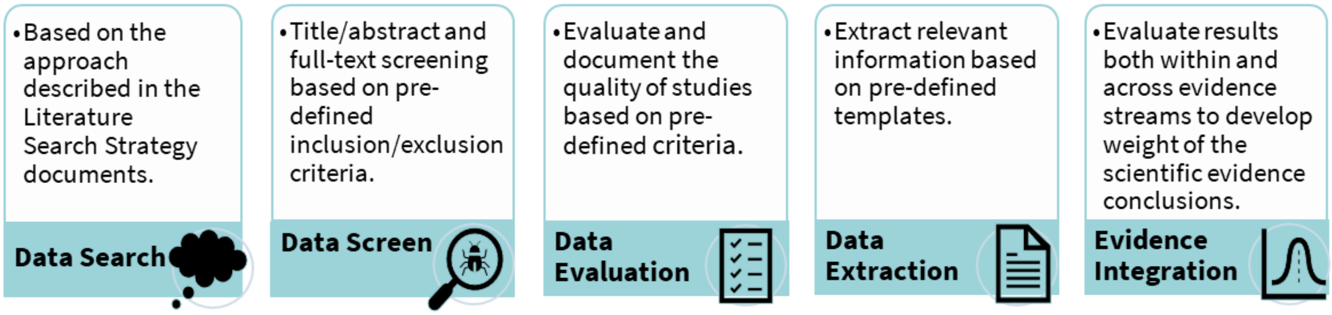


Figure 2-5. Diagram of the Systematic Review Process

The Agency also identified key assessments not identified from systematic review, conducted by other EPA programs and other U.S. and international organizations. Depending on the source, these assessments may include information on COUs (or the equivalent), hazards, exposures, and potentially exposed or susceptible subpopulations. For more details, see the *Draft Systematic Review Protocol for 1,3-Butadiene* (U.S. EPA, 2024ac).

2.4 Organization of the Risk Evaluation

Figure 2-6 illustrates the organization the draft risk evaluation and related TSDs for 1,3-butadiene (see also Appendix C). This draft risk evaluation for 1,3-butadiene includes five additional major sections and several appendices:

- Section 3 summarizes basic physical and chemical characteristics as well as the fate and transport of 1,3-butadiene.
- Section 4 includes an overview of releases and concentrations of 1,3-butadiene in the environment.
- Section 5 presents the human health risk assessment, including the exposure, hazard, and risk characterization based on the COUs. It includes a discussion of PESS based on both greater exposure and/or susceptibility, as well as a description of aggregate and sentinel exposures. The section also discusses assumptions and uncertainties and how they potentially impact the strength of the evidence of the draft risk evaluation.
    - Section 5.3.5 provides considerations for potentially exposed or susceptible subpopulations.
- Section 6 provides a discussion and analysis of the environmental risk assessment, including the environmental exposure and risk characterization based on the COUs for 1,3-butadiene. It also discusses assumptions and uncertainties and how they potentially impact the strength of the evidence of the draft risk evaluation.
- Section 7 presents EPA's proposed determination of whether the chemical presents an unreasonable risk to human health or the environment as a whole-chemical approach and under the assessed COUs.
- Appendix A provides a list of key abbreviations and acronyms used throughout this draft risk evaluation.
- Appendix B provides a summary of the federal, state, and international regulatory history of 1,3-butadiene.

- Appendix C includes a list and citations for all TSDs and supplemental files included in the draft risk evaluation for 1,3-butadiene.
- Appendix D provides a summary of updates made to COUs for 1,3-butadiene from the final scope document to this draft risk evaluation.
- Appendix E provides descriptions of the 1,3-butadiene COUs evaluated by EPA.
- Appendix F provides the draft occupational exposure value for 1,3-butadiene that was derived by EPA.
- Appendix H provides additional tables and figures for general population risks.

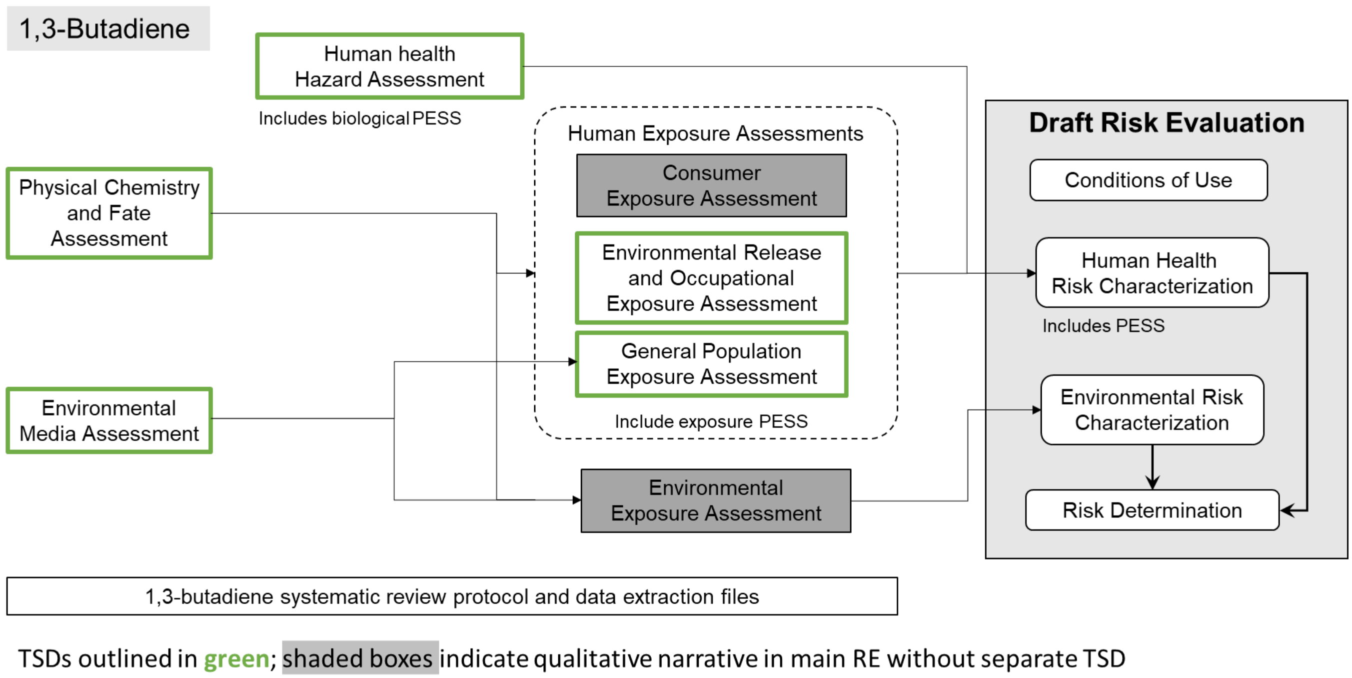


Figure 2-6. Document Map of Draft Risk Evaluation for 1,3-Butadiene

3 CHEMISTRY AND FATE AND TRANSPORT OF 1,3-BUTADIENE

Physical and chemical properties determine the behavior and characteristics of a chemical that inform its conditions of use, environmental fate and transport, potential toxicity, exposure pathways, routes, and hazards. Environmental fate and transport includes environmental partitioning, accumulation, degradation, and transformation processes. Environmental transport is the movement of the chemical within and between environmental media, such as air, water, soil, and sediment. Thus, understanding the environmental fate of 1,3-butadiene informs the specific exposure pathways, and potential human and environmental exposed populations that EPA considered in this draft risk evaluation. This section summarizes the physical and chemical properties, and environmental fate and transport of 1,3-butadiene.

3.1 Summary of Chemistry and Environmental Fate and Transport

1,3-Butadiene is a colorless gas with a mildly aromatic or gasoline-like odor (Rumble, 2018b; NLM, 2003). It is moderately soluble in aqueous systems, with a water solubility of 735 mg/L (NLM, 2003). It is a highly volatile organic compound, with a −4.54 °C boiling point and a vapor pressure of 1,900 mm Hg (NIST, 2022; National Toxicology Program (NTP), 1993).

With greater than 90 percent of 1,3-butadiene released to air as reported by EPA's Toxics Release Inventory Program (TRI; see *Draft Environmental Release and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2024y)), EPA expects air to be the major environmental compartment for 1,3-butadiene. 1,3-Butadiene will degrade in air rapidly (half-life of 1.6–2.6 hours) by reaction with photochemically produced hydroxyl radicals in the atmosphere during the day to form formaldehyde and acrolein (Khaled et al., 2019; Vimal, 2008; Klamt, 1993). It will also react more slowly with nitrate radicals and ozone in the atmosphere, with half-lives of 3 to 9 hours and 34 hours, respectively (U.S. EPA, 2012b; Zhao et al., 2011; Andersson and Ljungström, 1989). Based on an estimated octanol-air partition coefficient (K_{OA}) of 31.5 to 33.7 (U.S. EPA, 2012b), 1,3-butadiene is not expected to associate strongly with airborne particulates; hence, it is not expected to undergo dry deposition. Overall, 1,3-butadiene in the atmosphere is expected to remain largely in the vapor phase, where it is not expected to persist or undergo long-range transport.

TRI reported very low releases of 1,3-butadiene to water (U.S. EPA, 2024y). Based on a Henry's Law constant of 0.076 atm·m^3/mol at 25 °C (Rumble, 2018a) and a vapor pressure of 1,900 mm Hg at 20 °C (National Toxicology Program (NTP), 1993), volatilization from water surfaces is expected to be a significant process for 1,3-butadiene, thus mitigating its persistence in aquatic environments. 1,3-Butadiene is not expected to bioaccumulate in aquatic organisms given an estimated BCF of 9.55 L/kg (U.S. EPA, 2012b). Overall, 1,3-butadiene is primarily released to and will generally partition to air where it has low persistence potential. A detailed description of the selected physical and chemical and fate values and other fate analyses are contained in the *Draft Physical Chemistry and Fate Assessment for 1,3-Butadiene* (U.S. EPA, 2024z). The graphic summary of the fate assessment is shown in Figure 3-1.

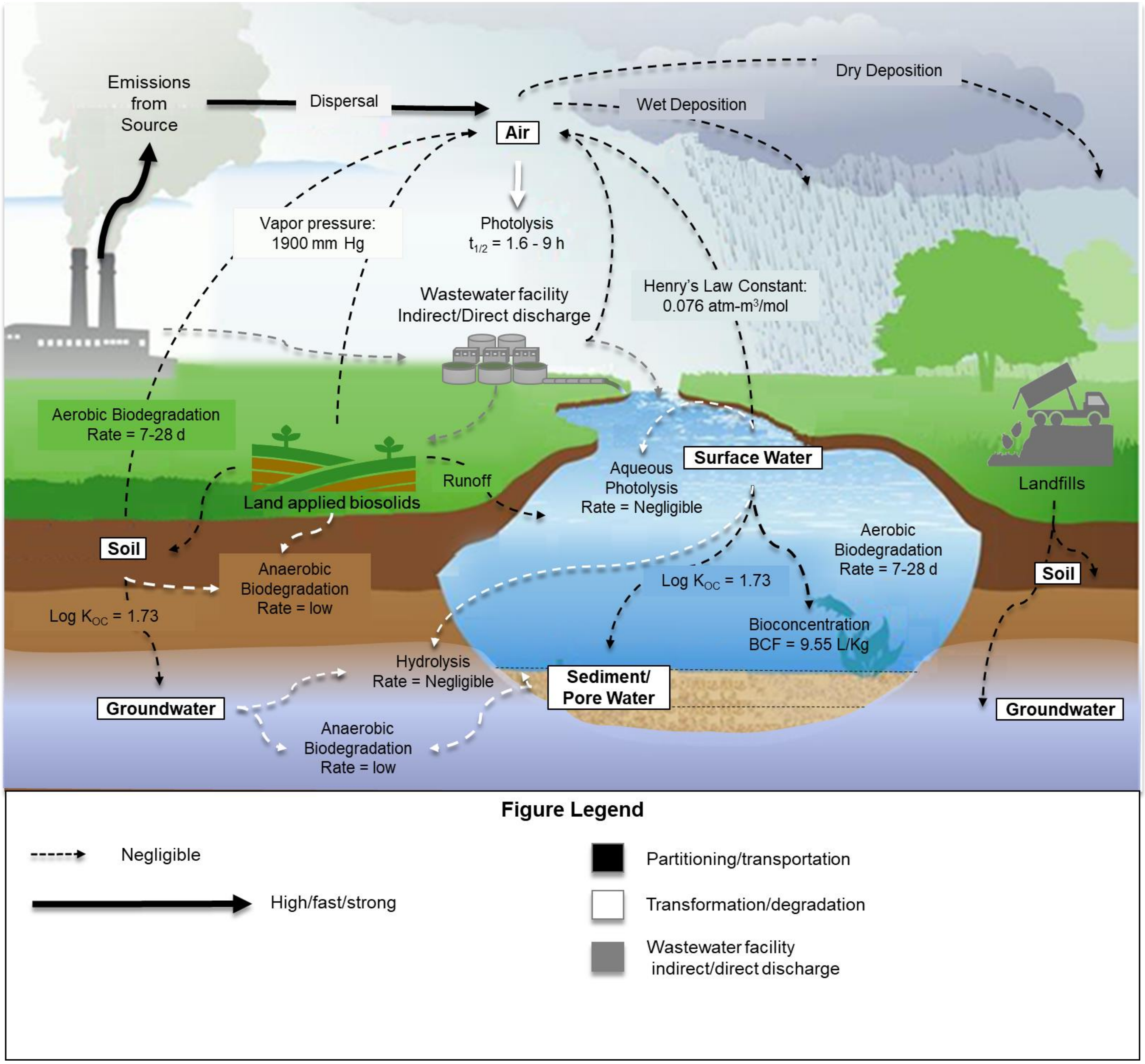


Figure 3-1. Transport, Partitioning, and Degradation of 1,3-Butadiene in the Environment

The diagram depicts the distribution (grey arrows), transport, and partitioning (black arrows), as well as the transformation and degradation (white arrows) of 1,3-butadiene in the environment. The width of the arrow is a qualitative indication of the likelihood that the indicated partitioning will occur or the rate at which the indicated degradation will occur (*i.e.*, wider arrows indicate more likely partitioning or more rapid degradation).

3.2 Weight of Scientific Evidence Conclusions for Chemistry, Fate, and Transport

The general confidence in the physical and chemical properties for 1,3-butadiene is robust. Measured data were identified from high-quality studies for all physical and chemical properties. Evaluation of the weight of scientific evidence for the fate and transport of 1,3-butadiene is shown below and is based on categorization described in the Draft Systematic Review Protocol (U.S. EPA, 2021a).

Given consistent results from numerous high-quality studies, there is robust confidence that 1,3-butadiene will

- photodegrade rapidly in air to yield formaldehyde and acrolein;
- not partition to organic matter in water; and
- not hydrolyze significantly in water.

Given limited results from high-quality studies, there is moderate confidence that 1,3-butadiene will

- biodegrade rapidly in aerobic river water or wetland sediment;
- biodegrade rapidly in aerobic soil;
- not sorb to soil/sediment particles;
- not biodegrade rapidly in anaerobic sediment;
- be degraded by methane-utilizing bacteria to form 1,2-epoxybutene; and
- not bioaccumulate in fish.

4 RELEASES AND CONCENTRATIONS OF 1,3-BUTADIENE IN THE ENVIRONMENT

EPA estimated environmental releases and concentrations of 1,3-butadiene. Section 4.1 summarizes the approach and methodology for estimating release and presents estimates of environmental releases. Section 4.2 summarizes the approach and methodology for estimating environmental concentrations as well as a summary of concentrations of 1,3 butadiene in the environment. Complete descriptions of these analyses are presented in the *Draft Environmental Releases and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2024y).

4.1 Summary of Environmental Releases

4.1.1 Industrial and Commercial

EPA's first source of information to estimate releases from each OES is programmatic databases. These databases provide annual facility releases, from which daily release estimates are obtained by dividing the annual release by the number of expected release days. Once these data are obtained from the databases, each facility is mapped to one of the OESs described in Section 4.1.1. After mapping is complete, each OES may have release data from multiple facilities. These data are considered together to inform the releases that are expected to occur due to the OES. There are cases when there are few or no facilities mapped to a given OES. In these cases, gaps are filled with release modeling. For 1,3-butadiene, only one OES (Application of adhesives and sealants) required the use of release modeling due to lack of programmatic data.

The other important components of the environmental release assessment are number of release days and the number of facilities. Number of release days may be obtained through literature or through assumptions based on generic industry information, often from Emission Scenario Documents (ESDs) or Generic Scenarios (GS). Number of facilities may be obtained through programmatic data, literature, or through assumptions and modeling based on Bureau of Labor Statistics (BLS)[1] and Statistics of U.S. Businesses (SUSB)[2] data.

4.1.1.1 Summary of Daily Environmental Release Estimates

Figure 4-1 shows an overview for how the different assessment components and data sources feed into the Daily Release Estimates for each OES.

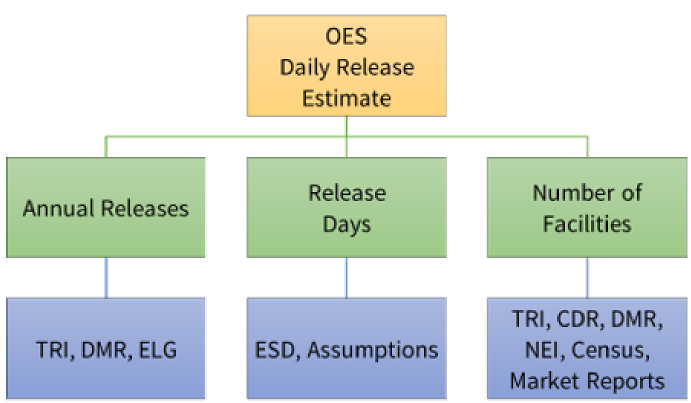


Figure 4-1. An Overview of How EPA Estimated Daily Releases for Each OES

[1] https://www.bls.gov/.
[2] https://www.census.gov/programs-surveys/susb.html.

In Table 4-1, EPA provides a summary for each of the occupational exposure scenarios (OESs) by indicating the type of release and number of facilities. EPA provides high-end and central tendency daily and annual release estimates. A majority of releases of 1,3-butadiene were to air, with land and water releases occurring at vastly fewer sites. The OES with the highest expected releases were Manufacturing, Plastic and rubber compounding, and Application of adhesives and sealants. For more detail on these procedures for estimating environmental releases, see the *Draft Environmental Releases and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2024y).

Releases were not quantified from Commercial Use in Fuels and related products, which includes 1,3-butadiene used as a fuel binder for solid rocket fuels, and 1,3-butadiene's presence in liquid petroleum gas (LPG) used as a fuel. Releases were not quantified for this COU because, in the case of the use as a fuel binder, this is not a use of 1,3-butadiene monomer but rather polymers created from 1,3-butadiene and other monomers. Although residual 1,3-butadiene monomer has the potential to be present in these polymers, the concentration of residual 1,3-butadiene would be minimal. Thus, the release of 1,3-butadiene from this use is negligible. With respect to LPG, these releases were not quantified due to (1) uncertainty in the amount of 1,3-butadiene in LPG product; (2) dispersed use of LPG product across domestic, industrial, and commercial applications; (3) inability to determine a reasonable number of use sites; and (4) predicted minimal or unquantifiable releases from connecting equipment/cylinder leaks and due to the high combustion efficiency of LPG fuel.

Releases were also not quantitatively assessed for the commercial COUs covered by the OES of Use of plastics and rubber products and Use of lubricants and greases. Reasonably available evidence suggests that 1,3-butadiene monomer does not exist at concentrations above 6.6 ppm in rubber products or above quantifiable levels in lubricants and greases. In EPA's investigations, any 1,3-butadiene indicated in SDSs or other product reports referred either to upstream steps or to reacted polymeric forms.

817 **Table 4-1. Summary of Environmental Releases by Occupational Exposure Scenarios**

Occupational Exposure Scenario (OES)	Estimated Annual Release Range across Sites (kg/site-yr)		Type of Discharge [b], Air Emission [c], or Transfer for Disposal [d]	Estimated Daily Release Range across Sites (kg/site-day) [e]		Number of Facilities	Source(s) [g]
	Central Tendency	High-End [a]		Central Tendency	High-End		
Manufacturing	2.3	371	Surface water	6.5E−03	1.1	4	TRI
	7,500	2.1E04	WWT	22	59	3	TRI
	360	8,419	Fugitive air	1.0	24	37	TRI
	649	7,139	Fugitive air	1.9	20	45	NEI
	1,142	3.3E04	Stack air	3.3	95	39	TRI
	665	1.7E04	Stack air	2.0	46	45	NEI
	0.45	120	Land	1.3E−03	0.34	9	TRI
Repackaging	2.3	4.3	Surface water	6.5E−03	1.2E−02	1	TRI
	18	3,559	Fugitive air	5.1E−02	10	22	TRI
	1.6	999	Fugitive air	4.6E−03	2.8	89	NEI
	21	1,970	Stack air	5.9E−02	5.6	24	TRI
	23	1,127	Stack air	7.4E−02	3.2	89	NEI
	2.3	6.8	Land	6.5E−03	1.9E−02	2	TRI
Processing as a reactant	2.3	21	Surface water	6.5E−03	6.0E−02	4	TRI
	1.2	6.3	POTW	3.5E−03	1.8E−02	3	TRI
	0.5	0.5	WWT	1.3E−03	1.3E−03	1	TRI
	64	1,778	Fugitive air	0.18	5.08	54	TRI
	49	2,986	Fugitive air	0.13	8.2	70	NEI
	94	4,419	Stack air	0.27	13	53	TRI
	54	3,632	Stack air	0.15	10	70	NEI
	0.69	207	Land	2.0E−03	0.59	13	TRI

Occupational Exposure Scenario (OES)	Estimated Annual Release Range across Sites (kg/site-yr)		Type of Discharge [b], Air Emission [c], or Transfer for Disposal [d]	Estimated Daily Release Range across Sites (kg/site-day) [e]		Number of Facilities	Source(s) [g]
	Central Tendency	High-End [a]		Central Tendency	High-End		
Processing – incorporation into formulation, mixture, or reaction product	7.7	8.8	Surface water	3.1E−02	3.5E−02	2	TRI
	1.4	2.5	POTW	5.4E−03	1.0E−02	2	TRI
	79	120	WWT	0.32	0.48	1	TRI
	10	712	Fugitive air	4.0E−02	2.8	47	TRI
	3.9	282	Fugitive air	1.5E−02	0.89	153	NEI
	56	1,349	Stack air	0.22	5.4	49	TRI
	12	455	Stack air	3.7E−02	1.2	153	NEI
	27	1.0E04	Land	0.11	40	4	TRI
Plastics and rubber compounding	22	51	Surface water	7.5E−02	0.17	4	TRI
	2.3	266	WWT	7.6E−03	0.89	3	TRI
	635	8,385	Fugitive air	2.1	28	31	TRI
	453	8,048	Fugitive air	1.7	22	65	NEI
	903	1.7E04	Stack air	3.0	56	33	TRI
	142	9,294	Stack air	0.43	33	65	NEI
	49	366	Land	0.16	1.2	7	TRI
Plastics and rubber converting	113	215	Fugitive air	0.38	0.72	1	TRI
	0.57	18	Fugitive air	1.9E−03	7.3E−02	76	NEI
	113	215	Stack air	0.38	0.72	2	TRI
	6	46	Stack air	1.9E−02	0.14	76	NEI
	113	113	Land	0.38	0.38	1	TRI
Use of laboratory chemicals	6.4E−02	6.3	Fugitive air	2.6E−04	2.5E−02	5	NEI
	37	53	Stack air	0.1	0.14	5	NEI
Application of paints and coatings	0.2	31	Fugitive air	5.7E−04	0.12	28	NEI
	13	370	Stack air	4.4E−02	1.1	28	NEI

Occupational Exposure Scenario (OES)	Estimated Annual Release Range across Sites (kg/site-yr)		Type of Discharge [b], Air Emission [c], or Transfer for Disposal [d]	Estimated Daily Release Range across Sites (kg/site-day) [e]		Number of Facilities	Source(s) [g]
	Central Tendency	High-End [a]		Central Tendency	High-End		
Application of adhesives and sealants	108	108	Stack air	0.41	0.43	1	NEI
	19	205	Fugitive or stack air	0.11	1.0	2–299,581 generic sites	Environ-mental release modeling
	589	2,878	Incineration or landfill	2.7	15		
	2.7E04	1.2E05	Air, incineration, or landfill	124	631		
Recycling	5.2	11	Surface water	1.5E−02	3.1E−02	2	TRI
	20	160	Fugitive air	5.8E−02	0.46	9	TRI
	20	183	Fugitive air	5.8E−02	1.3E−02	7	NEI
	13	475	Stack air	3.6E−02	1.4	11	TRI
	3.9	459	Stack air	1.3E−02	1.3	7	NEI
	1.6E−04	1.6E−04	Land	4.6E−07	4.6E−07	1	TRI
Waste handling, disposal, and treatment	4.5E−02	3.6	Fugitive air	1.8E−04	1.4E−02	6	TRI
	0.54	20	Fugitive air	1.5E−03	7.8E−02	282	NEI
	1.7E−01	113	Stack air	6.9E−04	0.45	6	TRI
	1.4E−03	0.42	Stack air	5.4E−06	1.7E−03	282	NEI
	5,781	6,226	Land	23	25	2	TRI
Distribution in Commerce	N/A [f]						

[a] "High-end" are defined as 95th percentile releases
[b] Direct discharge to surface water and indirect discharges to WWT or POTW are included
[c] Emissions via fugitive air; stack air; or treatment via incineration
[d] Transfer to surface impoundment, land application, or landfills
[e] Where available, EPA used peer-reviewed literature (*e.g.*, Generic Scenarios (GSs) or Emission Scenario Documents (ESDs) to provide a basis to estimate the number of release days of 1,3-butadiene within an OES.
[f] While EPA considers distribution of commerce activities such as loading and unloading as part of each use' OES, EPA also reviewed NRC data and DOT data for the 2016–2021 calendar years for incident reports pertaining to distribution of 1,3-butadiene (DOT Hazmat Incident Report Data, (NRCe, 2009)).
[g] TRI data from years 2016–2021, and NEI data from years 2017 and 2020

4.1.1.2 Weight of Scientific Evidence Conclusions for Environmental Releases from Industrial and Commercial Sources

Table 4-2 summarizes the weight of scientific evidence ratings for each media of release for each OES. For more detail, see the *Draft Environmental Releases and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2024y).

Table 4-2. Summary of the Weight of Scientific Evidence Ratings for Environmental Releases

Occupational Exposure Scenario (OES)	Release Media	Reported Data[a]	Data Quality Ratings for Reported Data	Modeling	Data Quality Ratings for Modeling[b]	Weight of Scientific Evidence Conclusion
Manufacturing	Surface water	✓	H	×	N/A	Moderate to Robust
	Fugitive air (NEI)	✓	M	×	N/A	
	Fugitive air (TRI)	✓	H	×	N/A	
	Stack air (NEI)	✓	M	×	N/A	
	Stack air (TRI)	✓	H	×	N/A	
	Land	✓	H	×	N/A	
Repackaging	Surface water	✓	H	×	N/A	Moderate to Robust
	Fugitive air (NEI)	✓	M	×	N/A	
	Fugitive air (TRI)	✓	H	×	N/A	
	Stack air (NEI)	✓	M	×	N/A	
	Stack air (TRI)	✓	H	×	N/A	
	Land	✓	H	×	N/A	
Processing as a reactant	Surface water	✓	H	×	N/A	Moderate to Robust
	Fugitive air (NEI)	✓	M	×	N/A	
	Fugitive air (TRI)	✓	H	×	N/A	
	Stack air (NEI)	✓	M	×	N/A	
	Stack air (TRI)	✓	H	×	N/A	
	Land	✓	H	×	N/A	
Processing – incorporation into formulation, mixture, or reaction product	Surface water	✓	H	×	N/A	Moderate to Robust
	Fugitive air (NEI)	✓	M	×	N/A	
	Fugitive air (TRI)	✓	H	×	N/A	
	Stack air (NEI)	✓	M	×	N/A	
	Stack air (TRI)	✓	H	×	N/A	
	Land	✓	H	×	N/A	
Plastics and rubber compounding	Surface water	✓	H	×	N/A	Moderate to Robust
	Fugitive air (NEI)	✓	M	×	N/A	
	Fugitive air (TRI)	✓	H	×	N/A	
	Stack air (NEI)	✓	M	×	N/A	
	Stack air (TRI)	✓	H	×	N/A	
	Land	✓	H	×	N/A	
Plastics and rubber converting	Surface water	✓	H	×	N/A	Moderate to Robust
	Fugitive air (NEI)	✓	M	×	N/A	
	Fugitive air (TRI)	✓	H	×	N/A	

Occupational Exposure Scenario (OES)	Release Media	Reported Data[a]	Data Quality Ratings for Reported Data	Modeling	Data Quality Ratings for Modeling[b]	Weight of Scientific Evidence Conclusion
	Stack air (NEI)	✓	M	×	N/A	
	Stack air (TRI)	✓	H	×	N/A	
	Land	✓	H	×	N/A	
Use of laboratory chemicals	Fugitive air (NEI)	✓	M	×	N/A	Moderate
	Stack air (NEI)	✓	M	×	N/A	
Application of paints and coatings	Fugitive air (NEI)	✓	M	×	N/A	Moderate
	Stack air (NEI)	✓	M	×	N/A	
Application of adhesives and sealant	Stack air (NEI)	✓	M	✓	N/A	Moderate
	Fugitive or stack air	×	N/A	✓	M	
	Incineration or landfill	×	N/A	✓	M	
	Air, incineration, or landfill	×	N/A	✓	M	
Recycling	Surface Water	✓	H	×	N/A	Moderate to Robust
	Fugitive Air (NEI)	✓	M	×	N/A	
	Fugitive Air (TRI)	✓	H	×	N/A	
	Stack Air (NEI)	✓	M	×	N/A	
	Stack Air (TRI)	✓	H	×	N/A	
	Land	✓	H	×	N/A	
Waste handling, disposal, and treatment	Surface water		–		–	Moderate to Robust
	Fugitive Air (NEI)	✓	M	×	N/A	
	Fugitive Air (TRI)	✓	H	×	N/A	
	Stack Air (NEI)	✓	M	×	N/A	
	Stack Air (TRI)	✓	H	×	N/A	
	Land	✓	H	×	N/A	

[a] Reported data includes data obtained from EPA databases (*i.e.*, TRI, NEI).
[b] Data quality ratings for models include ratings of underlying literature sources used to select model approaches and input values/distributions such as a GS/ESD used in tandem with Monte Carlo modeling.

4.2 Summary of Concentrations of 1,3-Butadiene in the Environment

4.2.1 Environmental Exposure Scenarios

4.2.1.1 Air Pathway

EPA searched peer-reviewed literature for air monitoring and environmental sampling studies, as well as databases to obtain concentrations of 1,3-butadiene in air. EPA found measured data on 1,3-butadiene in ambient air, indoor air, landfill gas and personal exposure monitoring samples from peer reviewed studies through systematic review. For ambient air, concentrations from five U.S. studies ranged from 0.01 to 1.91 µg/m^3. In addition, monitoring data were extracted from EPA's Ambient Monitoring

Technology Information Center (AMTIC) database where 24-hour concentrations ranged from 0.0 to 122.8 µg/m^3. For more details, see *Draft Environmental Media Concentrations for 1,3-Butadiene* (U.S. EPA, 2024p). Based on the physical and chemical properties, and concentrations reported from databases and scientific literature, a quantitative exposure assessment was conducted for the ambient air pathway for general population. See Section 5.1.3.1 for more details.

4.2.1.2 Surface Water and Sediment Pathway

The Water Quality Portal (WQP) (NWQMC, 2022) is a publicly available resource which integrates water quality data from the USGS National Water Information System (NWIS) (USGS, 2013) and the EPA Water Quality Exchange (WQX) Data Warehouse (U.S. EPA, 2019c). The NWIS database contains current and historical water data from more than 1.5 million sites across the nation. The WQX is the EPA's repository of water quality monitoring data collected by water resource management groups across the country. The complete set of 1,3-butadiene monitoring results for surface water stored in the Water Quality Portal (WQP) (NWQMC, 2022) was retrieved in January 2024. Without exception, all surface water samples reported 1,3-butadiene concentrations below the minimum detection limit (MDL). Based on the low reported releases to surface water (see *Draft Environmental Release and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2024y)), the low solubility in water of 735 mg/L (NLM, 2003), high volatility from water, low estimated organic carbon:water partition coefficient (Koc) value of 54 (U.S. EPA, 2012c) and WQP data reporting 1,3-butadiene concentrations for all surface water samples below the minimum detection limit (MDL), EPA has decided not to conduct a quantitative assessment of exposure for surface water or sediment. For more details, see *Draft Environmental Media Concentrations for 1,3-Butadiene* (U.S. EPA, 2024p) and *Draft Water Quality Portal (WQP) Monitoring Data 2011 to 2023 for 1,3-Butadiene* (U.S. EPA, 2024ad).

4.2.1.3 Drinking Water Pathway

Public water systems (PWSs) are regulated under the Safe Drinking Water Act (SDWA)[3] to enforce common standards for drinking water across the country. To assess concentrations of 1,3-butadiene in water known to be distributed as drinking water, monitoring data collected by PWSs were evaluated. Concentrations of 1,3-butadiene found in finished (*i.e.*, treated) drinking water were collected from the EPA's published Third Unregulated Contaminant Monitoring Rule (UCMR3)[4] data set, which includes samples collected between 2013 to 2015 (U.S. EPA, 2017b). Based on the physical and chemical properties of 1,3-butadiene (*i.e.*, its low water solubility and high tendency to volatilize from water as well as UCMR3 data showing that 1,3-butadiene is not detected in drinking water), EPA has decided not to conduct a quantitative assessment of exposure for drinking water. For more details, see *Draft Environmental Media Concentrations for 1,3-Butadiene* (U.S. EPA, 2024p).

4.2.1.4 Land Pathway

The complete set of 1,3-butadiene monitoring results for groundwater stored in the Water Quality Portal (WQP) (NWQMC, 2022) was retrieved in January 2024. The WQP data indicated less than 1 percent detection frequency in groundwater. Based on the low volume of releases to land (see *Draft Environmental Release and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2024y)), the low risk of failure of the predominant release scenario (see *Draft Environmental Media Concentrations for 1,3-Butadiene* (U.S. EPA, 2024p)), the physical and chemical properties of 1,3-butadiene (see *Draft Chemistry, Fate and transport Assessment for 1,3-Butadiene* (U.S. EPA, 2024z)) as well as monitoring data indicating less than 1 percent detection frequency in groundwater (NWQMC, 2022), EPA did not perform a quantitative analysis for the land pathway because exposure to the general population is not expected to occur. For more details, see *Draft Environmental Media Concentrations*

[3] See https://www.epa.gov/sdwa for more information.
[4] See https://www.epa.gov/dwucmr/third-unregulated-contaminant-monitoring-rule for more information.

for 1,3-Butadiene (U.S. EPA, 2024p), *Draft Chemistry, Fate and transport Assessment for 1,3-Butadiene* (U.S. EPA, 2024z) and *Draft Water Quality Portal (WQP) Monitoring Data 2011 to 2023 for 1,3-Butadiene* (U.S. EPA, 2024ad).

4.2.2 Weight of Scientific Evidence Conclusions for Environmental Concentrations

Based on the physical and chemical properties of 1,3-butadiene (*i.e.*, high volatility, low solubility, and low sorption tendencies) (U.S. EPA, 2024z), the low release volume to land and water (U.S. EPA, 2024y) and the minimal detection of 1,3-butadiene in surface and groundwater, EPA has robust confidence that air is the major pathway of exposure for 1,3-butadiene, and that contributions to exposure from the land and water pathways will be infrequent and at low levels. As a result, air is the only pathway that will be assessed quantitatively.

For regions where monitoring data are available, EPA has robust confidence in the overall characterization of environmental media concentrations for 1,3-butadiene as it relies upon standard reporting databases with strictly regulated monitoring requirements, such as AMTIC, WQP, and UCMR, and extracted data from peer-reviewed literature that received medium to high-quality ratings from EPA's systematic review process. In addition, states with a concentration of facilities releasing 1,3-butadiene are included in the monitoring databases. Due to the presence of 1,3-butadiene releasing facilities, these states would be expected to have the largest 1,3-butadiene releases. Therefore, EPA has robust confidence in the representativeness of the databases.

5 HUMAN HEALTH RISK ASSESSMENT

1,3-Butadiene – Human Health Risk Assessment (Section 5):
Key Points

EPA evaluated all reasonably available information to support human health risk characterization of 1,3-butadiene for workers, ONUs, consumers, bystanders, as well as the general population exposed to ambient air releases. These exposures are described in Section 0; human health hazards in Section 5.2; and human health risk characterization in Section 5.3.

Occupational Exposure Key Points
- EPA used inhalation monitoring data to evaluated acute, intermediate, and chronic exposures to workers and ONUs for each OES. Where no monitoring data existed relevant to certain OESs, analogous monitoring data were used.
- Due to a robust activity-specific database, EPA has high confidence that risk estimates derived from central tendency values are reflective of real-world workplace exposures.
- Inhalation exposures to 1,3-butadiene from most industrial and commercial OES are expected to be low, with the exception of the repackaging and laboratory use OESs.
- Uncertainty is introduced to the exposure assessment due to lack of directly applicable quantifiable monitoring data for certain OESs, thus leading to the use of analogous monitoring data, and in site-specific differences in use practices and engineering controls.

Consumer Exposure Key Points
- Based on product searches and systematic review data, EPA has determined that 1,3-butadiene, a monomer incorporated into polymer-derived products such as synthetic rubbers and adhesives or sealants, are stable in consumer products and not expected to degrade and expose the consumer to the 1,3-butadiene monomer.

General Population Exposure Key Points
- EPA used HEM to model exposures to the general population from industrial releases to ambient air reported to TRI for 2016–2021.
- Concentrations from industrial releases of 1,3-butadiene that can be attributed to COUs based on modeling at discrete distances from releasing points range from 0.0–383.4 µg/m³ with highest concentrations attributed to manufacturing and processing related to OESs/COUs.

Hazard Key Points
- The human equivalent concentration (HEC) to be used for risk estimation of intermediate and chronic exposures is 2.5 ppm (5.5 mg/m^3) based on reduced fetal body weight in mice with a total uncertainty factor of 30.
- The chronic occupational unit risk (UR) to be used for subsequent risk estimation of cancer to workers is 0.0062 per ppm (2.8×10^{-6} per µg/m^3) based on leukemia in a large cohort of human workers. EPA notes that the occupational UR was corrected late in the draft risk evaluation process; the corrected UR is 0.0049 per ppm (2.2×10^{-6} per µg/m^3).
- Due to the mutagenic mode of action, the general population inhalation unit risk (IUR) is 0.0098 per ppm (4.4×10^{-6} per µg/m^3) based on incorporation of age-dependent adjustment factors to account for exposed younger lifestages.

Risk Assessment Key Points
- Occupational scenarios
  - Non-routine laboratory technician activities represent the highest risk among OESs across COUs. Non-cancer margin of exposure (MOE) risk estimates were 0.31 at high-end exposure and 4.5 at central tendency exposure (compared to benchmark of 30, lower is higher risk). Extra cancer risks estimates were 1.0×10^{-3} at the central tendency exposure.
  - For Manufacturing and Importing COUs, non-cancer MOE risk estimates were as low as 4.6 and extra cancer risk estimates were as high as 1.0×10^{-3} at the central tendency exposure for both workers and ONUs.
  - For OESs in Processing COUs, excluding risks from laboratory technician non-routine activities, non-cancer MOE risk estimates were as low as 24 and extra cancer risks estimates were as high as 1.7×10^{-5} at the central tendency exposure.
  - For OESs in Disposal COU, non-cancer MOE risk estimates were as low as 22 and extra cancer risks estimates were 1.3×10^{-4} at the central tendency exposure.
- General Population Exposed to Environmental Releases
  - There were no non-cancer MOEs below the benchmark of 30.
  - Based on distance modeling results and the 95th percentile modeled concentrations, cancer risks were as high as 4.1×10^{-4} , 6.0×10^{-5} and 2.1×10^{-5} at the 100, 100–1,000 m, and 1,000 m distances, respectively, across all TRI 2016–2021 reporting years with Processing – plastics and rubber compounding COU/OES resulting in the highest risks.
  - The estimated cancer risks across all census blocks for the same reporting years ranged from 0 to 7.4×10^{-5} with Manufacture – manufacturing COU-OES as the highest attributor among all the COUs-OESs followed by Processing – processing as a reactant and then Processing – plastics and rubber compounding COUs-OESs
  - Based on geospatial analysis, elevated cancer risks are concentrated along the Gulf Coast region from TX to LA.

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5.1 Summary of Human Exposures

5.1.1 Occupational Exposures

5.1.1.1 Summary of Occupational Exposure Assessment

EPA's general approach for estimating occupational exposures and the specific basis for each estimate is discussed in the *Draft Environmental Releases and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2024y). Table 5-1 summarizes the occupational inhalation exposure results for each OES. EPA used inhalation monitoring data to evaluate acute, intermediate, and chronic exposures to workers and ONUs for each OES. Where no monitoring data existed relevant to certain OESs, analogous monitoring data were used. Analogous monitoring data refer to data from the same chemical but for a different yet similar activity or OES. Inhalation exposures to 1,3-butadiene from most industrial and commercial OESs are expected to be rather low, except for the repackaging and laboratory use OES. Dermal exposure was not assessed for 1,3-butadiene due to the volatility and transport method of the chemical.

Exposures were not quantified for commercial use of fuels and related products. Occupational exposures from liquid petroleum gas connections, cylinder leaks, and incomplete combustion are expected to be minimal. Exposures were also not quantitatively assessed for the commercial COUs covered by the OES of Use of plastics and rubber products and Use of lubricants and greases. Reasonably available evidence suggests that 1,3-butadiene monomer does not exist at concentrations above 6.6 ppm in rubber products or above quantifiable levels in lubricants and greases. Any 1,3-butadiene indicated in SDSs or other product reports likely referred either to upstream steps or to reacted polymeric forms.

Table 5-1. Summary of Occupational Inhalation Exposure Results by Occupational Exposure Scenarios

<table>
<tr><th rowspan="2">Occupational Exposure Scenario (OES)</th><th rowspan="2">Worker Description</th><th rowspan="2">Exposure Days (day/yr)</th><th colspan="2">Worker Inhalation Estimates (ppm)</th><th colspan="2">ONU Inhalation Estimates (ppm)</th><th rowspan="2">Sources/Notes</th></tr>
<tr><th>High-End</th><th>Central Tendency</th><th>High-End</th><th>Central Tendency</th></tr>
<tr><td rowspan="7">Manufacturing</td><td>Infrastructure/ distribution operations</td><td>250</td><td>0.45</td><td>2.5E−02</td><td rowspan="7">1.7E−02</td><td rowspan="7">8.0E−03</td><td rowspan="7">ToxStrategies (2021) data for manufacturing and processing facilities</td></tr>
<tr><td>Instrument and electrical</td><td>250</td><td>0.16</td><td>2.0E−02</td></tr>
<tr><td>Laboratory technician</td><td>250</td><td>0.24</td><td>2.5E−02</td></tr>
<tr><td>Machinery and specialists' group</td><td>250</td><td>0.28</td><td>6.0E−03</td></tr>
<tr><td>Maintenance technician</td><td>250</td><td>0.23</td><td>0.15</td></tr>
<tr><td>Operations onsite</td><td>250</td><td>0.2</td><td>2.0E−02</td></tr>
<tr><td>Safety, health, and engineering</td><td>250</td><td>0.36</td><td>3.8E−02</td></tr>
<tr><td>Processing – repackaging</td><td>–</td><td>26–128</td><td>15</td><td>1.1</td><td colspan="2">1.1</td><td>Used analogous data from loading/unloading during manufacturing and processing. ONU data not available; used the central tendency from worker estimates.</td></tr>
<tr><td rowspan="7">Processing as a reactant</td><td>Infrastructure/ distribution operations</td><td>250</td><td>0.45</td><td>2.5E−02</td><td rowspan="7">1.7E−02</td><td rowspan="7">8.0E−03</td><td rowspan="7">ToxStrategies (2021) data for manufacturing and processing facilities</td></tr>
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<tr><td>Operations onsite</td><td>250</td><td>0.2</td><td>2.0E−02</td></tr>
<tr><td>Safety, health, and engineering</td><td>250</td><td>0.36</td><td>3.8E−02</td></tr>
</table>

Occupational Exposure Scenario (OES)	Worker Description	Exposure Days (day/yr)	Worker Inhalation Estimates (ppm)		ONU Inhalation Estimates (ppm)		Sources/Notes
			High-End	Central Tendency	High-End	Central Tendency	
Processing – incorporation into formulation, mixture, or reaction product	Infrastructure/ distribution operations	250	0.45	2.5E−02	1.7E−02	8.0E−03	ToxStrategies (2021) data for manufacturing and processing facilities
	Instrument and electrical	250	0.16	2.0E−02			
	Laboratory technician	250	0.24	2.5E−02			
	Machinery and specialists' group	250	0.28	6.0E−03			
	Maintenance technician	250	0.23	0.15			
	Operations onsite	250	0.2	2.0E−02			
	Safety, health, and engineering	250	0.36	3.8E−02			
Plastics and rubber compounding	–	250	0.3	3.0E−02	3.0E−02		Based on NIOSH/OSHA data. ONU data not available; used the central tendency from worker estimates.
Plastics and rubber converting	–	250	0.3	2.0E−02	2.0E−02		Based on NIOSH/OSHA data.
Use of laboratory chemicals	Laboratory technician	174–250	9.0E−02	6.0E−02	1.7E−02	8.0E−03	Used analogous data from manufacturing/processing (laboratory technicians).
Application of paints, coatings, adhesives, and sealants	–	250	9.0E−02	5.0E−02	5.0E−02		Based on NIOSH/OSHA data. All values were below the LOD. Used LOD for the HE and LOD/2 for CT. ONU data not available; used the central tendency from worker estimates.
Recycling	–	250	1.3	0.23	0.23		Used analogous data from waste handling activities during manufacturing / processing. ONU data not available; used the central tendency from worker estimates.
Waste handling, treatment, and disposal	–	250	1.3	0.23	0.23		Used analogous data from waste handling activities during manufacturing / processing. ONU data not available; used the central tendency from worker estimates.
NIOSH = National Institute for Occupational Safety and Health; OSHA = Occupational Safety and Health Administration							

5.1.1.2 Weight of Scientific Evidence Conclusions for Occupational Exposure

EPA used 1,3-butadiene monitoring data that were either directly applicable to each scenario or from another comparable scenario as analogous. The use of monitoring data is preferable to other assessment approaches such as modeling or the use of occupational exposure limits (OELs). EPA used personal breathing zone (PBZ) air concentration data to assess inhalation exposures, with the data source for the data used in the majority of scenarios having a high data quality rating from the systematic review process (ToxStrategies, 2021).

The primary limitations to these data include: the uncertainty of the representativeness of the data for scenarios to which the data is used as analogous, and the fact that much of the data for both workers and ONUs from the source were reported as below the LOD. EPA also assumed 250 exposure days per year in each case. Exposure days are assumed to be the same as operating days, but with a maximum of 250 days because EPA assumed that a single worker would not work more than 250 days per year. However, it is uncertain whether this captures actual worker schedules and exposures.

In Table 5-2, EPA summarizes the weight of scientific evidence ratings for the occupational exposures for each OES. The Agency has the highest confidence (moderate to robust) in Manufacturing and processing (for which most of the monitoring data was based) along with Plastic and rubber converting. The lowest confidence is for Application of paints/coatings and Application of adhesives/sealants (slight to moderate), for which all monitored values fell below the LOD. Other OESs were moderate and primarily used analogous data from manufacturing/processing. For more detail, see *the Draft Environmental Releases and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2024y).

Table 5-2. Summary of the Weight of Scientific Evidence Ratings for Occupational Exposures

Occupational Exposure Scenario (OES)	Inhalation Exposure												
	1,3-Butadiene Monitoring					Analogous Monitoring[a]					Modeling		WOSE Conclusion
	Worker	# Data Points	ONU	# Data Points	Overall Quality Determin.	Worker	# Data Points	ONU	# Data Points	Overall Quality Determin.	Worker	ONU	
Manufacturing	✓	3,532	✓	39	H	×	N/A	×	N/A	N/A	×	×	Moderate to Robust
Repackaging	×	N/A	×	N/A	N/A	✓	158	×	0	H	×	×	Moderate
Processing as a reactant	✓	3,532	✓	39	H	×	N/A	×	N/A	N/A	×	×	Moderate to Robust
Processing – incorporation into formulation, mixture, or reaction product	✓	3,532	✓	39	H	×	N/A	×	N/A	N/A	×	×	Moderate to Robust
Plastic and rubber compounding	×	N/A	×	N/A	N/A	✓	53	×	0	M-H	×	×	Moderate
Plastic and rubber converting	✓	53	×	0	M-H	×	N/A	×	N/A	N/A	×	×	Moderate to Robust
Use of lab chemicals	×	N/A	×	N/A	N/A	✓	215	✓	39	H	×	×	Moderate
Application of paints and coatings	✓	43	×	0	M	×	N/A	×	N/A	N/A	×	×	Slight to Moderate
Application of adhesives and sealants	✓	43	×	0	M	×	N/A	×	N/A	N/A	×	×	Slight to Moderate
Recycling	×	N/A	×	N/A	N/A	✓	10	×	0	H	×	×	Moderate
Waste handling, disposal, and treatment	×	N/A	×	N/A	N/A	✓	10	×	0	H	×	×	Moderate

WOSE = weight of scientific evidence
[a] "Analogous data" refers to data from the same chemical and similar OESs.

5.1.2 Consumer Exposures

5.1.2.1 Summary of Consumer Exposure Assessment

According to reports in the 2016 CDR, the use of plastic and rubber products, including synthetic rubbers, were identified as consumer conditions of use for 1,3-butadiene. EPA qualitatively assessed whether consumers using or disposing of plastic and rubber products may be exposed to 1,3-butadiene through vapor emissions which may lead to inhalation exposure, given its volatility at room temperature. And, in addition, whether bystanders present during the consumer use or disposal of 1,3-butadiene plastic and rubber products may also be exposed to vapor emissions leading to an inhalation exposure.

Based on product searches and data identified from systematic review (U.S. EPA, 2024ac, 2019d), EPA has determined that 1,3-butadiene, a monomer used in polymer-derived consumer products such as synthetic rubbers, is stable in these products and not expected to degrade and expose the consumer to the 1,3-butadiene monomer. These polymers include but are not limited to, acrylonitrile-butadiene-styrene (ABS) resins and styrene-butadiene rubber (SBR).

Residual butadiene concentrations in polymers and downstream concentrations are very low and often not detectable. Processing of synthetic polymers into rubber or plastic products further reduces any remaining residual butadiene resulting in minimal to no potential end-user exposures (EPA-HQ-OPPT-2018-0451-0041). Also, since 1,3-butadiene is a highly volatile vapor at room temperature, oral and dermal exposures to 1,3-butadiene during consumer use of plastic and rubber products are not expected (ECHA, 2019). Based on this, consumer products or articles containing 1,3-butadience are not quantitatively assessed in this draft risk evaluation.

5.1.3 General Population Exposures to Environmental Releases

EPA expects the ambient air pathway to be the predominant human exposure pathway to 1,3-butadiene in the outdoor environment. 1,3-Butadiene is released from industrial facilities as uncontrolled fugitive releases (*e.g.*, process equipment leaks, process vents, building windows, building doors, roof vents) and stack releases that may be either uncontrolled (*e.g.*, direct releases out a stack) or controlled with a pollution control device (*e.g.*, baghouse, scrubber, thermal oxidizer). Once released to the ambient air, 1,3-butadiene may move off-site into the surrounding areas where the general population may be exposed through inhalation.

5.1.3.1 Summary of General Population Exposure Assessment

Based on the fate assessment for 1,3-butadiene, the monitored concentrations from the AMTIC database (U.S. EPA, 2022b), and the measured concentrations identified through systematic review (U.S. EPA, 2024p), EPA conducted a quantitative assessment for ambient air exposure to the general population. Ambient air concentrations of 1,3-butadiene based on facility releases from the TRI 2016-2021 reporting years were modeled using a tiered approach with the Integrated Indoor-Outdoor Air calculator (IIOAC) as a screening tool and followed by the HEM for refined modeling. EPA assumed that the general population is exposed to modeled ambient air concentrations 24 hours a day, 365 days a year over a lifetime. Therefore, exposure concentrations were equal to ambient air concentrations.

The 95th percentile modeled results from IIOAC for ambient concentrations living near industrial facilities (within 100–1,000 m [0.062–0.62 miles]) releasing 1,3-butadiene to the ambient air ranged from 0.0 to 109.5 µg/m^3, with the highest concentrations modeled at 100 m from facility releases. Since IIOAC 95th and 50th modeled concentrations resulted in corresponding risk estimates at or above the cancer risk benchmark at 1,000 m from facility releases, EPA proceeded with refined modeling using the HEM. The 95th percentile modeled results from HEM ranged from 0.0 to 91.2 µg/m³ for populations living within 100 to 1,000 m (0.062–0.62 miles) from industrial facilities releasing 1,3-butadiene. For all distances modeled with HEM (10–50,000 m, or 0.006 to 31.06 miles), the 95th percentile modeled concentration ranged from 0.0 to 383.4 µg/m³ with the highest concentrations modeled within the first 30 to 60 m away from facility releases. See the *Draft General Population Exposures for 1,3-Butadiene* (U.S. EPA, 2024r) for the assessment.

5.1.3.2 Weight of Scientific Evidence Conclusions for General Population Exposure

EPA has robust confidence in the overall characterization of exposures for this ambient air exposure assessment as it relies upon direct reported releases from databases that received a high-quality rating from EPA's systematic review process and peer-reviewed models to estimate ambient concentrations at distances from releasing facilities. Use of additional peer-reviewed models (AirToxScreen and HEM) along with monitoring data (AMTIC) to further contextualize ambient air concentrations of 1,3-butadiene, provide added strength and confidence to the approaches and methods used in this draft ambient air exposure assessment. EPA acknowledges that the assumptions made for the general population being exposed to modeled ambient air concentrations 24 hours a day, 365 days a year, over a lifetime contributes uncertainty to the estimates.

The use of reported release data across multiple years of data provides a more comprehensive ambient air exposure assessment and ensure higher release years are not missed. Furthermore, use of actual reported releases minimizes uncertainties around estimated releases using theoretical distributions and provides added confidence that modeled concentrations and exposures are actual and not based in modeling apart from EPA estimated releases for the Adhesives and sealants OES.

5.2 Summary of Human Health Hazard

In alignment with Section 4.2, EPA quantitatively evaluated hazards via the inhalation route; oral and dermal exposure is not expected. Inhalation hazards were assessed through systematic review of reasonably available evidence, which included human epidemiology, laboratory animal toxicology, and mechanistic data (including *in vitro* studies). EPA refined the systematic approach for 1,3-butadiene by reviewing previous authoritative reviews by federal agencies to better target the assessment. To this end, EPA utilized the IRIS *Health Assessment of 1,3-Butadiene* (2002a) and ATSDR *Toxicological Profile for 1,3-Butadiene* (2012) to identify the primary hazards and key studies. Key studies from these assessments were supplemented with both literature that was "filtered" based on whether it was informative for dose-response analysis.

1,3-Butadiene is readily absorbed through the lungs and distributed throughout the body, with higher partitioning to adipose tissue. The primary metabolites are reactive mono- or di-epoxides, which can interact with biomolecules and induce toxicity. Qualitatively, metabolic pathways are identical between mice, rats, and humans. However, they are quantitatively different, with mice producing much greater levels of metabolites, especially di-epoxides. 1,3-Butadiene is primarily eliminated through exhalation, with additional excretion via urination, and individual urinary metabolites corresponding to specific epoxy metabolites and/or pathways. These metabolites are considered to be the source of toxicity, so species-specific toxicokinetic differences can largely influence relative species sensitivity.

EPA began the assessment by focusing on the endpoints and studies considered for deriving hazard values in (U.S. EPA, 2002a) and (ATSDR, 2012). Ovarian atrophy was the basis of the chronic reference concentration (RfC) in (U.S. EPA, 2002a) while (ATSDR, 2012) elected not to derive an inhalation minimum risk level (MRL) due to uncertainty in how to accurately extrapolate the mouse data to humans. Following a mode of action (MOA) analysis, EPA concluded that ovarian atrophy observed in mice is not appropriate for quantitative use in human health risk assessment due to evidence suggesting greatly increased susceptibility in mice and difficulty in confidently quantifying cross-species differences. Instead, EPA determined that three other critical hazard outcomes were appropriate for dose-response analysis. These non-cancer health outcomes were (1) maternal and related developmental toxicity, (2) male reproductive system and resulting developmental toxicity, and (3) hematological and immune effects. 1,3-Butadiene is a potent multi-organ carcinogen in laboratory animals, notably inducing lymphomas in mice and exhibiting greater carcinogenic potential in mice than rats. Epidemiological evidence consistently links occupational 1,3-butadiene exposure to increased mortality from lymphatic and hematopoietic cancers. EPA determined that 1,3-butadiene "is carcinogenic to humans", based primarily on robust human, animal, and mechanistic evidence for lymphohematopoietic cancers, although varying evidence for other cancer types was also identified. Further, the weight of scientific evidence supports a mutagenic mode of action for carcinogenicity.

A hazard value was not derived for acute exposures because it is unlikely any adverse effects will result following a single exposure at concentrations relevant to human exposures. Candidate endpoints for an acute point of departure (POD) from repeat-dose studies were considered but have substantial uncertainties as to whether they are relevant to acute exposures and were also found to be less protective than the intermediate/chronic POD. EPA performed dose-response analysis for multiple repeated-dose non-cancer endpoints under each hazard domain. Decreased fetal weight associated with other developmental toxicity outcomes was selected as the most sensitive and robust human-relevant endpoint for use in risk characterization of intermediate and chronic exposures, with a human equivalent concentration (HEC) of 2.5 ppm (5.5 mg/m^3) derived from benchmark dose modeling following dichotomization of male mouse fetal weight data. All other candidate PODs (germ cell mutation and anemia) were within 2 to 4 times of this value.

EPA used an occupational epidemiological cohort with 50+ years of follow-up and subsequent exposure estimate updates to derive inhalation hazard values for leukemia applicable to general population and occupational exposures. Due to an identified mutagenic mode of action for cancer, EPA applied an age-dependent adjustment factor (ADAF) to the unit risk (UR) for leukemia for the general population to yield the IUR; that is, risk scenarios where children or adolescents under 16 years old may be exposed (U.S. EPA, 2005b). The IUR for general population risk estimation is 0.0098 per ppm (4.4×10^{-6} per µg/m^3) and the chronic unit risk for occupational scenarios applied to adolescent and adult workers 16 years or older is 0.0062 per ppm (2.8×10^{-6} per µg/m^3)[5].

EPA has robust overall confidence in the assessments and associated hazard values for maternal/developmental toxicity and leukemia, which will be used for risk estimation. These confidence ratings were based on the weight of scientific evidence considering evidence integration, selection of the critical endpoint and study, relevance to exposure scenarios, dose-response considerations, and incorporation of PESS.

Full details are provided in the *Draft Human Health Hazard Assessment for 1,3-Butadiene* (U.S. EPA, 2024t).

5.2.1 Weight of Scientific Evidence Conclusions for Human Health Hazard

EPA evaluated the confidence for human health hazard conclusions based on the following factors: evidence integration conclusions, selection of the most critical endpoint and study, relevance to

[5] The occupational unit risk was corrected as described *1,3-Butadiene: Corrected lifetable analyses for leukemia and bladder cancer* (U.S. EPA, 2024a). The corrected occupational unit risk = 0.0049 per ppm (2.2×10^{-6} per µg/m^3) (see also Table 5-3).

exposure scenarios, dose-response considerations, and incorporation of PESS. More details on how EPA evaluated these factors are provided in Section 6 of the *Draft Human Health Hazard Assessment for 1,3-Butadiene* (U.S. EPA, 2024t).

Based on comparison of results from short term studies with intermediate-duration studies, EPA has only indeterminate to slight confidence in any potential health effects following a single exposure at relevant human exposure levels. Intermediate PODs are expected to be protective of acute exposures. Therefore, EPA did not derive an acute POD.

EPA has robust overall confidence for the evidence integration, study/endpoint selection, exposure scenario applicability, dose-response, and PESS sensitivity of the conclusions and PODs for maternal/developmental toxicity**,** including the POD based on reduced fetal weight that will be used for risk estimates.

There is robust human, animal, and mechanistic evidence associating leukemia and other lymphohematopoietic cancers with 1,3-butadiene exposure. An IUR for leukemia was derived from a study incorporating years of updates to a large occupational cohort covering more than 60 years of follow up and a novel lifetable analysis was performed to account for extra risk relative to background population rates. Both men and women were included in the analysis, and an ADAF was applied to incorporate elevated childhood susceptibility due to the mutagenic mode of action and in accordance with EPA guidance (U.S. EPA, 2005b). Based on the above factors, the Agency has robust overall confidence in the hazard assessment for leukemia. EPA did not combine cancer risks from leukemia and bladder due to inconsistent results across publications and concern for smoking as a confounder in the association between bladder cancer and 1,3-butadiene exposure; however, total cancer risk may be underestimated without incorporating other tumor sites.

5.3 Human Health Risk Characterization

5.3.1 Risk Assessment Approach

EPA calculated non-cancer and cancer risk estimates for occupational and general population exposures following intermediate, chronic, and lifetime exposures. Risks were not estimated for acute exposures because sensitive organ-level endpoints are unlikely to result from a single exposure at concentrations relevant to human exposures (see Section 5.2 and the *Draft Human Health Hazard Assessment for 1,3-Butadiene* (U.S. EPA, 2024t)). Table 5-3 presents the scenarios, populations, assumptions, and hazard values used for risk estimation.

Table 5-3. Use Scenarios, Populations of Interest, and Toxicological Endpoints Used for Risk Estimation

Population of Interest and Exposure Scenario	**Workers and Occupational Non-users (ONUs)** EPA estimated risks to workers and ONUs ≥16 years old via inhalation only following intermediate and chronic exposures.
	General Population Exposed to Environmental Releases EPA estimated risks to the general population of any lifestage living near facilities releasing 1,3-butadiene into the environment via inhalation only following chronic or lifetime exposure. [a]
Health Effects, Hazard Values and Uncertainty Factors	**Non-cancer POD for Intermediate and Chronic Risk Estimates** HEC = 2.5 ppm (5,500 µg/m^3) based on decreased fetal weight • Adjusted for continuous exposure (24 hr/day, 7 days/week) *Benchmark MOE* = 30 (3x UF_A × 10x UF_H)
	Cancer Hazard Values for Chronic and Lifetime Cancer Risk Estimates Occupational unit risk = 0.0062 per ppm (2.8×10^{-6} per µg/m^3)[b] for leukemia • Adjusted for continuous (24 hr/day, 7 days/week) exposure and resting breathing rate (20 m^3/day); Used for estimating risks to workers ≥16 years old. General population IUR (ADAF-adjusted) = 0.0098 per ppm (4.4×10^{-6} per µg/m^3) • Only for estimating risks to the general population where individuals <16 years old may be exposed.

UF_A = interspecies uncertainty factor; UF_H = intraspecies uncertainty factor.
[a] EPA conservatively assumes that the general population may be exposed for the entirety of their lifetime. Therefore, general population chronic and lifetime exposures are equivalent.
[b] The occupational unit risk was corrected as described in *1,3-Butadiene: Corrected Lifetable Analyses for Leukemia and Bladder Cancer* (U.S. EPA, 2024a). The corrected occupational unit risk = 0.0049 per ppm (2.2×10^{-6} per µg/m^3)

5.3.1.1 Non-cancer Risk Calculations

EPA used a margin of exposure (MOE) approach to estimate non-cancer risks. The MOE is the ratio of the non-cancer hazard value (or POD) divided by a human exposure dose. The chronic MOEs for non-cancer inhalation risks were calculated using Equation 5-1

Equation 5-1. Margin of Exposure Calculation

$$MOE = \frac{Non - cancer\ Hazard\ Value\ (POD)}{Human\ Exposure}$$

Where:

MOE	=	Margin of exposure for intermediate or chronic risk estimation (unitless)
Non-cancer Hazard Value (POD)	=	Human equivalent concentration (HEC, µg/m^3)
Human Exposure	=	Exposure estimate (µg/m^3)

MOE risk estimates are compared to benchmark MOEs. Benchmark MOEs are the product of all uncertainty factors for each non-cancer POD. The MOE estimate is interpreted as a human health risk of concern if the MOE estimate is less than the benchmark MOE (*i.e.*, the total uncertainty factor). The larger the MOE, the more unlikely it is that a non-cancer adverse effect will occur. When determining whether a chemical substance presents unreasonable risk to human health or the environment, calculated risk estimates are not "bright-line" indicators of unreasonable risk, and EPA has the discretion to consider other risk-related factors in addition to risks identified in the risk characterization.

Non-cancer hazard values were based on data from laboratory animal toxicology studies. The POD, reduced fetal body weight, is protective of other non-cancer endpoints, particularly germ cell mutations (target organ: spermatids and spermatozoa) and anemia which yielded similar POD values, after 10 and 40 weeks of exposure, respectively. In deriving HECs, EPA adjusted for dosimetry and continuous exposure duration in accordance with guidance documents (U.S. EPA, 2012a, 1994). The dosimetric impact of relative breathing rate was also considered when calculating risk estimates because increased breathing rate results in elevated internal dose/ concentration. Therefore, occupational exposure was adjusted upward based on the relative ratio of occupational vs. general population breathing rates. The default breathing rate is 0.6125 m^3/hr (based on the average of mean long-term inhalation rates for adult males and females combined aged 21–81 years), while the occupational breathing rate is 1.25 m^3/hr (corresponding to light activity level) from (U.S. EPA, 2011). Occupational exposures were then adjusted as time-weighted averages (TWAs) over continuous exposure (30 days for intermediate, 365 days for chronic) for direct comparison to the HEC.

5.3.1.2 Cancer Risk Calculations

Extra cancer risks for repeated exposures to a chemical were estimated using Equation 5-2.

Equation 5-2. Extra Lifetime Cancer Risk Calculation

$$Lifetime\ Cancer\ Risk = Human\ Exposure \times IUR/UR$$

Where:

Human Exposure	=	Exposure estimate (LADC in ppm or µg/m^3; LADD in mg/kg-day)
IUR/UR	=	Inhalation or Occupational Unit Risk; risk per unit of exposure (ppm or µg/m^3)

Consistent with NIOSH guidance , under TSCA EPA typically applies a 1×10^{-4} benchmark for occupational scenarios in industrial and commercial work environments subject to OSHA requirements. EPA typically considers the general population and consumer benchmark for cancer risk to be within the range of 1×10^{-4} to 1×10^{-6}. Again, it is important to note that these benchmarks are not bright lines and EPA has discretion to find unreasonable risks based on other risk-related considerations based on analysis. Exposure-related considerations (*e.g.*, duration, magnitude, population exposed) can affect EPA's estimates of the excess lifetime cancer risk.

The general population IUR was adjusted for continuous ambient exposure by the default occupational ventilation rate and for the intermittent work week schedule (U.S. EPA, 1994). Because the IUR was derived from an occupational cohort study, the value was adjusted for continuous exposure by the general population (10 m^3/day and 240 days/year to 20 m^3/day and 365 days/year). The general population IUR was applied to general population risks because populations living near a release site may be exposed from birth. The chronic occupational unit risk is the cancer hazard value derived from the study cohort without ADAF applied because workers and ONUs are assumed to be at least 16 years old. As with non-cancer risks, occupational exposures were adjusted as time-weighted averages over continuous exposure (365 days, 78 years for lifetime exposures) for direct comparison to the UR.

5.3.2 Risk Estimates for Workers

Occupational risk estimates utilized monitoring exposure measurements from workplace inhalation monitoring data collected by government agencies such as OSHA and NIOSH, monitoring data found in published literature (*i.e.*, personal exposure monitoring data and area monitoring data), and monitoring data submitted via public comments EPA-HQ-OPPT-2018-0451-0053. Studies were evaluated using the evaluation strategies laid out in the *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances* (U.S. EPA, 2021a) and *Draft Systematic Review Protocol for 1,3-Butadiene* (U.S. EPA, 2024ac). These data provided measurements at the level of individual worker populations, or similarly exposed groups (SEGs). This granularity allowed EPA to differentiate even within OESs among different types of activities and frequencies. The majority of occupational exposure sampling data points, collected primarily from ACC's monitoring report (ToxStrategies, 2021) as well as existing OSHA or NIOSH data, were not quantifiable values but were identified as being below the limit of detection (LOD). For data sets including exposure data that were reported as below the LOD, EPA estimated the exposure concentrations for these data, following EPA's *Guidelines for Statistical Analysis of Occupational Exposure Data*. Based on these guidelines, EPA used the LOD value as the high-end estimate and half the LOD as central tendency. As stated above, calculated risk estimates are not "bright-line" indicators of unreasonable risk relative to benchmarks, and EPA has the discretion to consider other risk-related factors in addition to risks identified in the risk characterization. Therefore, EPA is summarizing the range of non-cancer and cancer risk estimates for each COU across all respective OESs and SEGs without declaring any conclusions on unreasonable risk.

Sensitive organ-level endpoints are unlikely to result from a single exposure at concentrations relevant to human exposures (Section 5.2 and the *Draft Human Health Hazard Assessment for 1,3-Butadiene* (U.S. EPA, 2024t)). Therefore, low risks from all COUs are expected from acute occupational exposures. Similarly, measurable dermal exposures are not expected due to the low boiling point, volatility, and transport method of 1,3-butadiene (see Section 5.1.1 and *Draft Environmental Releases and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2024y)), so low risks from all COUs are expected from occupational dermal exposure. Additionally, inhalation exposures were not quantified for Commercial Use of Fuels and related products as well as Commercial COUs covered by the OES of Use of plastics and rubber products and Use of lubricants and greases. Exposures are expected to be primarily minimal/negligible and risk is expected to be low for these COUs. See Sections 3.11 and 3.14 in the *Draft Environmental Releases and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2024y) for more information.

Although both intermediate and chronic exposures were measured, only intermediate non-cancer risks are summarized below because they are protective of chronic exposures for the same health endpoint. All risk estimates are presented in Table 5-4. See Appendix F for derivation of the existing chemical occupational exposure value, which summarizes the occupational exposure scenario and sensitive health endpoints into a single value, as well as the LOD for available governmental air sampling analytical methods. Non-routine laboratory technician activities which can include line sampling presented the greatest non-cancer risk estimates with an MOE of 0.24 for 12-hour shifts for both central tendency and high end. This is often more than 10-fold higher than other activities within life cycle stage/categories (Table 5-4). In such cases, this SEG was excluded in ranges reported below. EPA notes that the occupational UR was corrected late in the draft risk evaluation process (U.S. EPA, 2024a). The corrected UR is 0.0049 per ppm (2.2×10^{-6} per µg/m^3), down from 0.0062 per ppm. The values below and in Table 5-4 do not reflect the corrected occupational UR. Table 5-4 will be corrected to reflect the lower occupational UR in the *Risk Evaluation for 1,3-Butadiene*.

Note that in cases where there were no ONU exposure data available, it was assumed that ONU exposure is equal to the central tendency worker exposure. In these cases, ONUs may have only a single MOE.

Manufacture – Domestic Manufacturing, Processing – as a Reactant (Intermediate), Processing – Incorporation into Formulation, Mixture, or Reaction Product, and Processing–Recycling

- Excluding risk from non-routine laboratory technician activity, non-cancer MOEs (benchmark = 30) from central tendency exposure ranged from 22 (highest risk) for 12-hour shifts of maintenance activities to 984 (lowest risk) for 8-hour shifts of turnaround of machinery and specialists.
- Excluding risk from non-routine laboratory technician activity, non-cancer MOEs (benchmark = 30) from high end exposure ranged from 1.1 (highest risk) for 12-hour shifts of maintenance turnaround activities to 656 (lowest risk) for 8-hour shifts of turnaround of machinery and specialists.
- Extra cancer risks from central tendency exposure ranged from 1.0×10^{-3} (highest risk) for 12-hour shifts of non-routine laboratory technician activities to 2.5×10^{-7} (lowest risk) for 8-hour shifts of turnaround of machinery and specialists.
- Extra cancer risks from high end exposure ranged from 1.3×10^{-3} (highest risk) for 12-hour shifts of non-routine laboratory technician activities to 4.9×10^{-7} (lowest risk) for 8-hour shifts of turnaround of machinery and specialists.

Manufacture – Importing and Processing – Repackaging

- Non-cancer MOEs (benchmark = 30) from central tendency exposure were 4.6 for 8-hour shifts of both workers and ONUs.
- Non-cancer MOEs (benchmark = 30) from high end exposure ranged from 0.33 (highest risk) for 8-hour shifts of workers to 4.6 (lowest risk) for 8-hour shifts of ONUs.
- Extra cancer risks from central tendency exposure were 6.4×10^{-4} for 8-hour shifts of both workers and ONUs.
- Extra cancer risks from high end exposure ranged from 1.1×10^{-2} (highest risk) for 8-hour shifts of workers to 8.3×10^{-4} (lowest risk) for 8-hour shifts of ONUs.

Processing – as a Reactant (Polymerization)

- Non-cancer MOEs (benchmark = 30) from central tendency exposure ranged from 22 (highest risk) for 12-hour shifts of both workers and ONUs to 173 (lowest risk) for 8-hour shifts of both workers and ONUs.
- Non-cancer MOEs (benchmark = 30) from high end exposure ranged from 12 (highest risk) for 12-hour shifts of workers to 173 (lowest risk) for 8-hour shifts of ONUs.
- Extra cancer risks from central tendency exposure ranged from 7.9×10^{-5} (highest risk) for 12-hour shifts of both workers and ONUs to 1.7×10^{-5} (lowest risk) for 8-hour shifts of both workers and ONUs.
- Extra cancer risks from high end exposure ranged from 2.0×10^{-4} (highest risk) for 8-hour and 12-hour shifts of workers to 2.2×10^{-5} (lowest risk) for 8-hour shifts of ONUs.

Processing – Incorporation into Article

- Non-cancer MOEs (benchmark = 30) from central tendency exposure ranged from 37 (highest risk) for 12-hour shifts of workers and ONUs to 202 (lowest risk) for 8-hour shifts of workers and ONUs.

- Non-cancer MOEs (benchmark = 30) from high end exposure ranged from 12 (highest risk) for 12-hour shifts of workers to 202 for (lowest risk) for 8-hour shifts of ONUs.
- Extra cancer risks from central tendency exposure ranged from 5.1×10^{-5} (highest risk) for 12-hour shifts of workers and ONUs to 1.4×10^{-5} (lowest risk) for 8-hour shifts of workers and ONUs.
- Extra cancer risks from high end exposure ranged from 2.2×10^{-4} (highest risk) for 8-hour shifts of workers to 1.4×10^{-5} for (lowest risk) for 8-hour shifts of ONUs.

Commercial Use – Other Use

- Excluding risk from non-routine laboratory technician activity, non-cancer MOEs (benchmark = 30) from central tendency exposure ranged from 134 (highest risk) for 12-hour shifts of laboratory technician activities to 295 (lowest risk) for 8-hour shifts of ONUs.
- Excluding risk from non-routine laboratory technician activity, non-cancer MOEs (benchmark = 30) from high end exposure ranged from 2.6 (highest risk) for 12-hour shifts of ONUs to 21 (lowest risk) for 8-hour shifts of laboratory technicians.
- Extra cancer risks from central tendency exposure ranged from 1.0×10^{-3} (highest risk) for 12-hour shifts of non-routine laboratory technician activities to 9.6×10^{-6} (lowest risk) for 12-hour shifts of ONUs.
- Extra cancer risks from high end exposure ranged from 1.3×10^{-3} (highest risk) for 12-hour shifts of non-routine laboratory technician activities to 1.7×10^{-4} (lowest risk) for 12-hour shifts of laboratory technicians.

Commercial Use – Paints and Coatings–Adhesives and Sealants; Industrial Use–Adhesives and Sealants

- Non-cancer MOEs (benchmark = 30) from central tendency exposure were 111 for 8-hour shifts of both workers and ONUs.
- Non-cancer MOEs (benchmark = 30) from high end exposure ranged from 55 (highest risk) for 8-hour shifts of workers to 111 (lowest risk) for 8-hour shifts of ONUs.
- Extra cancer risks from central tendency exposure were 2.6×10^{-5} for 8-hour shifts of both workers and ONUs.
- Extra cancer risks from high end exposure ranged from 6.8×10^{-5} (highest risk) for 8-hour shifts of workers to 3.4×10^{-5} (lowest risk) for 8-hour shifts of ONUs.

Disposal – Disposal

- Non-cancer MOEs (benchmark = 30) from central tendency exposure were 22 for all SEGs.
- Non-cancer MOEs (benchmark = 30) from high end exposure ranged from 3.9 (highest risk) for workers to 22 (lowest risk) for ONUs.
- Extra cancer risks from central tendency exposure were 1.3×10^{-4} for all SEGs.
- Extra cancer risks from high end exposure ranged from 9.8×10^{-4} (highest risk) for workers to 1.7×10^{-4} (lowest risk) for ONUs.

Although risk estimates were found to be excessive at high-end for most OESs and SEGs, several OESs were also found to have risk at central tendency exposures. Among these OESs were non-routine laboratory technicians, which showed non-cancer risk estimates approximately two orders of magnitude below benchmark and cancer risk estimates 7 to 10 in 10,000, even at central tendency exposures. This SEG represented the highest risk across all COUs. Maintenance SEGs from 12-hour shifts also demonstrated non-cancer risk estimates below 30 at both exposure levels. Among COUs with OES-specific worker SEGs, both workers and ONUs from 12-hour shifts of plastics and rubber compounding demonstrated potential non-cancer risk relative to benchmark at both exposure levels. Both workers and

ONUs from (1) recycling; (2) waste handling, treatment, and disposal; and (3) repackaging OES demonstrated potential non-cancer *and* cancer risk relative to benchmark at both exposure levels. Repackaging demonstrated the second highest non-cancer risk (and the highest cancer risk for workers at high-end exposures) compared to non-routine laboratory technician activities.

All risk estimates are presented below in Table 5-4. Colored shading and bold values indicate scenarios where risk estimates were below (for non-cancer) or above (for cancer) benchmarks. The *Draft Risk Calculator for Occupational Exposures for 1,3-Butadiene* (U.S. EPA, 2024aa) contains all calculations, exposure values, and exposure factors, used for risk estimation.

1327 **Table 5-4. Occupational Risk Summary Table**

Life Cycle Stage/Category	Subcategory	Occupational Exposure Scenario	Population/ SEG	Exposure Route and Duration	Exposure Level	Intermediate Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Chronic Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Cancer (Benchmark = 10E−04) [a]
Manufacture/ Domestic Manufacturing	Domestic manufacture	Manufacturing (8-hour shift)	Infrastructure/ Distribution Operations	Inhalation 8-hour TWA	Central Tendency	200	206	1.5E−05
					High-End	**11**	**11**	**3.4E−04**
			Infrastructure/ Distribution Operations – Nonroutine	Inhalation 8-hour TWA	Central Tendency	60	725	4.2E−06
					High-End	**28**	342	1.1E−05
			Instrument and Electrical	Inhalation 8-hour TWA	Central Tendency	251	258	1.2E−05
					High-End	31	32	**1.2E−04**
			Instrument and Electrical – Nonroutine	Inhalation 8-hour TWA	Central Tendency	490	2,064	1.5E−06
					High-End	245	1,073	3.6E−06
			Instrument and Electrical – Turnaround	Inhalation 8-hour TWA	Central Tendency	463	5,636	5.3E−07
					High-End	57	689	5.6E−06
			Laboratory Technician	Inhalation 8-hour TWA	Central Tendency	200	206	1.5E−05
					High-End	**21**	**22**	**1.8E−04**

Life Cycle Stage/Category	Subcategory	Occupational Exposure Scenario	Population/ SEG	Exposure Route and Duration	Exposure Level	Intermediate Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Chronic Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Cancer (Benchmark = 10E−04) [a]
			Laboratory Technician – Nonroutine	Inhalation 8-hour TWA	Central Tendency	**0.37**	**4.5**	**6.7E−04**
					High-End	**0.37**	**4.5**	**8.7E−04**
			Machinery and Specialists	Inhalation 8-hour TWA	Central Tendency	835	860	3.5E−06
					High-End	**18**	**19**	**2.1E−04**
			Machinery and Specialists – Turnaround	Inhalation 8-hour TWA	Central Tendency	984	1.2E04	2.5E−07
					High-End	656	7,984	4.9E−07
			Maintenance	Inhalation 8-hour TWA	Central Tendency	33	34	8.9E−05
					High-End	**21**	**22**	**1.8E−04**
			Maintenance – Nonroutine	Inhalation 8-hour TWA	Central Tendency	65	787	3.8E−06
					High-End	36	433	9.0E−06
						272	3,304	9.1E−07

Life Cycle Stage/Category	Subcategory	Occupational Exposure Scenario	Population/ SEG	Exposure Route and Duration	Exposure Level	Intermediate Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Chronic Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Cancer (Benchmark = 10E−04) [a]
			Maintenance – Turnaround	Inhalation 8-hour TWA	Central Tendency			
					High-End	**1.6**	**19**	**2.0E−04**
			Operations Onsite	Inhalation 8-hour TWA	Central Tendency	251	258	1.2E−05
					High-End	**25**	**26**	**1.5E−04**
			Operations Onsite – Nonroutine	Inhalation 8-hour TWA	Central Tendency	689	8,384	3.6E−07
					High-End	165	2,002	1.9E−06
			Operations Onsite – Turnaround	Inhalation 8-hour TWA	Central Tendency	281	3,422	8.8E−07
					High-End	131	1,597	2.4E−06
			Safety Health and Engineering	Inhalation 8-hour TWA	Central Tendency	132	136	2.2E−05
					High-End	**14**	**14**	**2.7E−04**
			ONU	Inhalation 8-hour TWA	Central Tendency	626	645	4.7E−06
					High-End	295	303	1.3E−05

Life Cycle Stage/Category	Subcategory	Occupational Exposure Scenario	Population/ SEG	Exposure Route and Duration	Exposure Level	Intermediate Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Chronic Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Cancer (Benchmark = 10E−04) [a]
Manufacture/ Domestic Manufacturing	Domestic manufacture	Manufacturing (12-hour shift)	Infrastructure/ Distribution Operations	Inhalation 12-hour TWA	Central Tendency	134	214	1.4E−05
					High-End	**7.4**	**12**	**3.3E−04**
			Infrastructure/ Distribution Operations – Nonroutine	Inhalation 12-hour TWA	Central Tendency	40	483	6.2E−06
					High-End	**19**	228	1.7E−05
			Instrument and Electrical	Inhalation 12-hour TWA	Central Tendency	167	268	1.1E−05
					High-End	**21**	33	**1.2E−04**
			Instrument and Electrical – Nonroutine	Inhalation 12-hour TWA	Central Tendency	327	1,376	2.2E−06
					High-End	163	715	5.4E−06
			Instrument and Electrical – Turnaround	Inhalation 12-hour TWA	Central Tendency	309	3,757	8.0E−07
					High-End	38	460	8.5E−06
			Laboratory Technician	Inhalation 12-hour TWA	Central Tendency	134	214	1.4E−05
					High-End	**14**	**23**	**1.7E−04**

Life Cycle Stage/Category	Subcategory	Occupational Exposure Scenario	Population/ SEG	Exposure Route and Duration	Exposure Level	Intermediate Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Chronic Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Cancer (Benchmark = 10E−04) [a]
			Laboratory Technician – Nonroutine	Inhalation 12-hour TWA	Central Tendency	**0.24**	**3.0**	**1.0E−03**
					High-End	**0.24**	**3.0**	**1.3E−03**
			Machinery and Specialists	Inhalation 12-hour TWA	Central Tendency	557	892	3.4E−06
					High-End	**12**	**19**	**2.0E−04**
			Machinery and Specialists – Turnaround	Inhalation 12-hour TWA	Central Tendency	656	7,984	3.8E−07
					High-End	438	5,323	7.3E−07
			Maintenance	Inhalation 12-hour TWA	Central Tendency	**22**	35	8.6E−05
					High-End	**14**	**23**	**1.7E−04**
			Maintenance – Nonroutine	Inhalation 12-hour TWA	Central Tendency	43	524	5.7E−06
					High-End	**24**	289	1.3E−05
			Maintenance – Turnaround	Inhalation 12-hour TWA	Central Tendency	181	2,203	1.4E−06
					High-End	**1.1**	**13**	**3.0E−04**

Life Cycle Stage/Category	Subcategory	Occupational Exposure Scenario	Population/ SEG	Exposure Route and Duration	Exposure Level	Intermediate Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Chronic Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Cancer (Benchmark = 10E−04) [a]
			Operations Onsite	Inhalation 12-hour TWA	Central Tendency	167	268	1.1E−05
					High-End	**17**	**27**	**1.5E−04**
			Operations Onsite – Nonroutine	Inhalation 12-hour TWA	Central Tendency	459	5,589	5.4E−07
					High-End	110	1,335	2.9E−06
			Operations Onsite – Turnaround	Inhalation 12-hour TWA	Central Tendency	188	2,281	1.3E−06
					High-End	88	1,065	3.7E−06
			Safety Health and Engineering	Inhalation 12-hour TWA	Central Tendency	88	141	2.1E−05
					High-End	**9.2**	**15**	**2.6E−04**
			ONU	Inhalation 12-hour TWA	Central Tendency	418	669	4.5E−06
					High-End	197	315	1.2E−05
Processing / Repackaging	Intermediate in: wholesale and retail trade;	Repackaging	Worker	Inhalation 8-hour TWA	Central Tendency	**4.6**	**4.7**	**6.4E−04**

Life Cycle Stage/Category	Subcategory	Occupational Exposure Scenario	Population/ SEG	Exposure Route and Duration	Exposure Level	Intermediate Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Chronic Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Cancer (Benchmark = 10E−04) [a]
Manufacture / Importing	monomer in: synthetic rubber manufacturing Importing				High-End	**0.33**	**0.34**	**1.1E−02**
			ONU	Inhalation 8-hour TWA	Central Tendency	**4.6**	**4.7**	**6.4E−04**
					High-End	**4.6**	**4.7**	**8.3E−04**
Processing/As a Reactant	Intermediate in: adhesive manufacturing; all other basic organic chemical manufacturing; fuel binder for solid rocket fuels; organic fiber manufacturing; petrochemical manufacturing; petroleum refineries; plastic material and resin manufacturing; propellant manufacturing; synthetic rubber manufacturing; paint and coating	Processing as a reactant (8-hour shift)	Infrastructure/ Distribution Operations	Inhalation 8-hour TWA	Central Tendency	200	206	1.5E−05
					High-End	**11**	**11**	**3.4E−04**
			Infrastructure/ Distribution Operations – Nonroutine	Inhalation 8-hour TWA	Central Tendency	60	725	4.2E−06
					High-End	**28**	342	1.1E−05
			Instrument and Electrical	Inhalation 8-hour TWA	Central Tendency	251	258	1.2E−05
					High-End	31	32	**1.2E-04**
			Instrument and Electrical – Nonroutine	Inhalation 8-hour TWA	Central Tendency	490	2,064	1.5E−06
					High-End	245	1,073	3.6E−06

Life Cycle Stage/Category	Subcategory	Occupational Exposure Scenario	Population/ SEG	Exposure Route and Duration	Exposure Level	Intermediate Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Chronic Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Cancer (Benchmark = 10E−04) [a]
Processing / Recycling	manufacturing; Wholesale and retail trade Recycling		Instrument and Electrical – Turnaround	Inhalation 8-hour TWA	Central Tendency	463	5,636	5.3E−07
					High-End	57	689	5.6E−06
			Laboratory Technician	Inhalation 8-hour TWA	Central Tendency	200	206	1.5E−05
					High-End	**21**	**22**	**1.8E−04**
			Laboratory Technician – Nonroutine	Inhalation 8-hour TWA	Central Tendency	**0.37**	**4.5**	**6.7E−04**
					High-End	**0.37**	**4.5**	**8.7E−04**
			Machinery and Specialists	Inhalation 8-hour TWA	Central Tendency	835	860	3.5E−06
					High-End	**18**	**19**	**2.1E−04**
			Machinery and Specialists – Turnaround	Inhalation 8-hour TWA	Central Tendency	984	1.2E04	2.5E−07
					High-End	656	7,984	4.9E−07
			Maintenance	Inhalation 8-hour TWA	Central Tendency	33	34	8.9E−05
					High-End	**21**	**22**	**1.8E−04**

Life Cycle Stage/Category	Subcategory	Occupational Exposure Scenario	Population/ SEG	Exposure Route and Duration	Exposure Level	Intermediate Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Chronic Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Cancer (Benchmark = 10E−04) [a]
			Maintenance – Nonroutine	Inhalation 8-hour TWA	Central Tendency	65	787	3.8E−06
					High-End	36	433	9.0E−06
			Maintenance – Turnaround	Inhalation 8-hour TWA	Central Tendency	272	3,304	9.1E−07
					High-End	**1.6**	**19**	**2.0E−04**
			Operations Onsite	Inhalation 8-hour TWA	Central Tendency	251	258	1.2E−05
					High-End	**25**	**26**	**1.5E−04**
			Operations Onsite – Nonroutine	Inhalation 8-hour TWA	Central Tendency	689	8,384	3.6E−07
					High-End	165	2,002	1.9E−06
			Operations Onsite – Turnaround	Inhalation 8-hour TWA	Central Tendency	281	3,422	8.8E−07
					High-End	131	1,597	2.4E−06
			Safety Health and Engineering	Inhalation 8-hour TWA	Central Tendency	132	136	2.2E−05

Life Cycle Stage/Category	Subcategory	Occupational Exposure Scenario	Population/ SEG	Exposure Route and Duration	Exposure Level	Intermediate Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Chronic Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Cancer (Benchmark = 10E−04) [a]
					High-End	**14**	**14**	**2.7E−04**
			ONU	Inhalation 8-hour TWA	Central Tendency	626	645	4.7E−06
					High-End	295	303	1.3E−05
Processing/As a Reactant	Intermediate in: adhesive manufacturing; all other basic organic chemical manufacturing; fuel binder for solid rocket fuels; organic fiber manufacturing; petrochemical manufacturing; petroleum refineries; plastic material and resin manufacturing; propellant manufacturing; synthetic rubber manufacturing; paint and coating manufacturing;	Processing as a reactant (12-hour shift)	Infrastructure/ Distribution Operations	Inhalation 12-hour TWA	Central Tendency	134	214	1.4E−05
					High-End	**7.4**	**12**	**3.3E−04**
			Infrastructure/ Distribution Operations – Nonroutine	Inhalation 12-hour TWA	Central Tendency	40	483	6.2E−06
					High-End	**19**	228	1.7E−05
			Instrument and Electrical	Inhalation 12-hour TWA	Central Tendency	167	268	1.1E−05
					High-End	**21**	33	**1.2E−04**
			Instrument and Electrical – Nonroutine	Inhalation 12-hour TWA	Central Tendency	327	1,376	2.2E−06
					High-End	163	715	5.4E−06
						309	3,757	8.0E−07

Life Cycle Stage/Category	Subcategory	Occupational Exposure Scenario	Population/ SEG	Exposure Route and Duration	Exposure Level	Intermediate Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Chronic Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Cancer (Benchmark = 10E−04) [a]
Processing/ Recycling	Wholesale and retail trade Recycling		Instrument and Electrical – Turnaround	Inhalation 12-hour TWA	Central Tendency			
					High-End	38	460	8.5E−06
			Laboratory Technician	Inhalation 12-hour TWA	Central Tendency	134	214	1.4E−05
					High-End	**14**	**23**	**1.7E−04**
			Laboratory Technician – Nonroutine	Inhalation 12-hour TWA	Central Tendency	**0.24**	**3.0**	**1.0E−03**
					High-End	**0.24**	**3.0**	**1.3E−03**
			Machinery and Specialists	Inhalation 12-hour TWA	Central Tendency	557	892	3.4E−06
					High-End	**12**	**19**	**2.0E−04**
			Machinery and Specialists – Turnaround	Inhalation 12-hour TWA	Central Tendency	656	7,984	3.8E−07
					High-End	438	5,323	7.3E−07
			Maintenance	Inhalation 12-hour TWA	Central Tendency	**22**	35	8.6E−05
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			Maintenance – Nonroutine	Inhalation 12-hour TWA	Central Tendency	43	524	5.7E−06
					High-End	**24**	289	1.3E−05
			Maintenance – Turnaround	Inhalation 12-hour TWA	Central Tendency	181	2,203	1.4E−06
					High-End	**1.1**	**13**	**3.0E−04**
			Operations Onsite	Inhalation 12-hour TWA	Central Tendency	167	268	1.1E−05
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					High-End	110	1,335	2.9E−06
			Operations Onsite – Turnaround	Inhalation 12-hour TWA	Central Tendency	188	2,281	1.3E−06
					High-End	88	1,065	3.7E−06
			Safety Health and Engineering	Inhalation 12-hour TWA	Central Tendency	88	141	2.1E−05

Life Cycle Stage/Category	Subcategory	Occupational Exposure Scenario	Population/ SEG	Exposure Route and Duration	Exposure Level	Intermediate Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Chronic Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Cancer (Benchmark = 10E−04) [a]
					High-End	**9.2**	**15**	**2.6E−04**
			ONU	Inhalation 12-hour TWA	Central Tendency	418	669	4.5E−06
					High-End	197	315	1.2E−05
Processing/ Incorporation into formulation, mixture, or reaction product	Processing aids, not otherwise listed in: petrochemical manufacturing; monomers used in: plastic product manufacturing; synthetic rubber manufacturing Other: adhesive manufacturing, paints and coatings manufacturing, petroleum lubricating oil and grease manufacturing, and all other chemical product and preparation manufacturing	Processing – incorporation into formulation, mixture, or reaction product (8-hour shift)	Infrastructure/ Distribution Operations	Inhalation 8-hour TWA	Central Tendency	200	206	1.5E−05
					High-End	**11**	**11**	**3.4E−04**
			Infrastructure/ Distribution Operations – Nonroutine	Inhalation 8-hour TWA	Central Tendency	60	725	4.2E−06
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						463	5,636	5.3E−07

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					High-End	**0.37**	**4.5**	**8.7E−04**
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Life Cycle Stage/Category	Subcategory	Occupational Exposure Scenario	Population/ SEG	Exposure Route and Duration	Exposure Level	Intermediate Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Chronic Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Cancer (Benchmark = 10E−04) [a]
			Maintenance – Nonroutine	Inhalation 8-hour TWA	Central Tendency	65	787	3.8E−06
					High-End	36	433	9.0E−06
			Maintenance – Turnaround	Inhalation 8-hour TWA	Central Tendency	272	3,304	9.1E−07
					High-End	**1.6**	**19**	**2.0E−04**
			Operations Onsite	Inhalation 8-hour TWA	Central Tendency	251	258	1.2E−05
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			Operations Onsite – Nonroutine	Inhalation 8-hour TWA	Central Tendency	689	8,384	3.6E−07
					High-End	165	2,002	1.9E−06
			Operations Onsite – Turnaround	Inhalation 8-hour TWA	Central Tendency	281	3,422	8.8E−07
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Processing/ Incorporation into formulation, mixture, or reaction product	Processing aids, not otherwise listed in: petrochemical manufacturing; monomers used in: plastic product manufacturing; synthetic rubber manufacturing Other: adhesive manufacturing, paints and coatings manufacturing, petroleum lubricating oil and grease manufacturing, and all other chemical product and	Processing – incorporation into formulation, mixture, or reaction product (12-hour shift)	Infrastructure/ Distribution Operations	Inhalation 12-hour TWA	Central Tendency	134	214	1.4E−05
					High-End	**7.4**	**12**	**3.3E−04**
			Infrastructure/ Distribution Operations – Nonroutine	Inhalation 12-hour TWA	Central Tendency	40	483	6.2E−06
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						309	3,757	8.0E−07

Life Cycle Stage/Category	Subcategory	Occupational Exposure Scenario	Population/ SEG	Exposure Route and Duration	Exposure Level	Intermediate Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Chronic Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Cancer (Benchmark = 10E−04) [a]
	preparation manufacturing		Instrument and Electrical – Turnaround	Inhalation 12-hour TWA	Central Tendency			
					High-End	38	460	8.5E−06
			Laboratory Technician	Inhalation 12-hour TWA	Central Tendency	134	214	1.4E−05
					High-End	**14**	**23**	**1.7E−04**
			Laboratory Technician – Nonroutine	Inhalation 12-hour TWA	Central Tendency	**0.24**	**3.0**	**1.0E−03**
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					High-End	438	5,323	7.3E−07
			Maintenance	Inhalation 12-hour TWA	Central Tendency	**22**	35	8.6E−05
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			Maintenance – Nonroutine	Inhalation 12-hour TWA	Central Tendency	43	524	5.7E−06
					High-End	**24**	289	1.3E−05
			Maintenance – Turnaround	Inhalation 12-hour TWA	Central Tendency	181	2,203	1.4E−06
					High-End	**1.1**	**13**	**3.0E−04**
			Operations Onsite	Inhalation 12-hour TWA	Central Tendency	167	268	1.1E−05
					High-End	**17**	**27**	**1.5E−04**
			Operations Onsite – Nonroutine	Inhalation 12-hour TWA	Central Tendency	459	5,589	5.4E−07
					High-End	110	1,335	2.9E−06
			Operations Onsite – Turnaround	Inhalation 12-hour TWA	Central Tendency	188	2,281	1.3E−06
					High-End	88	1,065	3.7E−06
			Safety Health and Engineering	Inhalation 12-hour TWA	Central Tendency	88	141	2.1E−05

Life Cycle Stage/Category	Subcategory	Occupational Exposure Scenario	Population/ SEG	Exposure Route and Duration	Exposure Level	Intermediate Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Chronic Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Cancer (Benchmark = 10E−04) [a]
					High-End	**9.2**	**15**	**2.6E−04**
			ONU	Inhalation 12-hour TWA	Central Tendency	418	669	4.5E−06
					High-End	197	315	1.2E−05
Processing / Processing as a reactant	Monomer used in polymerization process in: synthetic rubber manufacturing; plastic material and resin manufacturing	Plastics and rubber compounding	Worker	Inhalation 8-hour TWA	Central Tendency	173	178	1.7E−05
					High-End	**18**	**19**	**2.0E−04**
			ONU	Inhalation 8-hour TWA	Central Tendency	173	178	1.7E−05
					High-End	173	178	2.2E−05
			Worker	Inhalation 12-hour TWA	Central Tendency	**24**	38	7.9E−05
					High-End	**12**	**19**	**2.0E−04**
			ONU	Inhalation 12-hour TWA	Central Tendency	**24**	38	7.9E−05
					High-End	**24**	38	**1.0E−04**

Life Cycle Stage/Category	Subcategory	Occupational Exposure Scenario	Population/ SEG	Exposure Route and Duration	Exposure Level	Intermediate Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Chronic Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Cancer (Benchmark = 10E−04) [a]
Processing/ Incorporation into article	Other: polymer in: rubber and plastic product manufacturing	Plastics and rubber converting	Worker	Inhalation 8-hour TWA	Central Tendency	202	208	1.4E−05
					High-End	**17**	**18**	**2.2E−04**
			ONU	Inhalation 8-hour TWA	Central Tendency	202	208	1.4E−05
					High-End	202	208	1.9E−05
			Worker	Inhalation 12-hour TWA	Central Tendency	37	59	5.1E−05
					High-End	**12**	**19**	**2.1E−04**
			ONU	Inhalation 12-hour TWA	Central Tendency	37	59	5.1E−05
					High-End	37	59	6.6E−05
Commercial Use/ Other use	Laboratory chemicals	Use of laboratory chemicals	Laboratory Technician	Inhalation 8-hour TWA	Central Tendency	200	206	1.5E−05
					High-End	**21**	**22**	**1.8E−04**
			Laboratory Technician – Nonroutine	Inhalation 8-hour TWA	Central Tendency	**0.37**	**4.5**	**6.7E−04**
					High-End	**0.37**	**4.5**	**8.7E−04**

Life Cycle Stage/Category	Subcategory	Occupational Exposure Scenario	Population/ SEG	Exposure Route and Duration	Exposure Level	Intermediate Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Chronic Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Cancer (Benchmark = 10E−04) [a]
			ONU	Inhalation 8-hour TWA	Central Tendency	295	303	9.9E−06
					High-End	**3.9**	**4.0**	**9.8E−04**
			Laboratory Technician	Inhalation 12-hour TWA	Central Tendency	134	214	1.4E−05
					High-End	**14**	**23**	**1.7E−04**
			Laboratory Technician – Nonroutine	Inhalation 12-hour TWA	Central Tendency	**0.24**	**3.0**	**1.0E−03**
					High-End	**0.24**	**3.0**	**1.3E−03**
			ONU	Inhalation 12-hour TWA	Central Tendency	197	315	9.6E−06
					High-End	**2.6**	**4.1**	**9.4E−04**
Commercial Use / Paints and Coatings / Adhesives and sealants Industrial Use / Adhesives and Sealants	Paints and coatings, including aerosol spray paint Adhesives and sealants,	Paints, coatings, adhesives, and sealants	Worker	Inhalation 8-hour TWA	Central Tendency	111	114	2.6E−05
					High-End	55	57	6.8E−05
			ONU	Inhalation 8-hour TWA	Central Tendency	111	114	2.6E−05

Life Cycle Stage/Category	Subcategory	Occupational Exposure Scenario	Population/ SEG	Exposure Route and Duration	Exposure Level	Intermediate Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Chronic Non-cancer (HEC = 2.5 ppm, Benchmark = 30)	Cancer (Benchmark = 10E−04) [a]
	including epoxy resins				High-End	111	114	3.4E−05
Disposal	Disposal	Recycling	Worker	Inhalation 8-hour TWA	Central Tendency	**22**	**22**	**1.3E−04**
					High-End	**3.9**	**4.0**	**9.8E−04**
			ONU	Inhalation 8-hour TWA	Central Tendency	**22**	**22**	**1.3E−04**
					High-End	**22**	**22**	**1.7E−04**
Disposal	Disposal	Waste handling, treatment, and disposal	Worker	Inhalation 8-hour TWA	Central Tendency	**22**	**22**	**1.3E−04**
					High-End	**3.9**	**4.0**	**9.8E−04**
			ONU	Inhalation 8-hour TWA	Central Tendency	**22**	**22**	**1.3E−04**
					High-End	**22**	**22**	**1.7E−04**

[a] The occupational unit risk was corrected as described in *1,3-Butadiene: Corrected Lifetable Analyses for Leukemia and Bladder Cancer* (U.S. EPA, 2024a). The corrected occupational unit risk = 0.0049 per ppm (2.2×10^{-6} per µg/m^3). The cancer estimates herein do not reflect the 20 percent reduction in occupational UR.

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5.3.3 Risk Estimates for Consumers

The consumer COUs and associated disposal for 1,3-butadiene do not have quantitative risk estimates. However, EPA has qualitatively evaluated the COUs by assessing the possibility of 1,3-butadiene monomer exposure from polymer consumer use in Section 5.1.2 and concluded limited potential for exposure. Based on this analysis, no appreciable risks are expected from consumer COUs for the 1,3-butadiene monomer assessed in this risk evaluation.

5.3.4 Risk Estimates for General Population Exposed to Environmental Releases

As detailed in Section 4.2.1, EPA decided to conduct a quantitative exposure assessment for only the air pathway in order to evaluate non-cancer and cancer risks for the general population. As part of a tiered approach, EPA used the IIOAC model to estimate 1,3-butadiene ambient air concentrations across discrete distances between 100 to 1,000 m from TRI 2016 to 2021 reported facility releases and presented a range of modeled concentrations across all reporting years for each facility. The ambient air concentrations modeled with IIOAC were used for the risk calculations found in Section 5.3.1 for chronic non-cancer MOEs and inhalation cancer risks. Based on the results from IIOAC, non-cancer risks were not expected for the general population (Section 5.3.4.1). However, there were potential screening-level risk estimates at or above the cancer risk benchmark up to 1,000 m. Therefore, EPA used the HEM to refine 1,3-butadiene ambient air concentrations across discrete distances between 10 to 50,000 m from TRI facility releases and calculated inhalation cancer risks (Section 5.3.4.2).

EPA focused on modeled air concentrations for the following distances: 100 m, 100 to 1,000 m, and 1,000 m. These distances are also consistent with the community populations living near facilities as described in the fenceline methodology (Draft Screening Level Approach for Assessing Ambient Air and Water Exposures to Fenceline Communities Version 1.0).

In addition to modeling ambient air concentrations at discrete distances, HEM also models annual-averaged concentrations and estimates cancer risks at census blocks within 50,000 m from TRI facility releases. Census block-based results are aggregated across facilities; that is, if a census block is within proximity to more than one TRI facility release, then the modeled concentrations, and in turn, the estimated cancer risks, from each facility release are added together for that census block.

Sensitive organ-level endpoints are unlikely to result from a single exposure at concentrations relevant to human exposures (Section 5.2 and the *Draft Human Health Hazard Assessment for 1,3-Butadiene* (U.S. EPA, 2024t). Therefore, EPA expects low risks to the general population from acute exposures for all COUs. EPA evaluated chronic non-cancer risk for general population chronic exposure using the HEC of 2.5 ppm (5,500 μg/m^3) for reduced fetal weight with a benchmark MOE of 30. EPA evaluated lifetime cancer risk using the general population IUR of 0.0098 per ppm (4.4×10^{-6} per μg/m^3). See Section 5.2 and the *Draft Human Health Hazard Assessment for 1,3-Butadiene* (U.S. EPA, 2024t) for more details on the human health hazard values. If the calculated lifetime cancer risk was above the cancer risk benchmark of 1 in a million, or 1×10^{-6}, then potential risk was identified and further characterized.

There is uncertainty in underlying parameters required for accurately estimating releases for cases where 1,3-butadiene is present in LPG, and only minimal monomer 1,3-butadiene is expected to be released from final use products. As a result, EPA did not quantify releases and resulting general population exposures from Commercial use in fuels and related products or the Commercial COUs covered by the OES of Use of plastics and rubber products and Use of lubricants and greases. Risks from these COUs are expected to be low.

As the Agency incorporates refined or additional release data received during the public comment period and SACC review of the draft risk evaluation, it is possible that the risk estimates for specific COUs could change.

5.3.4.1 Inhalation Margin of Exposures by Discrete Distances

As part of a tiered analysis, EPA calculated ambient air concentrations and associated MOEs using Equation 5-1 at radial distances of 100, 100 to 1,000 and 1,000 m from TRI releases of 1,3-butadiene using IIOAC. No calculated MOE was below the benchmark of 30 for any IIOAC modeled concentrations from 100 to 1,000 m across all TRI facilities. The highest concentration and therefore lowest corresponding MOE was calculated for a facility corresponding with the Processing – plastics and rubber compounding COU/OES, at an MOE of 60, which is twice the benchmark of 30. Therefore, based on the MOE over the benchmark for the highest estimated concentrations from this assessment, non-cancer risks are not expected for the general population from inhalation of 1,3-butadiene from environmental releases and no further refinements were conducted. See the *Draft General Population Exposures for 1,3-Butadiene* (U.S. EPA, 2024r) for more details on the IIOAC modeling and results.

5.3.4.2 Inhalation Cancer Risks by Discrete Distances

Although the tiered analysis with IIOAC 95th percentile modeled concentrations resulted in no expectation for non-cancer risks, estimated cancer risks based on IIOAC 95th percentile and mean modeled concentrations were at or above the 1 in a million benchmark up to 1,000 m from facility releases. Since the risk estimates derived using IIOAC results were above this benchmark, EPA utilized HEM to conduct a more geographically refined analysis of ambient air concentrations using localized meteorological data and site-specific days of operation. Using 95th, 50th, and 10th percentile modeled concentrations from HEM, EPA calculated the lifetime cancer risks using Equation 5-2 and are summarized by OESs and associated COUs across the 100, 100 to 1,000 and 1,000 m distances in Table 5-5. Based on the 95th percentile modeled concentrations, cancer risks ranged from 1.9×10^{-13} to $4.1E\times10^{-4}$ from 100, 100 to 100 m and 1,000 m distances across all TRI 2016 to 2021 reporting years. Processing – plastics and rubber compounding COU/OES resulted in the highest risks while Manufacture – manufacturing COU/OES is associated with the furthest distance showing risk above the 1×10^{-6} benchmark at 5,000 m. Summary tables for cancer risks based on the 95th, 50th, and 10th percentile modeled from HEM across all distances by OESs and associated COUs across all distances from 10 to 50,000 m are presented in Appendix H.1.

For all TRI 2016 to 2021 modeled exposure concentrations and calculated MOEs and cancer risks for all distances from 10 to 50,000 m, see the supplemental file: *Draft Human Exposure Model (HEM) TRI 2016–2021 Exposure and Risk Analysis for 1,3-Butadiene* (U.S. EPA, 2024s).

Table 5-5. General Population Cancer Risk Summary Table at 100 to 1,000 m from Facility Releases Based on HEM Modeled Concentrations[a b c d]

Population	Exposure Route	Life Cycle Stage	Category	Subcategory	Exposure Scenario	Facility Count	Facility Count Within Benchmark Range	Exposure Concentration Statistic	100 m	100–1,000 m	1,000 m
General Population	Air Inhalation	Manufacture	Domestic manufacturing	Domestic manufacturing	Manufacturing	40	30	95th percentile	3.5E−04	6.0E−05	2.1E−05
							23	50th percentile	1.4E−04	1.3E−05	7.5E−06
							22	10th percentile	6.6E−05	4.6E−06	3.3E−06
		Processing	Processing as a reactant	Other: monomer used in polymerization process in: plastic material and resin manufacturing; manufacturing synthetic rubber and plastics	Plastics and Rubber Compounding	33	29	95th percentile	4.1E−04	3.2E−05	9.4E−06
							22	50th percentile	1.2E−04	6.6E−06	3.6E−06
							18	10th percentile	7.1E−05	2.9E−06	1.9E−06
		Processing	Processing – incorporation into article	Other: polymer in: rubber and plastic product manufacturing	Plastics and Rubber Converting	1	0	95th percentile	2.3E−12	6.5E−13	1.9E−13
							0	50th percentile	9.0E−13	2.4E−13	1.6E−13
							0	10th percentile	5.9E−13	1.6E−13	1.4E−13
		Processing	Processing – incorporation into formulation, mixture, or reaction product	Processing aids, not otherwise listed in: petrochemical manufacturing	Processing – Incorporation into Formulation, Mixture, or Reaction Product	53	16	95th percentile	7.6E−05	2.9E−05	1.4E−05
							9	50th percentile	1.7E−05	1.6E−06	1.3E−06
							6	10th percentile	5.8E−06	3.6E−07	2.3E−07
		Processing	Processing as a reactant	Intermediate in: adhesive manufacturing; all other basic organic chemical manufacturing; Fuel binder for solid rocket	Processing as a Reactant	57	31	95th percentile	1.4E−04	1.3E−05	3.5E−06

Population	Exposure Route	Life Cycle Stage	Category	Subcategory	Exposure Scenario	Facility Count	Facility Count Within Benchmark Range	Exposure Concentration Statistic	100 m	100–1,000 m	1,000 m
General Population	Air Inhalation			fuels; organic fiber manufacturing; petrochemical manufacturing; petroleum refineries; plastic material and resin manufacturing; propellant manufacturing; synthetic rubber manufacturing; paint and coating manufacturing; wholesale and retail trade			16	50th percentile	4.5E−05	2.1E−06	1.1E−06
							14	10th percentile	2.2E−05	8.0E−07	5.3E−07
		Disposal	Disposal	Disposal	Recycling	11	3	95th percentile	3.1E−06	3.8E−07	9.8E−08
							1	50th percentile	1.4E−06	6.3E−08	3.4E−08
							0	10th percentile	6.3E−07	3.3E−08	2.3E−08
					Waste Handling, Disposal, Treatment, and Recycling	7	0	95th percentile	7.9E−07	9.2E−08	3.1E−08
							0	50th percentile	7.8E−08	2.0E−08	1.1E−08
							0	10th percentile	3.0E−08	5.7E−09	3.7E−09
		Manufacture	Import	Import	Repackaging	23	6	95th percentile	9.0E−05	1.1E−05	2.3E−06
							5	50th percentile	3.7E−05	1.9E−06	9.9E−07
		Processing	Repackaging	Intermediate in: wholesale and retail trade			3	10th percentile	2.3E−05	7.5E−07	5.1E−07

[a] Cancer endpoint = leukemia (**(**U.S. EPA, 2024t**)**
[b] IUR = [9.8E−03] per ppm; [4.4E−06] per µg/m^3
[c] Maximum cancer risk
[d] Cancer Risk = Human Exposure × IUR (Benchmark = 1E−06 to 1E−04)

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5.3.4.3 Inhalation Cancer Risks by Census Blocks

EPA aggregated and summarized cancer risk estimates from HEM based on TRI 2016–2021 ambient air releases at the facility and census block levels. Further description of the modeling procedures and details on how cancer risks are calculated is available in the *Draft General Population Exposures for 1,3-Butadiene* (U.S. EPA, 2024r) as well as the HEM User Guides (SC&A, 2023). As an illustrative example, Figure 5-1 shows the cancer risk results for census blocks based on the most recent 2021 TRI reporting year. Figures for the other reporting years are presented in Appendix H.2. Elevated cancer risks are concentrated in areas along the Gulf Coast region from Texas to Louisiana, primarily between Houston and Baton Rouge shown in the zoomed-in map (Figure 5-2). Across the 2016 to 2021 TRI reporting years, the calculated cancer risks at census block centroids ranged from 0 to 1.3×10^{-4}; that is, some facilities are predicted to have no risk at any census blocks within 50 km, up to a facility with cancer risk as high as 1.3 in 10,000. The highest cancer risk estimated was based on 2017 TRI releases from the Ineos USA LLC - Chocolate Bayou Plant (TRI ID 77511MCCHM2MISO), a 1,3-butadiene manufacturing facility located in Alvin, TX (in the greater Houston area). Upon further investigation, it was determined that the latitude and longitude coordinates for this facility were erroneously reported in the TRI database for the 2016, 2017 and 2019 reporting years. Releases from this facility and associated ambient air concentrations were remodeled using the correct coordinates. After correction of the location of the Ineos USA LLC – Chocolate Bayou Plant facility, associated cancer risks in surrounding census blocks were reduced (updated maps for the 2016, 2017 and 2019 reporting years will be included in the final risk evaluation). The highest cancer risk was then determined to be associated with the Total Energies Petrochemical and Refining USA Inc. facility (TRI ID 77640FNLNDHIGHW), a 1,3-butadiene processing facility located in Port Arthur, TX (part of the greater Houston-Beaumont area). 2016 TRI releases from this facility resulted in an estimated cancer risk of 7.4×10^{-5}, or 7.4 in 100,000.

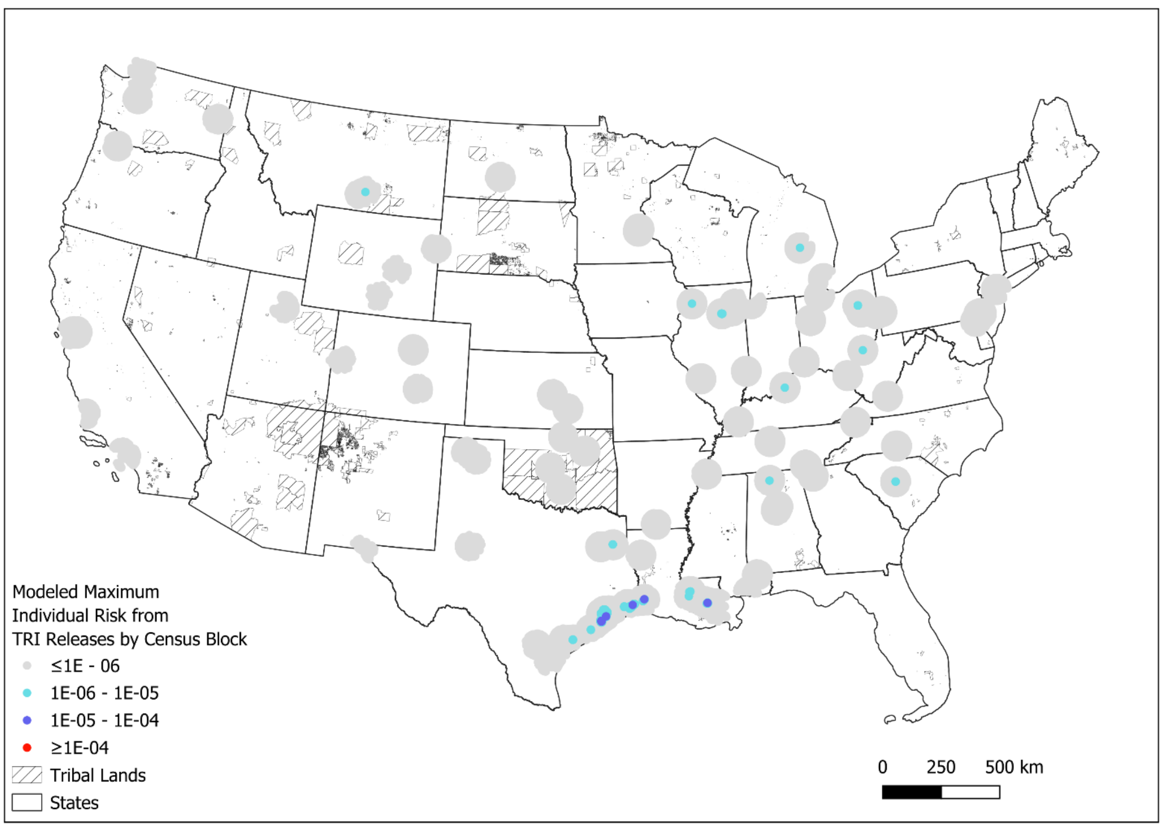

Figure 5-1. Map of Contiguous United States with HEM Model Results for Cancer Risks Aggregated and Summarized by Census Block for the 2021 TRI Reporting Year

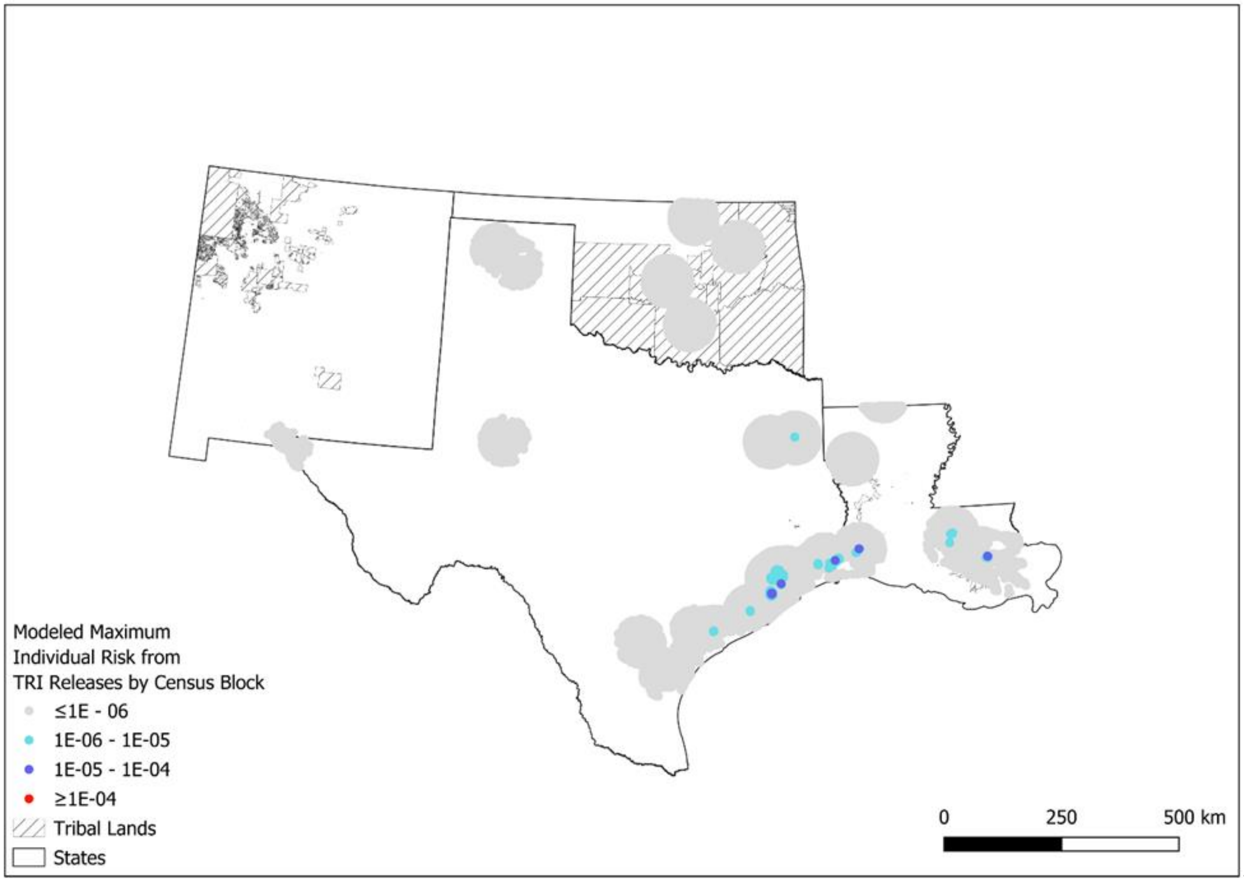

Figure 5-2. Southern United States Close-Up

Based on the general population IUR of 4.4×10^{-6} risk per µg/m^3, exposure concentrations of 0.227 µg/m^3 (1.03×10^{-4} ppm), 2.27 µg/m^3 (1.03×10^{-3} ppm) and 22.7 µg/m^3 (1.03×10^{-2} ppm) or greater, will result in risk at or above the 1 in a million (1×10^{-6}), 1 in 100,000 (1×10^{-5}) and 1 in 10,000 (1×10^{-4}) benchmarks, respectively. For all census blocks modeled, HEM utilizes population counts within each census block to calculate a total estimated population count; that is, number of people exposed, to 1,3-butadiene in ambient air that would result in cancer risk at each benchmark. Table 5-6 tabulates the number of modeled facilities, the range of census block cancer risks for all the modeled facilities, the total estimated population summed from all census blocks exposed above each benchmark value, and the number of facilities (N) attributed to the population count and is categorized by OESs and associated COUs for the 2016 to 2021 TRI reporting years. Updated results with the corrected location for the Ineos USA LLC - Chocolate Bayou Plant are noted with an italicized, superscripted “a” ([*a*]) for the years that this facility reported TRI releases in 2016, 2017, and 2019.

As an excerpt from Table 5-6, based on the 2021 TRI reporting year, there were a total of 37 manufacturing facilities that reported 1,3-butadiene releases. Cancer risks were estimated for the census blocks around those 37 manufacturing facilities. The estimated cancer risks across all of the census blocks around the 37 manufacturing facilities ranged from 6.5×10^{-11} to 8.9×10^{-5}. For the census blocks that had estimated cancer risks at or above the 1 in a million, 1 in 100,000, and 1 in 10,000 benchmarks, the population counts from each census block were summed together to show the total population count exposed at or above each benchmark. Of the 37 manufacturing facilities, releases from 15 facilities resulted in 80,461 people exposed to cancer risks at or above the 1 in a million benchmark and releases from 3 facilities resulted in 1,721 people exposed to cancer risks at or above the 1 in 100,000 benchmark. There were no populations exposed to cancer risk at or above the 1 in 10,000 benchmark. The 1 in a million benchmark is defined as 1 additional case of cancer expected to develop per 1 million people if exposed daily to 0.227 μg/m^3 (1.03×10^{-4} ppm) over a lifetime. 80,461 people with an estimated risk at or above 1 in a million but below the 1 in 100,000 benchmark results in 0.08 to 0.8 additional cases expected for the 80,461 people if exposed daily over a lifetime while 1,721 people with an estimated risk at or above 1 in 100,000 and an estimated maximum risk of 8.9×10^{-5} results in 0.017 to 0.15 additional cases expected for the 1,721 people if exposed daily over a lifetime. Altogether, based on the 2021 TRI reporting year for 1,3-butadiene releases from manufacturing facilities, there is range of 0.097 to 0.95 additional cases expected for that population if exposed daily over a lifetime.

Across the 2016 to 2021 TRI reporting years, the estimated cancer risks across all census blocks ranged from 0 to 7.4×10^{-5}; that is some census blocks within 50 km of facilities have no estimated risk of cancer from exposure to 1,3-butadiene while other census blocks have estimated cancer risk as high as 7.4 in 10,000. The total number of people across all OESs and associated COUs with an estimated cancer risk at or above the 1 in a million-benchmark ranged from 79,907 to 156,303 people. The Manufacture – manufacturing COU-OES is identified as the highest contributor among all the COUs-OESs, followed by Processing – incorporation into formulation, mixture, or reaction product and then Processing – plastics and rubber compounding and Processing as a reactant COUs-OESs. The census block with highest estimated risk (ID 66001009) has a population of 3 people exposed to risk of 7.4×10^{-5} (7.4 in 100,000). This census block is located within 1,000 m from the Total Energies Petrochemical and Refining USA Inc. facility.

Table 5-7 shows the demographic breakdown nationwide and for all census blocks within 50,000 m from TRI facilities along with average cancer risk based on populations categorized by racial and ethnic groups, age, and other sociodemographic factors. Average cancer risk estimates ranged from 0.008 to 0.03 in a million across all demographic categories; that is, 0.008 to 0.03 additional cases expected per 1 million people if exposed daily over a lifetime.

A source of uncertainty in these analyses is the assumption that the TRI-reported emissions from each facility are from a standardized stack of 10 m in height and ground-level area source of 10 by 10 m as described in the *Draft Environmental Releases and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2024y). This assumption is a source of uncertainty for large multi-acre facilities with disperse sources and could bias results either to more or less risk based on the relation between the assumed point of release and the exposed population. In other words, if the actual releases are more dispersed and farther from the exposed populations then modeled, the results would be an overestimate of risk. However, if the actual releases are closer to the edge of the facility boundaries or upwind of population centers then the estimates could be an underestimate. As a check on the direction of uncertainty, EPA cross walked the cancer risk estimates with previous assessments, described below, of the same facilities with more refined analyses of emissions processes.

5.3.4.4 Inhalation Cancer Risks Estimated by Previous EPA Assessments

As described in Appendix B, 1,3-butadiene is a hazardous air pollutant (HAP) subject to Clean Air Act (CAA) sections 112(d) and 112(f). As a result, most of the highest-emitting facilities for 1,3-butadiene are subject to regular risk and technology reviews (RTR) by applicable source category, including residual risk reviews. Emissions of all HAPs from a modeled facility are generally estimated at the process level for the source category and aggregated with all other HAPs for a whole-facility estimate of attributable risk.

While the objective of these RTRs serves a different purpose, the underlying modeling to estimate ambient air concentrations are comparable to the HEM census block modeling of same facilities reporting to TRI. The RTRs have relied on the IRIS Health Assessment of 1,3-Butadiene (2002a) with an IUR of 3×10^{-5} per µg/m^3, compared to the less potent IUR of 4.4×10^{-6} per µg/m^3, described above in Section 5.3. Thus, the RTRs would be expected to show approximately 7 times higher risks for the same lifetime exposures. Other differences include the underlying population analysis, this evaluation relied on 2020 census data while the recent RTRs used 2010 census data with adjustments for maximum individual risk.

The facilities identified in this risk evaluation analysis with the highest associated cancer risks at downwind census blocks were cross walked with the most recent RTR whole facility assessments which estimated risks from HAP emissions, including 1,3-butadiene. Similarly, the facilities with the highest maximum individual risk attributable to 1,3-butadiene in the most recent and relevant RTR, the *Residual Risk Assessment for the Synthetic Organic Chemical Manufacturing Industry (SOCMI) Source* (U.S. EPA, 2024ah) were also cross-walked with the highest cancer risks estimated in this risk evaluation. Most of the 1,3-butadiene facilities associated with the highest census block risks were evaluated in the SOCMI RTR with the exception of the following three facilities which were most recently covered by the Polymer and Resin Group 1 source category: Firestone Polymers (TRI ID 70602FRSTNLA108), Lion Elastomers Orange (TRI ID 77630FRSTNFARMR), and Arlanxeo (TRI ID 77631PLYSRFM100).

For all facilities, the maximum individual risk attributable to 1,3-butadiene from each facility in the SOCMI RTR were found to be similar or lower than the highest census block risk estimates from this evaluation after correcting for the updated IUR. Therefore, EPA is confident that the uncertainty associated with modeling TRI-reported emissions from standardized stack and area sources is health protective and the cancer risk estimates do not underestimate risks to proximate communities.

Table 5-6. Inhalation Cancer Risk Population Count Based on HEM Modeling Results Using 2020 Census Blocks for TRI 2016–2021 Releases

Year	Life Cycle Stage	Category	Subcategory	OES	Facility Count (N)	Cancer Risk Range for all Census Blocks within 50 km		Number People Exposed to ≥ 1 in 1,000,000 Risk (1E−06)	N	Number People Exposed to ≥ 1 in 100,000 Risk (1E−05)	N	Number People Exposed to ≥1 in 10,000 Risk (1E−04)	N
						Min	Max						
2016	Manufacturing	Domestic manufacturing	Domestic manufacturing	Manufacturing	38	0.0E00	1.1E−04 (1.2E−05)[a]	67,291 (43,839)[a]	13	1,655 (32)[a]	2 (1)[a]	80 (0)[a]	1 (0)[a]
	Processing	Processing as a reactant	Other: monomer used in polymerization process in: plastic material and resin manufacturing; manufacturing synthetic rubber and plastics	Plastics and rubber compounding	29	7.9E−09	1.8E−05	5,231	10	184	3	0	0
	Processing	Processing – incorporation into formulation, mixture, or reaction product	Processing aids, not otherwise listed in: petrochemical manufacturing	Processing – incorporation into formulation, mixture, or reaction product	46	0.0E00	7.4E−05	41,314	1	1,179	1	0	0
	Processing	Processing as a reactant	Intermediate in: adhesive manufacturing; all other basic organic chemical manufacturing; fuel binder for solid rocket fuels; organic fiber manufacturing; petrochemical manufacturing; petroleum refineries; plastic material and resin manufacturing; propellant manufacturing; synthetic rubber manufacturing; wholesale and retail trade	Processing as a reactant	53	0.0E00	4.3E−06	128	4	0	0	0	0
	Disposal	Disposal	Disposal	Recycling	10	1.4E−10	4.5E−07	0	0	0	0	0	0
	Manufacturing	Import	Import	Repackaging	16	5.1E−11	3.1E−06	273	1	0	0	0	0
	Processing	Repackaging	Intermediate in: Wholesale and retail trade										

Year	Life Cycle Stage	Category	Subcategory	OES	Facility Count (N)	Cancer Risk Range for all Census Blocks within 50 km		Number People Exposed to ≥ 1 in 1,000,000 Risk (1E−06)	N	Number People Exposed to ≥ 1 in 100,000 Risk (1E−05)	N	Number People Exposed to ≥1 in 10,000 Risk (1E−04)	N
						Min	Max						
	Disposal	Disposal	Disposal	Waste handling, disposal, treatment, and recycling	4	1.8E−11	1.8E−07	0	0	0	0	0	0
				Grand Total	**196**			**114,237 (90785)[a]**	**29**	**3,018 (1395)[a]**	**6 (5)[a]**	**80 (0)[a]**	**1 (0)[a]**
2017	Manufacturing	Domestic Manufacturing	Domestic manufacturing	Manufacturing	38	0.0E00	1.3E−04 (1.1E−05)[a]	70,555 (42,125)[a]	14	2,588 (28)[a]	2 (1)[a]	80 (0)[a]	1 (0)[a]
	Processing	Processing as a reactant	Other: monomer used in polymerization process in: plastic material and resin manufacturing; manufacturing synthetic rubber and plastics	Plastics and rubber compounding	29	8.2E−10	1.4E−05	7172	13	170	2	0	0
	Processing	Processing – incorporation into formulation, mixture, or reaction product	Processing aids, not otherwise listed in: petrochemical manufacturing	Processing – incorporation into formulation, mixture, or reaction product	44	0.0E00	6.4E−05	33977	1	877	1	0	0
	Processing	Processing as a reactant	Intermediate in: adhesive manufacturing; all other basic organic chemical manufacturing; fuel binder for solid rocket fuels; organic fiber manufacturing; petrochemical manufacturing; petroleum refineries; plastic material and resin manufacturing; propellant manufacturing; synthetic rubber manufacturing; wholesale and retail trade	Processing as a reactant	52	0.0E00	3.6E−06	525	7	0	0	0	0
	Disposal	Disposal	Disposal	Recycling	11	3.6E−10	4.9E−07	0	0	0	0	0	0

Year	Life Cycle Stage	Category	Subcategory	OES	Facility Count (N)	Cancer Risk Range for all Census Blocks within 50 km		Number People Exposed to ≥ 1 in 1,000,000 Risk (1E−06)	N	Number People Exposed to ≥ 1 in 100,000 Risk (1E−05)	N	Number People Exposed to ≥1 in 10,000 Risk (1E−04)	N
						Min	Max						
	Manufacturing	Import	Import	Repackaging	10	3.0E−09	2.9E−06	1,813	2	0	0	0	0
	Processing	Repackaging	Intermediate in: wholesale and retail trade										
	Disposal	Disposal	Disposal	Waste handling, disposal, treatment, and recycling	3	1.4E−12	8.1E−08	0	0	0	0	0	0
				Grand Total	**187**			**114,042 (85,612)[a]**	**37**	**3,635 (1,075)[a]**	**5 (4)[a]**	**80**	**1**
2018	Manufacturing	Domestic manufacturing	Domestic manufacturing	Manufacturing	37	1.2E−10	7.3E−05	80,424	13	1308	2	0	0
	Processing	Processing as a reactant	Other: monomer used in polymerization process in: plastic material and resin manufacturing; manufacturing synthetic rubber and plastics	Plastics and rubber compounding	28	3.2E−10	9.3E−06	1,346	12	0	0	0	0
	Processing	Processing – incorporation into article	Other: polymer in: Rubber and plastic product manufacturing	Plastics and rubber converting	1	8.0E−13	8.0E−13	0	0	0	0	0	0
	Processing	Processing – incorporation into formulation, mixture, or reaction product	Processing aids, not otherwise listed in: petrochemical manufacturing	Processing – incorporation into formulation, mixture, or reaction product	41	0.0E00	2.4E−06	10	1	0	0	0	0
	Processing	Processing as a reactant	Intermediate in: adhesive manufacturing; all other basic organic chemical manufacturing; fuel binder for solid rocket fuels; organic fiber manufacturing; petrochemical manufacturing; petroleum	Processing as a reactant	51	0.0E00	2.2E−06	522	6	0	0	0	0

Year	Life Cycle Stage	Category	Subcategory	OES	Facility Count (N)	Cancer Risk Range for all Census Blocks within 50 km		Number People Exposed to ≥ 1 in 1,000,000 Risk (1E−06)	N	Number People Exposed to ≥ 1 in 100,000 Risk (1E−05)	N	Number People Exposed to ≥1 in 10,000 Risk (1E−04)	N
						Min	Max						
			refineries; plastic material and resin manufacturing; propellant manufacturing; synthetic rubber manufacturing; wholesale and retail trade										
	Disposal	Disposal	Disposal	Recycling	11	4.0E−10	7.7E−07	0	0	0	0	0	0
	Manufacturing	Import	Import	Repackaging	13	3.0E−09	1.4E−06	1,480	2	0	0	0	0
	Processing	Repackaging	Intermediate in: wholesale and retail trade										
	Disposal	Disposal	Disposal	Waste handling, disposal, treatment, and recycling	4	2.0E−12	9.2E−08	0	0	0	0	0	0
				Grand Total	**186**			**83,782**	**34**	**1,308**	**2**	**0**	**0**
2019	Manufacturing	Domestic Manufacturing	Domestic Manufacturing	Manufacturing	36	1.3E−10	1.0E−04 (2.3E−05)[a]	172,773 (150,547)[a]	15	3,450 (1827)	4 (3)[a]	80 (0)[a]	1 (0)[a]
	Processing	Processing as a reactant	Other: monomer used in polymerization process in: plastic material and resin manufacturing; manufacturing synthetic rubber and plastics	Plastics and rubber compounding	28	3.2E−10	1.1E−05	1,986	11	161	1	0	0
	Processing	Processing – incorporation into formulation, mixture, or reaction product	Processing aids, not otherwise listed in: petrochemical manufacturing	Processing – incorporation into formulation, mixture, or reaction product	47	0.0E00	2.5E−06	0	0	0	0	0	0

Year	Life Cycle Stage	Category	Subcategory	OES	Facility Count (N)	Cancer Risk Range for all Census Blocks within 50 km		Number People Exposed to ≥ 1 in 1,000,000 Risk (1E−06)	N	Number People Exposed to ≥ 1 in 100,000 Risk (1E−05)	N	Number People Exposed to ≥1 in 10,000 Risk (1E−04)	N
						Min	Max						
	Processing	Processing as a reactant	Intermediate in: Adhesive manufacturing; All other basic organic chemical manufacturing; Fuel binder for solid rocket fuels; Organic fiber manufacturing; Petrochemical manufacturing; Petroleum refineries; Plastic material and resin manufacturing; Propellant manufacturing; Synthetic rubber manufacturing; Wholesale and retail trade	Processing as a Reactant	51	6.1E−11	9.4E−06	2,670	7	0	0	0	0
	Disposal	Disposal	Disposal	Recycling	11	5.1E−10	2.9E−07	0	0	0	0	0	0
	Manufacturing	Import	Import	Repackaging	14	0.0E00	2.2E−06	1,100	2	0	0	0	0
	Processing	Repackaging	Intermediate in: Wholesale and retail trade										
	Disposal	Disposal	Disposal	Waste Handling, Disposal, Treatment, and Recycling	4	1.6E−12	9.2E−08	0	0	0	0	0	0
				Grand Total	**191**			**178,529 (156,303)[a]**	**35**	**3,611 (1,988)[a]**	**5 (4)[a]**	**80 (0)[a]**	**1 (0)[a]**
2020	Manufacturing	Domestic Manufacturing	Domestic Manufacturing	Manufacturing	38	1.3E−10	8.4E−05	74,858	13	1,288	1	0	0
	Processing	Processing as a reactant	Other: Monomer used in polymerization process in: Plastic material and resin manufacturing; Manufacturing synthetic rubber and plastics	Plastics and Rubber Compounding	29	7.7E−10	2.4E−05	3,724	11	162	2	0	0

Year	Life Cycle Stage	Category	Subcategory	OES	Facility Count (N)	Cancer Risk Range for all Census Blocks within 50 km		Number People Exposed to ≥ 1 in 1,000,000 Risk (1E−06)	N	Number People Exposed to ≥ 1 in 100,000 Risk (1E−05)	N	Number People Exposed to ≥1 in 10,000 Risk (1E−04)	N
						Min	Max						
	Processing	Processing – incorporation into formulation, mixture, or reaction product	Processing aids, not otherwise listed in: Petrochemical manufacturing	Processing – incorporation into formulation, mixture, or reaction product	43	0.0E00	2.7E−06	0	0	0	0	0	0
	Processing	Processing as a reactant	Intermediate in: Adhesive manufacturing; All other basic organic chemical manufacturing; Fuel binder for solid rocket fuels; Organic fiber manufacturing; Petrochemical manufacturing; Petroleum refineries; Plastic material and resin manufacturing; Propellant manufacturing; Synthetic rubber manufacturing; Wholesale and retail trade	Processing as a Reactant	52	0.0E00	1.1E−05	781	7	1		0	0
	Disposal	Disposal	Disposal	Recycling	11	1.5E−10	2.7E−07	0	0	0	0	0	0
	Manufacturing	Import	Import	Repackaging	12	0.0E00	2.9E−06	544	3	0	0	0	0
	Processing	Repackaging	Intermediate in: Wholesale and retail trade										
	Disposal	Disposal	Disposal	Waste Handling, Disposal, Treatment, and Recycling	4	3.5E−12	8.3E−08	0	0	0	0	0	0
				Grand Total	**189**			**79,907**	**34**	**1,451**	**3**	**0**	**0**
2021	Manufacturing	Domestic Manufacturing	Domestic Manufacturing	Manufacturing	37	6.5E−11	8.9E−05	80,461	15	1,721	3	0	0

Year	Life Cycle Stage	Category	Subcategory	OES	Facility Count (N)	Cancer Risk Range for all Census Blocks within 50 km		Number People Exposed to ≥ 1 in 1,000,000 Risk (1E−06)	N	Number People Exposed to ≥ 1 in 100,000 Risk (1E−05)	N	Number People Exposed to ≥1 in 10,000 Risk (1E−04)	N
						Min	Max						
	Processing	Processing as a reactant	Other: Monomer used in polymerization process in: Plastic material and resin manufacturing; Manufacturing synthetic rubber and plastics	Plastics and Rubber Compounding	31	6.4E−10	3.2E−05	40,86	13	161	1	0	0
	Processing	Processing – incorporation into formulation, mixture, or reaction product	Processing aids, not otherwise listed in: Petrochemical manufacturing	Processing – incorporation into formulation, mixture, or reaction product	41	0.0E00	2.7E−06	0	0	0	0	0	0
	Processing	Processing as a reactant	Intermediate in: Adhesive manufacturing; All other basic organic chemical manufacturing; Fuel binder for solid rocket fuels; Organic fiber manufacturing; Petrochemical manufacturing; Petroleum refineries; Plastic material and resin manufacturing; Propellant manufacturing; Synthetic rubber manufacturing; Wholesale and retail trade	Processing as a Reactant	49	0.0E00	1.1E−05	812	7	1	1	0	0
	Disposal	Disposal	Disposal	Recycling	11	1.7E−10	2.4E−07	0		0		0	
	Manufacturing	Import	Import	Repackaging	12	0.0E00	6.4E−06	1,356	3	0	0	0	0
	Processing	Repackaging	Intermediate in: Wholesale and retail trade										
	Disposal	Disposal	Disposal	Waste Handling, Disposal, Treatment, and Recycling	3	3.5E−12	9.2E−08	0	0	0	0	0	0

Year	Life Cycle Stage	Category	Subcategory	OES	Facility Count (N)	Cancer Risk Range for all Census Blocks within 50 km		Number People Exposed to ≥ 1 in 1,000,000 Risk (1E−06)	N	Number People Exposed to ≥ 1 in 100,000 Risk (1E−05)	N	Number People Exposed to ≥1 in 10,000 Risk (1E−04)	N
						Min	Max						
				Grand Total	**184**			**86,715**	**38**	**1,883**	**5**	**0**	**0**

[a] Denotes updated results with corrected location for Inoes Chocolate Bayou Plant

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Table 5-7. Human Exposure Model (HEM) Demographic Cancer Risk Results Nationwide

Distribution of Cancer Risk for Racial and Ethnic Groups, Age Groups, Adults without a High School Diploma, People Living in Low Income Households, and People Living in Linguistic Isolation – 50 km Study Area Radius

Year	Descriptor	Total Population	White	People of Color [c]	African American	Native American	Other and Multi-racial	Hispanic or Latino [d]	Age (years) 0–17	Age (years) 18–64	Age (years) ≥65	People Living Below the Poverty Level	People Living Below Twice the Poverty Level	Total Number ≥25 Years Old	Number ≥25 Years Old without a High School Diploma	People Living in Linguistic Isolation
All	Nationwide demographic breakdown															
	Total population[a]	329,824,950	196,283,090	133,541,860	39,997,867	2,076,003	28,894,345	62,573,645	73,907,898	202,887,029	53,030,023	42,311,284	99,653,072	225,188,926	26,087,112	17,242,818
	Percentage of total		59.5%	40.5%	12.1%	0.6%	8.8%	19.0%	22.4%	61.5%	16.1%	12.8%	30.2%	68.3%	11.6%	5.2%
2016	Proximity results															
	Total population within 50 km of any facility	110,900,368	58,474,444	52,425,924	15,892,328	431,730	12,872,392	23,229,473	24,612,214	69,557,736	16,730,418	13,739,964	31,167,722	76,311,023	9,165,100	6,918,769
	Percentage of total		52.7%	47.3%	14.3%	0.4%	11.6%	20.9%	22.2%	62.7%	15.1%	12.4%	28.1%	68.8%	12.0%	6.2%
	Average risk (in one million) [e]	0.02	0.01	0.02	0.02	0.008	0.01	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03
2017	Proximity results															
	Total population within 50 km of any facility	99,416,428	52,232,582	47,183,846	14,443,744	398,265	12,010,455	20,331,383	21,874,530	62,351,960	15,189,937	12,457,100	28,032,826	68,620,325	8,266,315	6,365,954
	Percentage of total		52.5%	47.5%	14.5%	0.4%	12.1%	20.5%	22.0%	62.7%	15.3%	12.5%	28.2%	69.0%	12.0%	6.4%
	Average risk (in one million) [e]	0.02	0.02	0.03	0.03	0.01	0.01	0.04	0.03	0.02	0.02	0.03	0.03	0.02	0.03	0.03
2018	Proximity results															
	Total population within 50 km of any facility	105,570,626	56,289,137	49,281,489	14,696,118	432,512	13,143,845	21,009,014	23,151,403	66,342,311	16,076,912	12,996,068	29,283,747	72,999,660	8,572,772	6,635,136
	Percentage of total		53.3%	46.7%	13.9%	0.4%	12.5%	19.9%	21.9%	62.8%	15.2%	12.3%	27.7%	69.1%	11.7%	6.3%
	Average risk (in one million) [e]	0.02	0.01	0.02	0.02	0.008	0.009	0.04	0.02	0.02	0.01	0.02	0.02	0.02	0.03	0.03
2019	Proximity results															

Distribution of Cancer Risk for Racial and Ethnic Groups, Age Groups, Adults without a High School Diploma, People Living in Low Income Households, and People Living in Linguistic Isolation – 50 km Study Area Radius

Year	Descriptor	Total Population	White	People of Color [c]	African American	Native American	Other and Multi-racial	Hispanic or Latino [d]	Age (years) 0–17	Age (years) 18–64	Age (years) ≥65	People Living Below the Poverty Level	People Living Below Twice the Poverty Level	Total Number ≥25 Years Old	Number ≥25 Years Old without a High School Diploma	People Living in Linguistic Isolation
	Total population within 50 km of any facility	106,339,741	57,371,278	48,968,463	14,957,553	434,080	12,533,118	21,043,712	23,343,102	66,858,003	16,138,635	13,106,134	29,533,562	73,513,418	8,629,228	6,623,056
	Percentage of total		54.0%	46.0%	14.1%	0.4%	11.8%	19.8%	22.0%	62.9%	15.2%	12.3%	27.8%	69.1%	11.7%	6.2%
	Average risk (in one million) [e]	0.02	0.02	0.03	0.03	0.009	0.01	0.04	0.02	0.02	0.02	0.03	0.03	0.02	0.03	0.03
2020	Proximity results															
2020	Total population within 50 km of any facility	103,238,135	55,055,508	48,182,627	14,879,280	410,928	12,196,430	20,695,990	22,674,417	64,895,383	15,668,335	12,810,913	28,813,070	71,328,812	8,466,056	6,531,694
2020	Percentage of total		53.3%	46.7%	14.4%	0.4%	11.8%	20.0%	22.0%	62.9%	15.2%	12.4%	27.9%	69.1%	11.9%	6.3%
2020	Average risk (in one million) [e]	0.02	0.01	0.02	0.02	0.008	0.01	0.04	0.02	0.02	0.01	0.02	0.02	0.02	0.03	0.03
2021	Proximity results															
2021	Total population within 50 km of any facility	104,974,141	56,348,397	48,625,744	14,835,396	377,634	12,463,647	20,949,067	23,018,202	66,027,341	15,928,598	12,929,561	29,133,736	72,585,658	8,535,192	6,599,365
2021	Percentage of total		53.7%	46.3%	14.1%	0.4%	11.9%	20.0%	21.9%	62.9%	15.2%	12.3%	27.8%	69.1%	11.8%	6.3%
2021	Average risk (in one million) [e]	0.02	0.01	0.03	0.02	0.01	0.01	0.04	0.02	0.02	0.02	0.03	0.03	0.02	0.03	0.03

[a] Total nationwide population includes all 50 states plus Puerto Rico.
Distributions by race, ethnicity, age, education, income, and linguistic isolation are based on demographic information at the census block group level. Risks from UpdatedUIR_AddedREs_2016R emissions are modeled at the census block level.
[b] Modeled risks are for a 70-year lifetime, based on the predicted outdoor concentration and not adjusted for exposure factors.
[c] The People of Color population includes people identifying as African American, Native American, Other and Multiracial, or Hispanic/Latino. Measures are taken to avoid double counting of people identifying as both Hispanic/Latino and a racial minority.
[d] In order to avoid double counting, the “Hispanic or Latino” category is treated as a distinct demographic category for these analyses. A person is identified as one of five racial/ethnic categories above: White, African American, Native American, Other and Multiracial, or Hispanic/Latino.
[e] The population-weighted average risk takes into account risk levels at all populated block receptors in the modeled domain for the entire source category.

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5.3.5 Risk Characterization for Potentially Exposed or Susceptible Subpopulations

For the 1,3-butadiene risk evaluation, EPA considered information that could support increased exposure or biological susceptibility compared to the general population (see Appendix D for full list of factors). EPA was able to incorporate considerations for multiple PESS factors into risk estimates, as presented in Table 5-8. EPA considered these PESS factors through the use of exposure factors, uncertainty factors, PESS group-specific data. In some cases, information on PESS factors may have supported the weight of scientific evidence for a particular hazard or exposure value. For the non-cancer health endpoint, EPA performed dose-response analysis for multiple repeat-dose non-cancer endpoints under each hazard domain. Decreased fetal weight associated with other developmental toxicity outcomes was selected as the most sensitive and robust human-relevant endpoint for use in risk characterization of intermediate and chronic exposures. For the cancer health endpoint, EPA used an occupational epidemiological cohort, comprised of both male and female workers, with more than 50 years of follow-up and subsequent exposure estimate updates to derive inhalation hazard values for leukemia applicable to general population and occupational exposures. Due to an identified mutagenic mode of action for cancer, EPA applied an age-dependent adjustment factor (ADAF) for the general population to account for elevated childhood susceptibility. The combination of using the most sensitive endpoint protective of the pregnant worker, robust evidence from a large, highly exposed occupational human cohort tracked over many decades along with the application of an ADAF, allows the derived hazard values used for non-cancer and cancer risk characterizations to fully account for potentially exposed or susceptible subpopulations. Full details on all available information relating to biological susceptibility are presented in Section 7.2 of the *Draft Human Health Hazard Assessment for 1,3-Butadiene* (U.S. EPA, 2024t)—including PESS factors with only indirect evidence or otherwise insufficient information to incorporate into hazard or risk values.

1566 **Table 5-8. Summary of PESS Factors Incorporated into Risk Estimates**

PESS Factor	Potential Increased Exposures Incorporated into Exposure Assessment	Sources of Uncertainty for Exposure Assessment	Potential Sources of Biological Susceptibility Incorporated into Hazard Assessment	Sources of Uncertainty for Hazard Assessment
Lifestage	• Lifestage-specific exposures were not incorporated into the risk evaluation.	• Exposures were quantified as air concentrations and not internal dose. However, UF_H is expected to account for any toxicokinetic differences (U.S. EPA, 2012a).	• Direct evidence of a developmental effect was the basis for the intermediate/chronic POD used for risk estimation. • Increased susceptibility of children to cancer was addressed by incorporation of an ADAF into the general population IUR.	• EPA expects that this PESS factor is sufficiently accounted for in risk estimates.
Pre-existing Disease	*Not applicable*	*Not applicable*	• Application of a 10× UF_H to account for human variability.	• Especially susceptible individuals may not be accounted for by standard approaches.
Occupational and Consumer Exposures	• Occupational exposure sampling data was broken down into subsets of worker roles that identify higher exposure activities. • Worker exposures and hazard values incorporated adjustments for relative breathing rate per day of exposed workers compared to the general population.	• The majority of occupational exposure sampling data points used in generating estimates of occupational exposure were not quantifiable values but were identified as being below the limit of detection (LOD). • Exposure factors change over time and differing assumptions may result in risk estimates varying by up to 30%.	*Not applicable*	*Not applicable*
Geography/Site-specific	• Populations who reside nearby facility releases of 1,3-butadiene were taken into consideration with modeled exposure concentrations by distance	• The estimates of risks via ambient air are dependent on inputs and assumptions described in Section 2 of the *Draft General Population Exposures for 1,3-Butadiene* (U.S. EPA, 2024r) and calculations based on census data and equations from the Human Exposure Model (HEM) as detailed in the HEM User's Guides	*Not applicable*	*Not applicable*

PESS Factor	Potential Increased Exposures Incorporated into Exposure Assessment	Sources of Uncertainty for Exposure Assessment	Potential Sources of Biological Susceptibility Incorporated into Hazard Assessment	Sources of Uncertainty for Hazard Assessment
Sociodemographic Status	• Cancer risks were estimated for racial and ethnic groups, age groups, poverty and linguistically isolated areas	• The estimates of risks via ambient air are dependent on inputs and assumptions described in Section 2 of the *Draft General Population Exposures for 1,3-Butadiene* (U.S. EPA, 2024r) and calculations based on census data and equations from the Human Exposure Model (HEM) as detailed in the HEM User's Guides	• EPA utilized the most sensitive sex from rodent assays for non-cancer dose-response modeling and incorporated data from both sexes in cancer modeling.	• EPA was unable to quantify sociodemographic differences other than sex.
Genetics/ Epigenetics	*Not applicable*	*Not applicable*	• Application of a linear low-dose cancer dose-response model should account for varying susceptibility across populations. • Application of a 10x UF_H to account for human variability.	• Hazard values are based on wild-type rodents and a broad occupational population and may underestimate risks for populations with sensitizing mutations.
Aggregate Exposures	• Cancer risks were estimated based on aggregate modeled exposure concentrations at census blocks	• The estimates of exposure via ambient air are dependent on inputs and assumptions described in Section 2 of the *Draft General Population Exposures for 1,3-Butadiene* (U.S. EPA, 2024r)	*Not applicable*	*Not applicable*

5.3.6 Risk Characterization for Aggregate Exposures

Section 2605(b)(4)(F)(ii) of TSCA requires EPA, as a part of the Risk Evaluation, to describe whether aggregate or sentinel exposures under the conditions of use were considered and the basis for their consideration. Further, in the final RE framework rule, EPA codified at 720.39(d)(8), a requirement that "EPA will consider aggregate exposures to the chemical substance, and, when supported by reasonably available information, consistent with the best available science and based on the weight of scientific evidence, include an aggregate exposure assessment in the risk evaluation, or will otherwise explain in the risk evaluation the basis for not including such an assessment."

EPA quantified risk estimates for TRI-reporting facilities. The highest risk estimates based on modeled air concentrations were focused along the Texas and Louisiana Gulf Coast (Figure 5-2). AMTIC monitoring stations report air concentrations of ambient 1,3-butadiene from all sources, including fuel combustion. Monitoring data provide an indication of the aggregate risk from all sources contributing to ambient air concentrations of 1,3-butadiene, which may be present in the real world and provide context for risks from individual TSCA COUs. The modeled and monitored air concentrations (AMTIC) are with an order of magnitude along the Texas and Louisiana Gulf Coast, indicating that the modeled numbers used for risk evaluation capture aggregate 1,3-butadiene exposure in the region of the United States showing highest risk estimates. Additionally, EPA incorporated aggregation of environmental exposures from multiple facilities to the general population within a given census track; modeled numbers reflect aggregation of facilities within 50 km of each other.

5.3.7 Overall Confidence and Remaining Uncertainties in Human Health Risk Characterization

There is robust confidence in the human health hazard values for both non-cancer and cancer endpoints (see Section 6 of the *Draft Human Health Hazard Assessment for 1,3-Butadiene* (U.S. EPA, 2024t)). The non-cancer HEC is supported by multiple effects observed at similar doses across studies at relevant exposure durations and despite large differences in metabolism across species, maternal-developmental effects were observed in both mice and rats (Sections 4.2.1.2 and 4.2.2.2.3 of (U.S. EPA, 2024t)). The general population cancer IUR/chronic occupational UR is based on a large occupational human cohort tracked over many decades with robust evidence for the leukemia endpoint (Sections 5.3.1.1 and 5.3.2 of (U.S. EPA, 2024t)). As mentioned in Section 5.2.1 however, cancer risk estimates may underestimate total cancer risk due to not incorporating bladder cancer risk, of which EPA is uncertain.

5.3.7.1 Occupational Risk Characterization

For the 1,3-butadiene risk evaluation, EPA has robust confidence in the inhalation exposure data. Several OES studies of 1,3-butadiene exposure were directly applicable and used to estimate inhalation exposures. Additionally, inhalation exposure data collected during OSHA enforcement activities provided additional sampling data across several industries and conditions of use. The primary strength of this data is the use of personal and applicable data that received a high rating during systematic review and data used in enforcement proceedings.

The primary limitations to these data include the uncertainty of the representativeness of the exposures in specific industries, uncertainty in the representativeness of the data towards the true distribution of inhalation concentrations in this scenario, that the data come primarily from one industry source, and that much of the data for both workers and ONUs from the source were reported as below the LOD. When reported monitoring data was a non-detect, EPA applied the submitter's methodology of using the LOD as the high-end estimate and ½ the LOD as the central tendency. These standard conservative assumptions were applied consistent with EPA's *Guidelines for Statistical Analysis of Occupational*

Exposure Data). EPA also assumed 250 exposure days per year for routine 8-hour shifts based on 1,3-butadiene exposure each working day for a typical worker schedule consistent with the OSHA PEL and other occupational exposure limits; it is uncertain whether this captures actual worker schedules and exposures. While for many COUs the majority of monitored values were non-detects, high-end (95%tile) values were typically based on measured, recorded values above the LOD. Central tendency estimates incorporated both measured values and statistical adjustments for non-detects. Exposure values are based on single-day measurements that are extrapolated to represent average daily concentrations over the specified duration. Therefore, high-end exposures and risk estimates are most appropriate for consideration of shorter-duration exposures (*i.e.*, intermediate) while central tendency values are more representative for chronic and lifetime exposures.

Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for the occupational exposure assessment overall is moderate and provides a plausible estimate of exposures in consideration of the strengths and limitations of reasonably available data. There is reduced confidence in conclusions of potential risks when risks relative to benchmark are indicated only at higher-end exposures. As stated above, this is especially true for cancer, which is based on average exposure across a lifetime, in contrast with intermediate exposures for which higher-end measurements are more applicable. Additionally, for these scenarios there is robust confidence when high-end exposures did *not* indicate risk relative to benchmarks. For example, EPA had the lowest confidence for exposure estimates from application of paints, coatings, adhesives, and sealants because all associated datapoints were below the LOD. However, potential risk was not identified for this OES even at high-end exposure set equivalent to the LOD, and therefore EPA has robust confidence that risk is not associated with this COU/OES.

There is moderate to robust confidence in the risk estimates relative to benchmarks for the two OES/SEGs with the highest exposure: non-routine laboratory technician and repackaging. Risk estimates for these scenarios were 1 to 2 orders of magnitude away from benchmarks, suggesting that any refinements to the monitoring sensitivity or other consideration would be highly unlikely to change the conclusions. Details for confidence in the exposure assessment for other OES are summarized in Section 5.1.1.2. For more detail, see *the Draft Environmental Releases and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2024y).

5.3.7.2 General Population Risk Characterization

Based on the weight of scientific evidence for general population exposures detailed in Section 5.1.3.2 and for human health hazard in Section 5.2.1: the high-rated quality of environmental release data combined with peer-reviewed models to assess general population exposure and the robust human, animal, and mechanistic evidence associating leukemia and other lymphohematopoietic cancers with 1,3-butadiene exposure, EPA has robust confidence in the general population risk characterization. The use of HEM risk results based on census block information, incorporating population count and sociodemographic data as well as providing geospatial visualizations, allows for a representative estimation of exposure concentrations and risk for the general population. However, EPA acknowledges that the assumptions made for the general population being exposed to modeled ambient air concentrations 24 hours a day, 365 days a year, over a lifetime contributes uncertainty to the estimates. There is also uncertainty as to whether risk is underestimated or overestimated due to photodegradation of 1,3-butadiene (See Section 3.1) not being accounted for in this risk evaluation.

6 ENVIRONMENTAL RISK ASSESSMENT

1,3-Butadiene – Environmental Risk Assessment (Section 6):
Key Points

EPA evaluated the reasonably available information for environmental exposures to 1,3-butadiene. The key points of the environmental exposures and hazards assessment are summarized below.

- Although 1,3-butadiene may be released to water, land, and air, 1,3-butadiene concentrations were not modeled for the surface water and land pathways because 1,3-butadiene is primarily released as a gas to air. It is not expected to persist in soil and water based on physical and chemical properties and environmental fate and transport characteristics.
- EPA qualitatively assessed environmental exposures of 1,3-butadiene in water and soil.
  - 1,3-Butadiene is not expected to be present in surface water given minimal releases to surface water, rapid biodegradation, and volatilization. Additionally, 1,3-butadiene has low sorption potential and is not expected to be present in sediment.
  - 1,3-Butadiene is not released to soil and air to soil deposition is not expected due to the physical and chemical properties (high volatility and reactivity and low sorption to organic material).
- 1,3-Butadiene releases in air are expected to be the predominant pathway of environmental exposure.
  - Extensive ambient air monitoring data are available for 1,3-butadiene and confirms that air is the primary exposure pathway.
  - Although these data demonstrate 1,3-butadiene concentrations in ambient air, the source is unknown. Concentrations of 1,3-butadiene in ambient air are likely from a combination of TSCA and other sources (*e.g.*, forest fires, mobile exhaust, etc.).
  - EPA summarizes available 1,3-butadiene ambient air monitoring data in this draft assessment.
- There is no risk to aquatic organisms as 1,3-butadiene is not appreciably released to, and does not persist in, surface water and exposure is not expected.
- There is no risk to terrestrial organisms through soil exposure as 1,3-butadiene does not partition, deposit, or persist in or on land and exposure is not expected.
- Although exposure of 1,3-butadiene to terrestrial organisms is expected via ambient air, exposures will be transient due to the reactive nature of 1,3-butadiene. Further, 1,3-butadiene exposure in ambient air cannot be attributed to a specific TSCA use. Thus, environmental risk to terrestrial organisms via ambient air was not quantitatively assessed.

6.1 Summary of Environmental Exposures

6.1.1 Summary of Exposures to Aquatic Species

1,3-Butadiene is not expected to be present in surface water due to its physical and chemical properties (gas form under ambient conditions, high volatility and reactivity, low sorption potential (*Draft Physical Chemistry and Fate Assessment* (U.S. EPA, 2024z)). 1,3-Butadiene releases to surface water are minimal (*Draft Environmental Release and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2024y)). Additionally, monitoring results from WQP indicate all surface water samples (n = 231) were below detection limits for 1,3-butadiene (0.04 μg/L) (*Draft Environmental Media Concentrations* *for 1,3-Butadiene* (U.S. EPA, 2024p)). Thus, multiple lines of evidence demonstrate 1,3-butadiene will not be present in surface water and aquatic organisms will not be exposed to 1,3-butadiene.

6.1.2 Summary of Exposures to Terrestrial Species

Releases of 1,3-butadiene to land make up less than one percent of 1,3-butadiene releases to the environment, and most land releases are to class I underground injection wells (*Draft Environmental Release and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2024y)). Class I wells are typically drilled thousands of feet below any drinking water aquifers and are constructed to contain injected waste streams and prevent movement into water systems or soil. Terrestrial organisms will not be exposed to 1,3-butadiene via the land pathway (soil, biosolids) based on the low volume of releases to land, the low risk of failure of class I injection wells, the physical and chemical properties of 1,3-butadiene (*i.e.*, low sorption potential) as well as monitoring data indicating less than one percent detection frequency (see *Draft Physical Chemistry and Fate Assessment for 1,3-Butadiene* and *Draft Environmental Media Concentrations for 1,3-Butadiene* (U.S. EPA, 2024p, z)).

Extensive ambient air data, both measured data and monitoring data, are available for 1,3-butadiene and confirm that air is the primary exposure pathway. Terrestrial organisms are likely exposed to 1,3-butadiene in air; however, the sources of 1,3-butadiene in ambient air are a combination of TSCA and other sources (*e.g.*, forest fires, mobile exhaust, etc.). EPA summarizes available 1,3-butadiene ambient air measured concentrations and monitoring data in *Draft Environmental Media Concentrations for 1,3-Butadiene* (U.S. EPA, 2024p).

6.1.3 Weight of Scientific Evidence Conclusions for Environmental Exposures

EPA uses several considerations when weighing the scientific evidence to determine confidence in the draft environmental risk assessment. These considerations include the quality of the database, consistency, strength, and precision, biological gradient/dose response, and relevance. This approach is consistent with the *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances* (U.S. EPA, 2021a). EPA has robust confidence in this environmental exposure assessment.

The 1,3-butadiene data from the WQP has a strong bias of samples collected from California, New York, Texas, Georgia, North Carolina, and Florida (which represents >39% of the U.S. population) relative to other areas and was missing data from Alaska, Delaware, Rhode Island, Hawaii, and Vermont (<2% of the U.S. population). The states with a higher number of data points are states where a higher percentage of the U.S. population resides. In addition, states with a concentration of facilities releasing 1,3-butadiene, such as Texas and Louisiana, are included in the monitoring database. Due to the presence of 1,3-butadiene releasing facilities, these states would be expected to have the largest 1,3-butadiene releases. Because data reflects that 1,3-butadiene is typically not detected above the detection limit in water, EPA has robust confidence that in areas with lower releases, 1,3-butadiene will not be in the water. In addition, based on the physical and chemical properties of 1,3-butadiene and low release quantities to water and land, EPA has confidence that the WQP data is representative of the entire United States. Notably, the WQP data is not specific to only TSCA COUs. Therefore, EPA has robust confidence in this environmental exposure assessment.

6.2 Environmental Risk Characterization

6.2.1 Risk Assessment Approach

EPA determined that, based on the fate properties of 1,3-butadiene (see Section 3 and *Draft Physical Chemistry and Fate Assessment for 1,3-Butadiene* (U.S. EPA, 2024z)), an in-depth analysis of releases to water or land and associated exposures from those releases were not needed for the water or land pathways since 1,3-butadiene does not persist in either medium. EPA used information from all reasonably available sources to characterize exposure, hazard, and risk posed from 1,3-butadiene to aquatic and terrestrial organisms.

6.2.2 Risk Estimates for Aquatic Species

1,3-Butadiene rapidly biodegrades in aerobic aquatic environments and rapidly volatilizes from water to air, and is therefore not expected to persist in water (see Section 3 and *Draft Physical Chemistry and Fate Assessment for 1,3-Butadiene* (U.S. EPA, 2024z)). Given (1) the physical and chemical properties governing the environmental fate of 1,3-butadiene in water, (2) limited release of 1,3-butadiene directly to surface water, and (3) available monitoring data demonstrating 1,3-butadiene was not detected in water, EPA does not expect that 1,3-butadiene will persist in surface water or groundwater. Therefore, EPA concludes there is no expected risk to aquatic organisms for all COUs due to no 1,3-butadiene exposure in water or sediment.

1,3-Butadiene is not expected to sorb to suspended solids based on its physical and chemical properties. As such, terrestrial exposures via soil and sediment are not expected and, therefore, are not quantified. Environmental fate and transport data indicate 1,3-butadiene does not bioaccumulate (see Section 3 and *Draft Physical Chemistry and Fate Assessment for 1,3-Butadiene* (U.S. EPA, 2024z)). Thus, there is no dietary exposure of 1,3-butadiene from aquatic organisms to terrestrial organisms and no risk is expected for all COUs.

6.2.3 Risk Estimates for Terrestrial Species

1,3-Butadiene does not sorb or bind to soil or sediment and does not persist on land (due to volatility and reactivity) (see Section 3 and *Draft Physical Chemistry and Fate Assessment for 1,3-Butadiene* (U.S. EPA, 2024z)). The predominant environmental release of 1,3-butadiene to land is disposal via underground injection into wells. Therefore, there are no appreciable direct releases to land (see Section 3 and *Draft Physical Chemistry and Fate Assessment for 1,3-Butadiene* (U.S. EPA, 2024z)). Considering these lines of evidence, 1,3-butadiene is not expected to persist in or on land. Therefore, EPA concludes there is no expected risk from any COU to terrestrial organisms via the land pathway due to no 1,3-butadiene exposure in soils. There is no expected risk from any COU via dietary exposure to terrestrial organisms is expected as 1,3-butadiene does not bioaccumulate (see Section 3 and *Draft Physical Chemistry and Fate Assessment for 1,3-Butadiene* (U.S. EPA, 2024z)).

Environmental fate and release data indicate that there is no expected risk to terrestrial organisms via soil exposure is expected. Specifically, 1,3-butadiene rapidly volatilizes, has low sorption potential, and has an estimated half-life of 7 to 28 days in soil. Further, environmental release of 1,3-butadiene to land accounts for less than one percent of total environmental releases.

Terrestrial organisms may be exposed to 1,3-butadiene via ambient air and extensive ambient air monitoring data are available. These data show that 1,3-butadiene is prevalent in ambient air and confirms that air is a major 1,3-butadiene exposure pathway. Although these data represent actual 1,3-butadiene concentrations in ambient air, the source is unknown and likely a combination of TSCA and other sources (*e.g.*, forest fires, mobile exhaust).
A potential terrestrial 1,3-butadiene exposure scenario may involve a fugitive or stack 1,3-butadiene release to ambient air from a TSCA COU that is inhaled by terrestrial organisms located in proximity to the release facility. Many terrestrial organisms are transient in the environment. As such, the aforementioned exposure scenario is most applicable to local and non-transient organisms such as plants. However, there are no available plant hazard data for 1,3-butadiene, and there is uncertainty in attributing exposure to a TSCA source. Therefore, risk to terrestrial plants cannot be determined.

6.2.4 Overall Confidence and Remaining Uncertainties in Environmental Risk Characterization

EPA used several considerations when weighing the scientific evidence to determine confidence in the draft environmental risk assessment. These considerations include the quality of the database, consistency, strength and precision, biological gradient/dose response, and relevance. This approach is consistent with the *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances* (U.S. EPA, 2021a). EPA has robust confidence in this environmental risk assessment.

The Agency has robust confidence in the conclusion that there is no expected risk to aquatic organisms resulting from TSCA COUs. Multiple lines of evidence support this conclusion. Environmental fate and transport data indicate 1,3-butadiene is expected to have negligible persistence in water (*Draft Physical Chemistry and Fate Assessment for 1,3-Butadiene* (U.S. EPA, 2024z)). There are also limited releases of 1,3-butadiene directly to surface water due to TSCA COUs and available monitoring data demonstrate that 1,3-butadiene has not been detected in water.

EPA has robust confidence in the conclusion that there is no expected risk to terrestrial organisms due to TSCA COUs via the land pathway. Multiple lines of evidence support this conclusion. Environmental fate and transport data indicate 1,3-butadiene does not sorb or bind to soil or sediment and has negligible persistence on land (due to volatility and reactivity) (see Section 3 and *Draft Physical Chemistry and Fate Assessment for 1,3-Butadiene* (U.S. EPA, 2024z)). Furthermore, 1,3-butadiene is reactive and volatile. There are also limited releases of 1,3-butadiene to land (see Section 3 and *Draft Physical Chemistry and Fate Assessment for 1,3-Butadiene* (U.S. EPA, 2024z)). These chemical and fate properties support a robust confidence conclusion.

EPA also has robust confidence that there is no expected risk to terrestrial organisms due to TSCA COUs via the dietary pathway. Environmental fate and transport data indicate 1,3-butadiene does not bioaccumulate (see Section 3 and *Draft Physical Chemistry and Fate Assessment for 1,3-Butadiene* (U.S. EPA, 2024z)). As 1,3-butadiene is also not expected to persist in the water and land pathways, the potential for dietary exposure is limited. These qualities support a robust confidence conclusion.

Risk to terrestrial organisms (*e.g.*, plants, mammals, birds) due to TSCA COUs via the air pathway cannot be determined. Concentrations of 1,3-butadiene in ambient air are due to TSCA and other sources. Additional factors which can impact EPA's ability to attribute exposure for a specific terrestrial organism to a specific TSCA COU are the transient nature of most terrestrial organisms, and the absence of specific activity pattern data of such organisms in or around a particular industrial process which could be attributed to a TSCA COU. Further, there are no relevant hazard data available to assess potential risk to terrestrial organisms.

Additional details on overall confidence and remaining uncertainties are described in the following technical support documents: *Draft Physical Chemistry and Fate Assessment for 1,3-Butadiene* (U.S. EPA, 2024z), *Draft Environmental Media Concentrations for 1,3-Butadiene* (U.S. EPA, 2024p), and *Draft Environmental Release and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2024y).

7 UNREASONABLE RISK DETERMINATION

TSCA section 6(b)(4) requires EPA to conduct a risk evaluation to determine whether a chemical substance presents an unreasonable risk of injury to health or the environment, without consideration of costs or other non-risk factors, including an unreasonable risk to a PESS identified by EPA as relevant to the risk evaluation, under the TSCA COUs.

EPA is preliminarily determining that 1,3-butadiene presents an unreasonable risk of injury to human health under the COUs. Based on the pathways evaluated in the draft risk evaluation for 1,3-butadiene, the Agency is preliminarily determining that risk of injury to the environment does not significantly contribute to EPA's preliminary determination of unreasonable risk. This draft unreasonable risk determination is based on the information in previous sections of this draft risk evaluation, the TSDs that support this draft risk evaluation, and their appendices in accordance with TSCA section 6(b). It is also based on (1) the best available science (TSCA section 26(h)); (2) weight of scientific evidence standards (TSCA section 26(i)); and (3) relevant implementing regulations in 40 CFR part 702, including the amendments to the procedures for chemical risk evaluations under TSCA finalized in May of 2024 (89 FR 37028; May 3, 2024).

As noted in the EXECUTIVE SUMMARY, 1,3-butadiene is primarily used as a chemical intermediate and as a monomer in the manufacture of polymers such as synthetic rubbers and elastomers. This involves polymerization of 1,3-butadiene with itself or with other monomers, then this polymerization product is incorporated into various rubber and plastic articles. Workers may be exposed to 1,3-butadiene when making these products or otherwise using it in the workplace. When it is manufactured or used to make products, 1,3-butadiene is mainly released into the air due to its volatility, with relatively small releases to land or water. If released into water or land, 1,3-butadiene will quickly volatilize from water and land surfaces. 1,3-Butadiene in air will photodegrade within a few hours by reacting with hydroxyl or nitrate radicals in the atmosphere. Therefore, EPA quantitatively evaluated hazards only via the inhalation route. Consistent with these properties, existing assessments (OEHHA, 2013; ATSDR, 2012; Grant et al., 2010; U.S. EPA, 2002a) also concluded that inhalation is the predominant route for human exposures and 1,3-butadiene exposure has not been quantified by any other routes. Additional sources of 1,3-butadiene exposure come from vehicle exhaust, tobacco smoke, burning wood, and forest fires.

Following EPA's *Guidelines for Carcinogen Risk Assessment* (U.S. EPA, 2005a), EPA determined that 1,3-butadiene is *Carcinogenic to Humans* with robust evidence across all evidence streams for lymphohematopoietic cancers, and the weight of scientific evidence supports a mutagenic mode of action for lymphohematopoietic cancers (Section 5.3 of Draft Human Health Assessment). Further, the non-cancer chronic POD is based on decreased fetal weight and was selected as the most robust, human relevant and protective endpoint for use in risk characterization of intermediate and chronic exposures, with a human equivalent concentration (HEC) of 2.5 ppm (5.5 mg/m^3) derived from benchmark dose modeling following dichotomization of mouse fetal weight data. All other representative PODs were within a few fold of this value.

Whether EPA makes a determination of unreasonable risk for a particular chemical substance under amended TSCA depends upon risk-related factors beyond exceedance of benchmarks. These include the endpoint under consideration, the reversibility of the effect, exposure-related considerations (*e.g.*, duration, magnitude, or frequency of exposure, or population exposed), and the confidence in the information used to inform the hazard and exposure values.

To determine whether an occupational COU significantly contributes to unreasonable risk, EPA compares the risk estimates of the occupational exposure scenario (OES) used to evaluate the COUs and considered whether the risk from the COU was best represented by the central tendency or high-end risk estimates.

EPA is preliminarily determining that the following COUs, considered singularly or in combination with other exposures, significantly contribute to the unreasonable risk:

- Manufacturing – domestic manufacturing;
- Manufacturing – import;
- Processing – processing as a reactant – intermediate (adhesive manufacturing; all other basic organic chemical manufacturing; fuel binder for solid rocket fuels; organic fiber manufacturing; petrochemical manufacturing; petroleum refineries; plastic material and resin manufacturing; propellant manufacturing; synthetic rubber manufacturing; paint and coating manufacturing; wholesale and retail trade);
- Processing – processing as a reactant – monomer used in polymerization process (synthetic rubber manufacturing; plastic material and resin manufacturing);
- Processing – incorporation into formulation, mixture, or reaction product – processing aids, not otherwise listed (petrochemical manufacturing; monomers used in: plastic product manufacturing; synthetic rubber manufacturing);
- Processing – incorporation into formulation, mixture, or reaction product – other (adhesive manufacturing, paint and coating manufacturing, petroleum lubricating oil and grease manufacturing, and all other chemical product and preparation manufacturing);
- Processing – incorporation into article – other (polymer in: rubber and plastic product manufacturing);
- Processing – repackaging – intermediate (wholesale and retail trade; monomer in: synthetic rubber manufacturing);
- Processing – recycling;
- Commercial use – other use – laboratory chemicals; and
- Disposal

EPA is preliminarily determining that the following COUs do not contribute significantly to the unreasonable risk:

- Industrial use – adhesives and sealants, including epoxy resins;
- Commercial use – fuels and related products;
- Commercial use – other articles with routine direct contact during normal use including rubber articles; plastic articles (hard);
- Commercial use – toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard);
- Commercial use – synthetic rubber (*e.g.*, rubber tires);
- Commercial use – furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles;
- Commercial use – packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft);
- Commercial use – automotive care products;
- Commercial use – lubricant additives, including viscosity modifier;
- Commercial use – paints and coatings, including aerosol spray paint;
- Commercial use – adhesives and sealants, including epoxy resins;

- Consumer use – other articles with routine direct contact during normal use including rubber articles; plastic articles (hard);
- Consumer use – toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard);
- Consumer use – synthetic rubber (*e.g.*, rubber tires);
- Consumer use – furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles;
- Consumer use – packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft); and
- Distribution in commerce.

7.1 Unreasonable Risk to Human Health

Calculated risk estimates (MOEs[6] or cancer risk estimates) can, when considered together, provide a risk profile of 1,3-butadiene by presenting a range of estimates for different health effects for different COUs. When characterizing the risk to human health from occupational exposures during risk evaluation under TSCA, EPA conducts assessments of risk and makes its determination of unreasonable risk from a scenario that does not assume use of respiratory protection or other personal protective equipment (PPE)[7]. A calculated MOE that is less than the benchmark MOE, in consideration of other risk-related factors, generally supports a determination of unreasonable risk of injury to health, based on non-cancer effects. Similarly, a calculated cancer risk estimate that is greater than the cancer benchmark generally supports a determination of unreasonable risk of injury to health from cancer. It is important to emphasize that these calculated risk estimates alone are not bright-line indicators of unreasonable risk.

7.1.1 Populations and Exposures EPA Assessed to Determine Unreasonable Risk to Human Health

EPA evaluated risk to workers, including occupational non-users (ONUs), consumers, bystanders, and the general population, using reasonably available monitoring and modeling data for inhalation exposures, as applicable. The Agency evaluated risk from inhalation exposure of 1,3-butadiene to workers, including ONUs, for relevant COUs. EPA has quantitatively assessed the commercial use of laboratory chemicals, paints and coatings, and adhesives and sealants. All other commercial/consumer uses were qualitatively assessed. As mentioned in Section 0, based on product searches and systematic review data, EPA has determined that 1,3-butadiene, a monomer used in polymer-derived products such as synthetic rubbers, is stable in these products and not expected to degrade and expose workers or consumers to the 1,3-butadiene monomer. For the general population, EPA has evaluated risk from chronic inhalation exposure from ambient air. No dermal or oral exposure is expected based on physico-chemical properties of 1,3-butadiene.

Descriptions of the data used for human health exposure and human health hazards are provided in Sections 0 and 5.2, respectively, in this draft risk evaluation. Uncertainties for overall exposures and hazards are presented in this draft risk evaluation and TSDs—including the *Draft General Population Exposure Assessment for 1,3-Butadiene*, the *Draft Environmental Media and General Population Screening for 1,3-Butadiene*, and the *Draft Environmental Release and Occupational Exposure*

[6] EPA derives non-cancer MOEs by dividing the non-cancer POD (HEC [mg/m^3] or HED [mg/kg-day]) by the exposure estimate (mg/m^3 or mg/kg-day). Section 5.3.1 has additional information on the risk assessment approach for human health.
[7] It should be noted that, in some cases, baseline conditions may reflect certain mitigation measures, such as engineering controls, in instances where exposure estimates are based on monitoring data at facilities that have engineering controls in place.

Assessment for 1,3-Butadiene —and all are considered in this preliminary unreasonable risk determination.

7.1.2 Summary of Human Health Effects

EPA is preliminarily determining that the unreasonable risk presented by 1,3-butadiene is due to

- non-cancer effects and cancer in workers from inhalation exposures; and
- cancer in the general population, including fenceline communities, from inhalation exposure.

With respect to health endpoints upon which EPA is basing this preliminary unreasonable risk determination for non-cancer effects, the Agency has robust overall confidence in the proposed POD based on decreased fetal weight for intermediate and chronic exposure scenarios. Similarly, for cancer, EPA has robust overall confidence in the proposed POD based on leukemia for chronic exposures. These confidence ratings were based on the weight of scientific evidence considering evidence integration, selection of the critical endpoint and study, relevance to exposure scenarios, dose-response considerations, and consideration of PESS. The confidence in the PODs is described in Section 5.2.

The health risk estimates for workers, including ONU's, consumers, and the general population are presented in Section 5.3. Specifically for human populations, the Agency quantitatively evaluated risk to (1) workers including ONUs via the inhalation route in Section 5.3.2; and (2) the general population via inhalation route in Section 5.3.4. Additionally, EPA considered PESS as discussed in Section 5.3.5.

For more information regarding EPA's approach for developing risk estimates for 1,3-butadiene, see the following supplement files: *Draft Human Health Hazard Assessment for 1,3-Butadiene* (U.S. EPA, 2024t), *Draft Environmental Releases and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2024y), *Draft Human Exposure Model (HEM) TRI 2016–2021 Exposure and Risk Analysis for 1,3-Butadiene* (U.S. EPA, 2024s), and *Draft General Population Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2024r). The *Draft Risk Calculator for Occupational Exposures for 1,3-Butadiene* (U.S. EPA, 2024aa) contains all calculations, exposure values, and exposure factors for workers and ONUs.

7.1.3 Basis for Unreasonable Risk to Human Health

In developing the exposure and hazard assessments for 1,3-butadiene, EPA analyzed reasonably available information to ascertain whether some human populations may have greater exposure and/or susceptibility than the general population to the hazard posed by 1,3-butadiene. For the 1,3-butadiene draft risk evaluation, EPA accounted for the following PESS: females of reproductive age, males of reproductive age, pregnant females, infants, children and adolescents, people exposed to 1,3-butadiene in the workplace, populations who reside near 1,3-butadiene-releasing facilities, and racial/ethnic groups. Additionally, the Agency identified a list of specific PESS factors that contribute to a group having increased exposure or biological susceptibility, such as lifestage in the basis for the intermediate/chronic POD, occupational exposures, nutrition, and lifestyle activities. EPA was able to incorporate considerations for multiple PESS factors into risk estimates, as presented in Section 5.3.5. Full details on all available information relating to biological susceptibility are presented in Section 9.2 of the *Draft Human Health Hazard Assessment for 1,3-Butadiene* (U.S. EPA, 2024t), including PESS factors with only indirect evidence or otherwise insufficient information to incorporate into hazard or risk values. Full details on all available information relating to biological susceptibility are presented in Section 7.2 of the *Draft Human Health Hazard Assessment for 1,3-Butadiene* (U.S. EPA, 2024s), including PESS factors with only indirect evidence or otherwise insufficient information to incorporate into hazard or risk values.

For 1,3-butadiene, the use of either central-tendency or high-end risk estimates is, in part, due to the amount of information available. For 1,3-butadiene, the occupational exposure estimates are based off a statistical distribution of multiple single day measurements. EPA assumes that these results are generally applicable to all working days; however, the uncertainty in this assumption increases as the single-day results are extrapolated to longer durations. Therefore, EPA generally used high-end estimates for workers in its preliminary risk determination for shorter term inhalation exposures (*i.e.*, intermediate non-cancer risk covering average exposures over one month) because the measured high-end exposures are more realistically consistent over shorter time periods, while central tendency estimates are used for longer term exposures (*i.e.*, several decades for chronic non-cancer and cancer). Central tendency is used for EPA's preliminary risk determination for chronic non-cancer and lifetime cancer estimates since longer-term average exposure (*e.g.*, 250 days per working years or 78 years for cancer estimates) would bias toward central tendency (*i.e.*, the more common risk estimates) vs. higher-end values (*i.e.*, less common risk estimates or 95th percentile or value at which 95% of all measurements fall below it). In the case of all occupational COUs to which EPA is preliminary determining significantly contributes to unreasonable risk, there is risk indicated for intermediate non-cancer using high-end estimates. This use of high-end for the intermediate duration is protective of PESS, because the sensitive endpoint for 1,3-butadiene is a developmental effect based on being exposed during a period of pregnancy and this timeframe is more representative of the exposure period of concern for this population.

In addition, risk estimates have been provided for both an 8- and a 12-hour TWA for certain manufacturing and processing conditions of use. These both represent real scenarios and shift lengths for workers exposed to 1,3-butadiene; therefore, EPA considered both shift lengths in its preliminary risk determination. For example, for two activities under the domestic manufacturing COU, Manufacturing – instrument and electric manufacturing and Manufacturing – maintenance – turnaround, unreasonable risks were found only for the 12-hour TWA and not the 8-hour TWA. The 12-hour TWA is associated with higher risk for intermediate non-cancer due to the number of shifts in a 30-day period working 12 hours/day compared to the 8-hour TWA (*i.e.*, the worker's hours may be condensed due to longer shift lengths in a given month, resulting in higher exposure). EPA is preliminarily determining that both of those activities significantly contribute to the unreasonable risk of 1,3-butadiene due to the unreasonable risk identified for the 12-hour TWA.

Risk estimates were not quantified for commercial or consumer uses of plastics, rubber, lubricants, and fuels since reasonably available evidence suggests that 1,3-butadiene monomer only exists at trace concentrations in these products and articles and is stable and not expected to depolymerize and expose the commercial/consumer user to the 1,3-butadiene monomer. For general population exposures, including exposures to fenceline communities, EPA modeled air concentrations from facilities, focusing on the distances of 100 m, 100 to 1,000 m, and 1,000 m from release points, and aggregated exposures from multiple facilities from all releasing facilities within a 50,000-meter radius to the general population within a given census block based on 2020 census data. EPA estimated cancer risks to the general population of any lifestage (*i.e.*, EPA derived an IUR which incorporates an ADAF to account for increased susceptibility to cancer from early life exposure to 1,3-butadiene) via lifetime inhalation exposure. For occupational risks, EPA estimated risks to workers and ONUs via inhalation only following intermediate, chronic, or lifetime exposure. As stated in Section 5.3.1, occupational risks were not estimated for acute exposures because effects observed in the toxicology animal database could not be attributed to a single-dose and are unlikely to result from a single exposure at concentrations relevant to humans. The non-cancer intermediate and chronic non-cancer POD is protective of susceptible populations; specifically, maternal/developmental toxicity resulting in decreased fetal weight. In addition, the POD, reduced fetal body weight, is protective of other non-cancer endpoints, particularly germ cell mutation (target organ: spermatids and spermatozoa) and anemia which yielded similar POD values. The UF of 10 for human variability that EPA has applied to the non-cancer intermediate and chronic MOE accounts for increased susceptibility of populations, such as children and elderly populations.

For cancer, EPA derived risk estimates based on a human, occupational exposure which reflects sentinel exposure and variability in the population. More information on how EPA characterized sentinel and aggregate risks is provided in Section 5.3.6 and the *Draft Human Health Hazard Assessment for 1,3-Butadiene* (U.S. EPA, 2024t).

7.1.4 Workers

Based on the occupational risk estimates and related risk factors, EPA is preliminarily determining that the non-cancer and cancer effects from worker intermediate inhalation exposure and chronic inhalation exposure to 1,3-butadiene in occupational settings for all COUs with quantified risk estimates, except for two commercial uses, to the unreasonable risk presented by 1,3-butadiene. These two are: Commercial use –paints and coatings – paints and coatings, including aerosol spray paint and Commercial use – adhesives and sealants – adhesives and sealants, including epoxy resins, significantly contribute. The risk estimates for non-cancer and cancer effects for workers can be found in Section 5.3.2. However, the cancer risk estimates have been changed for occupational exposure as described in *1,3-Butadiene: Corrected lifetable analyses for leukemia and bladder cancer* (U.S. EPA, 2024a). Although Table 5-4 does not reflect this change, EPA's preliminary risk determination described below accounts for this correction and the approximately 20 percent reduction in occupational unreasonable risk as a result. As discussed in Section 5.1.1.1, due to the volatility and transport methods of 1,3-butadiene, EPA did not evaluate routine dermal exposure to workers.

As stated in Section 5.3, occupational risk estimates utilized monitoring exposure measurements from workplace inhalation monitoring data collected by government agencies such as OSHA and NIOSH, monitoring data found in published literature (*i.e.*, personal exposure monitoring data and area monitoring data), and monitoring data submitted via public comments. Studies were evaluated using the evaluation strategies laid out in the *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances* (U.S. EPA, 2021a). For manufacturing and processing of 1,3-butadiene, EPA was also provided inhalation monitoring data by ACC. The ACC report includes 5,676 full-shift PBZ samples for workers and ONUs collected from 2010 to 2019 (ToxStrategies, 2021). The report includes a compilation and analyses of existing air concentrations of 1,3-butadiene from 47 consortium member facilities. These data were also able to be used to characterize worker exposure for some 1,3-butadiene's OESs beyond manufacturing and processing (such as laboratory use and waste handling) using the worker descriptions accompanying the data. This data set provided measurements at the level of individual worker populations, or similarly exposed groups (SEGs). This granularity allowed EPA to differentiate even within OES among different types of activities and frequencies. See Table 2-3 for descriptions of the function of 1,3-butadiene for each OES.

The majority of occupational exposure sampling data points, collected from OSHA, NIOSH, and ACC's monitoring report (ToxStrategies, 2021), were not quantifiable values but were identified as being below the limit of detection (LOD) which according to the sampling methods may range from approximately 0.0036 to 0.09 ppm for full shift sampling depending on individual sample conditions. In such cases, in accordance with EPA's *Guidelines for Statistical Analysis of Occupational Exposure Data* the data were scored as half the LOD value and incorporated into the overall distribution. To make a preliminary risk determination, the Agency analyzed the individual COUs by the Population/SEG to determine if the COU was best represented by central tendency or high-end estimates for workers and ONUs based on the description of the COU and the parameters and assumptions used in the occupational exposure scenarios. If an activity significantly contributed to the unreasonable risk for non-cancer or cancer for any Population/SEG within the COU, EPA preliminarily determined there was unreasonable risk to that activity within that COU.

There were COUs with MOEs below the benchmark of 30 at the high-end estimates for intermediate inhalation exposure for worker populations. As discussed previously, because of the robust data set associated with 1,3-butadiene in occupational settings, EPA is generally using high-end estimates for workers in its preliminary risk determination for shorter term exposures (*i.e.*, intermediate non-cancer risk or 30-day durations). However, EPA is generally using central tendency for longer term exposures (*i.e.*, chronic non-cancer and cancer) due to the effect of averaging this larger set of data over the longer period of time. Central tendency is generally used for EPA's preliminary risk determination for chronic non-cancer and cancer estimates for 1,3-butadiene since longer-term average exposure would bias toward central tendency (*i.e.*, the more common risk estimates) vs. higher-end values (*i.e.*, less common risk estimates or 95th percentile). In addition, risk estimates have been provided for both an 8- and a 12-hour TWA for certain manufacturing and processing conditions of use. Because these both represent real scenarios and shift lengths for workers exposed to 1,3-butadiene, EPA considered both shift lengths in its preliminary determination.

As previously mentioned, these calculated risk estimates alone are not bright-line indicators of unreasonable risk and EPA has the discretion to consider other risk-related factors in addition to risks identified in the risk characterization. There are estimated risks for workers associated with activities and COUs that approach or border the benchmark, including the maintenance activities which occur under three COUs: the domestic manufacturing; processing as a reactant – intermediate in various manufacturing industries; and processing – incorporation into formulation, mixture, or reaction product. The risk estimates for the maintenance activity are the same across the COUs. This is because the data associated with this activity are the used for each corresponding COU, with differing estimates for the 8- and 12-hour TWA due to the days exposed per year (*i.e.*, 250 days for 8-hour TWA and 167 days for 12-hour TWA). The high-end estimates for intermediate non-cancer for the maintenance activity at both timeframes are well below the benchmark MOE of 30 (*i.e.*, 21 for the 8-hour TWA and 14 for the 12-hour TWA). In addition, the estimates for the central tendency are borderline for intermediate non-cancer at the 8-hour TWA (*i.e.*, 33) and below the benchmark MOE for the 12-hour TWA for intermediate non-cancer (*i.e.*, 22). The central tendency estimates for chronic non-cancer for the maintenance activity at both timeframes are above the benchmark MOE of 30 (*i.e.*, 34 for the 8-hour TWA and 35 for the 12-hour TWA), but both well below for the high-end estimates (*i.e.*, 22 and 23 for the 8-hour TWA and the 12-hour TWA, respectively. Lastly, the cancer risk estimates are above a 1 in 10,000 risk for the high-end estimates at both the 8- and the 12-hour TWA, but well below 1 in 10,000 for workers using the central tendency.

As previously stated, there is increased uncertainty for longer-term timeframes due to the extrapolation of single-day results to longer durations. Because the distribution of the monitoring data associated with the maintenance activity indicates less of a range, we can assume less uncertainty over longer durations and that the high-end and central tendency estimates both appropriately represent risk for this activity for chronic non-cancer. Considering the indication of risk across the two timeframes, because the MOEs for both the intermediate and chronic non-cancer are close, indicating not a large range in the data for this activity, and because the central tendency borders the benchmark MOE, EPA is preliminarily determining the intermediate and chronic non-cancer significantly contribute to the unreasonable risk.

EPA is preliminarily determining that the activities listed below associated with domestic manufacturing significantly contribute to the unreasonable risk to workers presented by 1,3-butadiene, see Table 5-4 for occupational risk estimates. For two of those activities under the domestic manufacturing COU, Manufacturing – instrument and electric manufacturing and Manufacturing – maintenance – nonroutine, risks were indicated for the 12-hour TWA but not for the 8-hour TWA. However, as stated previously, EPA is considering both timeframes when preliminarily determining unreasonable risk and therefore, is finding that those two also significantly contribute to the unreasonable risk. The remaining activities significantly contribute at both the 8- and 12-hour TWA.

The following activities significantly contribute to the unreasonable risk to the domestic manufacturing COU based on the non-cancer and cancer effects from worker intermediate inhalation and chronic inhalation exposure to 1,3-butadiene in occupational settings:

- Manufacturing – Infrastructure/ Distribution Operations*
- Manufacturing – Infrastructure/ Distribution Operations – Nonroutine*
- Manufacturing – Instrument and Electrical* (12-hour TWA)
- Manufacturing – Laboratory Technician*
- Manufacturing – Laboratory Technician – Nonroutine**
- Manufacturing – Machinery and Specialists*
- Manufacturing – Maintenance*
- Manufacturing – Maintenance – Nonroutine* (12-hour TWA)
- Manufacturing – Maintenance – Turnaround*
- Manufacturing – Operations Onsite*
- Manufacturing – Safety Health and Engineering*

*= intermediate non-cancer only
**= non-cancer (intermediate and chronic) and cancer

EPA is preliminarily determining that all activities associated with Import and processing – repackaging significantly contribute to the unreasonable risk presented by 1,3-butadiene. EPA understands that import and repackaging sites are distributing to various downstream uses. Liquefied butadiene is shipped by pipelines, ships, barges, rail tank cars, tank trucks and bulk liquid containers. A portion of the 1,3-butadiene manufactured is also expected to be repackaged into smaller containers for commercial laboratory use. The following activities significantly contribute to the unreasonable risk based on the non-cancer and cancer effects from worker intermediate inhalation exposure and chronic inhalation exposure to 1,3-butadiene in occupational settings for both the 8- and 12-hour TWA:

- Manufacturing – Import – Worker**
- Manufacturing – Import – ONU**
- Processing – Repackaging – Worker**
- Processing – Repackaging – ONU**

**= non-cancer (intermediate and chronic) and cancer

EPA is preliminarily determining that the activities listed below associated with Processing – processing as a reactant – intermediate and Processing – processing as a reactant – monomer used in polymerization process significantly contribute to the unreasonable risk presented by 1,3-butadiene, see Table 5-4 for occupational risk estimates. For two of those activities under the processing as a reactant COU, Processing – processing as a reactant – instrumental and electrical and Processing – processing as a reactant – maintenance – nonroutine, risks were found only for the 12-hour TWA. The remaining activities significantly contribute at both the 8- and 12-hour TWA. The following activities significantly contribute to the unreasonable risk based on the non-cancer and cancer effects from worker intermediate inhalation exposure and chronic inhalation exposure to 1,3-butadiene in occupational settings:

- Processing – Processing as a Reactant – Intermediate – Infrastructure/ Distribution Operations*
- Processing – Processing as a Reactant – Intermediate – Infrastructure/ Distribution Operations – Nonroutine*
- Processing – Processing as a Reactant – Intermediate – Instrumental and Electrical* (12-hour TWA)
- Processing – Processing as a Reactant – Intermediate – Laboratory Technician*
- Processing – Processing as a Reactant – Intermediate – Laboratory Technician – Nonroutine**
- Processing – Processing as a Reactant – Intermediate – Machinery and Specialists*
- Processing – Processing as a Reactant – Intermediate – Maintenance*
- Processing – Processing as a Reactant – Intermediate – Maintenance – Nonroutine* (12-hour TWA)
- Processing – Processing as a Reactant – Intermediate – Maintenance – Turnaround*
- Processing – Processing as a Reactant – Intermediate – Operations Onsite*
- Processing – Processing as a Reactant – Intermediate – Safety Health and Engineering*
- Processing – Processing as a Reactant – Monomer used in polymerization process – Worker*
- Processing – Processing as a Reactant – Monomer used in polymerization process – ONU* (12-hr TWA)

*= intermediate non-cancer only
**= non-cancer (intermediate and chronic) and cancer

EPA is preliminarily determining that the activities listed below associated with Processing – incorporation into formulation, mixture, or reaction product significantly contribute to the unreasonable risk presented by 1,3-butadiene, see Table 5-4 for occupational risk estimates. For two of those activities under the incorporation into formulation, mixture, or reaction product COU, Processing – incorporation into formulation, mixture, or reaction product – instrument and electrical and Processing – incorporation into formulation, mixture, or reaction product – maintenance – nonroutine, risks were found only for the 12-hour TWA. The remaining activities significantly contribute at both the 8- and 12-hour TWA. The following activities significantly contribute to the unreasonable risk based on the non-cancer and cancer effects from worker intermediate inhalation exposure and chronic inhalation exposure to 1,3-butadiene in occupational settings:

- Processing – Incorporation into Formulation, Mixture, or Reaction Product – Infrastructure/ Distribution Operations*
- Processing – Incorporation into Formulation, Mixture, or Reaction Product – Infrastructure/ Distribution Operations – Nonroutine*
- Processing – Incorporation into Formulation, Mixture, or Reaction Product – Instrument and Electrical * (12-hour TWA)
- Processing – Incorporation into Formulation, Mixture, or Reaction Product – Laboratory Technician*
- Processing – Incorporation into Formulation, Mixture, or Reaction Product – Laboratory Technician – Nonroutine**
- Processing – Incorporation into Formulation, Mixture, or Reaction Product – Machinery and Specialists*
- Processing – Incorporation into Formulation, Mixture, or Reaction Product – Maintenance*

- Processing – Incorporation into Formulation, Mixture, or Reaction Product – Maintenance – Nonroutine*(12-hour TWA)
- Processing – Incorporation into Formulation, Mixture, or Reaction Product – Maintenance – Turnaround*
- Processing – Incorporation into Formulation, Mixture, or Reaction Product – Operations Onsite*
- Processing – Incorporation into Formulation, Mixture, or Reaction Product – Safety Health and Engineering*

*= intermediate non-cancer only
**= non-cancer (intermediate and chronic) and cancer

EPA is preliminarily determining that the activities listed below associated with Processing – Incorporation into Article – Plastics and Rubber Compounding significantly contributes to the unreasonable risk based on the non-cancer effects from worker intermediate inhalation exposure presented by 1,3-butadiene in occupational settings:

- Processing – Incorporation into Article – Other: Polymer in: Rubber and plastic product manufacturing (Worker)*

*= intermediate non-cancer only

EPA is preliminarily determining that all activities associated with Processing – recycling, commercial use – other use – laboratory chemicals, and Disposal significantly contribute to the unreasonable risk presented by 1,3-butadiene based on the non-cancer and cancer effects from worker intermediate inhalation exposure and chronic inhalation exposure to 1,3-butadiene in occupational settings. For one of those activities under the Commercial use –laboratory chemicals COU, Laboratory Technician – Nonroutine, risks for cancer effects were found only for the 12-hour TWA and non-cancer for both the 8- and 12-hour TWA.

The following occupational COUs do not have quantitative risk estimates for workers. However, EPA has qualitatively evaluated the COUs by integrating additional reasonably available information. The qualitative analyses are a best estimate of what EPA expects given the weight of scientific evidence (see Section 5.1.1):

- Distribution in commerce: EPA expects 1,3-butadiene to be transported in sealed containers from import sites to downstream processing and use sites, or for final disposal of 1,3-butadiene. EPA preliminarily expects, under standard operating procedures, that exposures and releases could occur during distribution in commerce but would not significantly contribute to the unreasonable risk presented by 1,3-butadiene because inhalation exposure is not expected.
- Commercial use – fuels and related products: Exposures were not quantitatively assessed for the commercial COUs covered by the OES of "Fuels and related products", which includes 1,3-butadiene used as a fuel binder for solid rocket fuels, and 1,3-butadiene's presence in liquid petroleum gas (LPG) used as a fuel. In the case of the use as a fuel binder, EPA understands this is not a use of 1,3-butadiene monomer, but rather polymers created from 1,3-butadiene and other monomers. EPA found evidence of 1,3-butadiene at small concentrations (less than 0.1%) in LPG. Occupational exposures from LPG connections, cylinder leaks, and incomplete combustion are expected to be minimal.
- Commercial use – lubricants and lubricant additives: Exposures were not quantitatively assessed for the commercial COUs covered by the OES of "Use of lubricants and greases." Reasonably

available evidence suggests that 1,3-butadiene monomer does not exist at concentrations above reporting thresholds in lubricants and greases. Based on conversations with companies who have listed 1,3-butadiene in their SDS, EPA believes 1,3-butadiene indicated in SDS or other products refer either to upstream steps or to reacted polymeric forms.

- Commercial use – other articles with routine direct contact during normal use including rubber articles; plastic articles (hard); Commercial use – Toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard); Commercial use – Synthetic Rubber; Commercial use – Furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles; Commercial use – Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft); Commercial use – Automotive care products: Exposures were also not quantitatively assessed for the commercial COUs covered by the OES of "Use of plastics and rubber products." Reasonably available evidence suggests that 1,3-butadiene monomer does not exist at concentrations above 6.6 ppm in rubber products and that 1,3-butadiene is stable in these products and not expected to degrade. Any 1,3-butadiene indicated in SDSs or other product reports likely referred either to upstream steps or to reacted polymeric forms. The Agency expects these articles to pose no significant risk for inhalation exposures to commercial workers who use articles in a similar fashion to consumers for these COUs. Thus, EPA is preliminarily determining that these COUs do not significantly contribute to the unreasonable risk presented by 1,3-butadiene.

7.1.5 Consumers

Based on the assessment of consumer risk and related risk factors, EPA is preliminarily determining that no consumer conditions of use significantly contribute to the unreasonable risk of 1,3-butadiene. The consumer COUs and associated disposal do not have quantitative risk estimates. EPA has qualitatively evaluated the consumer COUs by integrating reasonably available information demonstrating that butadiene polymer-derived consumer products, such as synthetic rubbers, are not expected to degrade and expose the consumer to the 1,3-butadiene monomer. The qualitative analyses are a best estimate of what the Agency expects given the weight of scientific evidence (see Section 5.1.2).

- Consumer use – Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard); Toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard); Synthetic Rubber (*e.g.*, rubber tires); Furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles; and Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft): Residual butadiene concentrations in polymers and downstream chemicals used to create these plastic and rubber articles are very low and often not detectable. Further, processing of synthetic polymers into rubber or plastic products reduces any remaining residual butadiene resulting in minimal to no potential end-user exposures. Therefore, EPA has determined this COU does not significantly contribute to the unreasonable risk to consumers presented by 1,3-butadiene.

- Disposal: Based on product searches and systematic review data, EPA has determined that 1,3-butadiene is stable in these products and not expected to degrade and expose the consumer to the 1,3-butadiene monomer from the use or disposal of these products.

7.1.6 General Population Including Fenceline Communities

EPA employed a qualitative, screening level approach for general population exposures to 1,3-butadiene for the land, surface water, sediment, and drinking water pathways. The Agency identified the ambient air pathway to be the predominant human exposure pathway to 1,3-butadiene in the outdoor environment and quantitatively assessed the risk of 1,3-butadiene to the general population, including fenceline communities. For further information see Section 4.2. EPA preliminarily finds that ambient air exposure from releases of 1,3-butadiene significantly contributes to the unreasonable risk from 1,3-butadiene for the sub-populations living near facilities manufacturing and processing 1,3-butadiene.

Land Pathway

EPA evaluated the complete set of monitoring data from EPA's Water Quality Portal, which includes 380 million water quality data records from 900 federal, state, tribal and other partners, in assessing exposures via the land pathway, as well as the surface water and sediment pathways, and drinking water pathway. 1,3-Butadiene is not released to soil, and air to soil deposition is not expected due to the physical and chemical properties of 1,3-butadiene (high volatility and reactivity and low sorption to organic material). Based on the low volume of releases to land, the low risk of failure of the predominant release scenario, the physical and chemical properties of 1,3-butadiene as well as monitoring data indicating less than 1 percent detection frequency, the land pathway is not considered a pathway of concern for exposure to the general population. As such, EPA preliminarily determines this pathway does not significantly contribute to unreasonable risk of 1,3-butadiene to the general population from the land pathway. For further information see Section 4.2.1.4.

Surface Water and Sediment Pathways

Based on the physical and chemical properties of 1,3-butadiene's; that is, it's low water solubility, high volatility from water, and low estimated Koc value, as well as the low reported releases to surface water and monitoring data showing no detection of 1,3-butadiene, EPA does not expect general population exposure to 1,3-butadiene to occur via the surface water or sediment pathways. As such, the Agency preliminarily determines this pathway does not significantly contribute to unreasonable risk of 1,3-butadiene to the general population from the surface water or sediment pathways. For further information see Section 4.2.1.2.

Drinking Water Pathway

Based on the physical and chemical properties of 1,3-butadiene; that is, its low water solubility and high tendency to volatilize from water, as well as the monitored data showing that 1,3-butadiene is not detected in drinking water, EPA does not expect general population exposure to 1,3-butadiene from drinking water. As such, EPA preliminarily determines this pathway does not significantly contribute to unreasonable risk of 1,3-butadiene to the general population from drinking water. For further information see Section 4.2.1.3.

Ambient Air Pathway

Recognizing the ubiquity of 1,3-butadiene in ambient air is due to contributions from many different sources, EPA considered and presented measured and modeled concentrations of 1,3-butadiene from multiple lines of evidence, data, and analyses in this ambient air exposure assessment to evaluate and contextualize 1,3-butadiene exposures in ambient air due to TSCA COUs. Based on the physical and chemical properties, and concentrations reported from databases and scientific literature, a quantitative exposure assessment was conducted for the ambient air pathway for the general population. 1,3-butadiene in the atmosphere is expected to remain largely in the vapor phase, where it is not expected to persist or undergo long-range transport. As such, EPA estimated risks to the general population of any lifestage living near facilities releasing 1,3-butadiene into the environment via inhalation only following chronic or lifetime exposure.

To evaluate non-cancer and cancer risks for general population, EPA modeled air concentrations for the following distances: 100 m, 100 to 1,000 m, and 1,000 m. These distances are also consistent with the community populations living near facilities as described in the fenceline methodology (Draft Screening Level Approach for Assessing Ambient Air and Water Exposures to Fenceline Communities Version 1.0).

For non-cancer risks, no calculated MOE was below the benchmark of 30 for all Draft Integrated Indoor Outdoor Air Calculator (IIOAC) modeled concentrations from 100 to 1,000 m across all TRI facilities. The highest concentration was calculated for a facility corresponding with the Processing – plastics and rubber compounding COU/OES, at an MOE of 60, which is twice the benchmark of 30. Therefore, EPA preliminarily determined that non-cancer risks from ambient air do not significantly contribute to the unreasonable risk from exposure to 1,3-butadiene for any COU.

For cancer risks, EPA is preliminarily determining that the ambient air pathway significantly contributes to the unreasonable risk from inhalation exposure to 1,3-butadiene. When the cancer risk estimates derived using IIOAC results, based on 95th percentile and mean modeled concentrations, were at or above the 1 in a million benchmark up to 1,000 m from facility releases, EPA utilized HEM to conduct a more geographically refined analysis of ambient air concentrations using localized meteorological data and site-specific parameters (when available). EPA calculated lifetime cancer risk using the lifetime average daily concentration (LADC) based on the 95th modeled annual air concentration and the general population IUR of 0.0098 per ppm (4.4×10^{-6} per $\mu g/m^3$). See Section 5.2 and the *Draft Human Health Hazard Assessment for 1,3-Butadiene* (U.S. EPA, 2024t)) for more details on the human health hazard values. As an example, from Table 5-6, for the 2021 TRI reporting year, for the manufacturing COU, there were a total of 37 manufacturing facilities that reported 1,3-butadiene releases, and cancer risks were estimated for the census blocks around those facilities. The estimated cancer risks across all of the census blocks around the 37 manufacturing facilities ranged from 6.5×10^{-11} to 8.9×10^{-5}.

As the Agency incorporates refined or additional release data received during the public comment period and SACC review of the draft risk evaluation, it is possible that the specific COUs preliminarily determined to significantly contribute to unreasonable risk could change.
The following COUs significantly contribute to unreasonable risk of cancer to fenceline communities in the general population due to inhalation of 1,3-butadiene:

- Manufacturing – domestic manufacturing: Even at the modeled distance of 1,000 m for both the 50th percentile and the 95th percentile, the risk estimates indicate cancer risk above the benchmark of 1 in a million (see Table 5-5), with risk estimates for the 95th percentile estimates for this COU at 1,000 m being 2.1×10^{-5}. In addition, the HEM risk estimates based on census block information indicates that there are populations exposed above this benchmark for the TRI reporting years 2016 to 2021, with some even above the 10 in a million. Based on EPA's robust confidence in the general population risk estimates, the radial distance modeling showing risk above the 1 in a million benchmark, and the census block data showing populations exposed for all six years, EPA is preliminarily determining that this COU significantly contributes to unreasonable risk to fenceline communities in the general population.

- Processing – processing as a reactant – monomer used in polymerization process in: synthetic rubber manufacturing; plastic material and resin manufacturing: Similarly to the domestic manufacturing COU, at both the 50th and 95th percentile for the highest modeled radial distance (*i.e.*, 1,000 m) the risk estimates are above the benchmark of 1 in a million, with the highest at 1,000 m being 9.4×10^{-6}. Census block information indicates that there are populations exposed above 1 in a million risk for all reported years and above 10 in a million risk for all years except

2018 where there was no reporting for those facilities. Again, based on EPA's robust confidence in the general population risk estimates, the radial distance modeling showing risk above the 1 in a million benchmark, and the census block data showing populations exposed for all six years, EPA is preliminarily determining that this COU significantly contributes to unreasonable risk to fenceline communities in the general population.

- Processing – incorporation into formulation, mixture, or reaction product - processing aids, not otherwise listed in: petrochemical manufacturing: Similarly to the previously discussed COUs, at both the 50th and 95th percentile for the highest modeled radial distance (*i.e.*, 1,000 m) the risk estimates are above the benchmark of 1 in a million, with the highest at the 95th percentile for 1,000 m being 1.4×10^{-5}. Fifty-three facilities reported to TRI during the 2016 to 2021 reporting years for this use. The risk estimates above 1 in a million are associated with two facilities. One facility (TRI ID: 77640FNLNDHIGHW) reported in 2016 to 2019 but releases indicated risk above the benchmark for only years 2016 and 2017. This facility's reporting indicates a decline in releases and therefore a decrease in the number of people exposed during the six reporting years and indicates that there are no populations exposed for the most recent four reported years (*i.e.*, 2021, 2020, 2019, 2018) above 1 in a million. The second facility (TRI ID: 77641TXCCHGATE2) reported for all 6 years (*i.e.*, 2016–2021) but releases indicated risk above the benchmark for only 2018. However, unlike the other facility, the reported release data does not indicate a decline. Based on the radial distance modeling showing risk above the 1 in a million benchmark, and the census block data showing populations exposed, EPA is preliminarily determining that this COU significantly contributes to unreasonable risk to fenceline communities in the general population.

The following COUs are above 1 in a million risk but do not significantly contribute to unreasonable risk of cancer to fenceline communities in the general population:

- Processing as a reactant – intermediate in: adhesive manufacturing; all other basic organic chemical manufacturing; fuel binder for solid rocket fuels; organic fiber manufacturing; petrochemical manufacturing; petroleum refineries; plastic material and resin manufacturing; propellant manufacturing; synthetic rubber manufacturing; wholesale and retail trade: The risk estimates at the 50th for the highest modeled radial distance (*i.e.*, 1,000 m) borders the 1 in a million benchmark (*i.e.*, 1.1×10^{-6}) and is above for the 95th (3.5×10^{-6}). EPA's model conservatively assumes the general population is being exposed to modeled ambient air (*i.e.*, outdoor) concentrations 24 hours a day, 365 days a year, over a lifetime. In addition, the estimates reflect the highest modeled concentration across all reported facilities (*i.e.*, the 50th percentile risk at 1,000 m represents the risk based on the highest 50th percentile modeled concentration at 1,000 m across all 57 processing facilities). Given these conservative assumptions, EPA is using the 50th percentile (*i.e.*, 1.1×10^{-6}) and in addition, based on the census block data, for all five reporting years, little to no people are above the 10 in a million risk and the range of people exposed based on reporting year varies for the 1 in a million benchmark. EPA is preliminary determining that this COU does not significantly contribute to unreasonable risk to fenceline communities in the general population.

For the other COUs, not previously listed and where EPA conducted a quantitative assessment, risk estimates did not indicate risk and none were above a 1 in a million risk. EPA does not expect risk for those COUs where EPA has conducted a qualitative assessment. In addition, EPA expects that general population inhalation exposures from distribution in commerce would be even lower than those for workers. Therefore, the Agency is preliminarily determining that distribution in commerce does not contribute significantly to the unreasonable risk of 1,3-butadiene due to the injury to health.

EPA has robust confidence in the overall characterization of environmental media concentrations for 1,3-butadiene as it relies upon databases that are publicly available and reviewed with quality control and assurance protocols. The Agency also has robust confidence in the overall characterization of exposures for the ambient air exposure assessment as it relies upon direct reported releases from databases that received a high-quality rating from EPA's systematic review process and peer-reviewed models to derive exposure concentrations at distances from releasing facilities where individuals reside for many years. Furthermore, use of actual reported releases minimizes uncertainties around estimated releases using theoretical distributions and provides added confidence that modeled concentrations and exposures are real and not hypothetical apart from EPA estimated releases for adhesives and sealants OES. The greatest uncertainty is associated with the contribution of 1,3-butadiene to the total ambient monitoring data due to non-attributable sources related to fuel use, combustion, and mobile emissions. Another source of uncertainty in is the assumption that the TRI-reported emissions from each facility are from a standardized stack of 10 m in height and ground-level area source of 10 by 10 m as described in the *Draft Environmental Releases and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2024y).

7.2 Unreasonable Risk to the Environment

Based on the pathways evaluated in the draft risk evaluation for 1,3-butadiene, EPA preliminarily determines that risk to the environment does not significantly contribute to the unreasonable risk determination for 1,3-butadiene. Given the fate properties of 1,3-butadiene, an in-depth analysis of releases to water or land and associated exposures from those releases were not conducted. The environmental risk characterization for 1,3-butadiene involved a review of release and monitoring data which demonstrated limited release and that 1,3-butadiene was not detected in water. In addition, EPA does not expect that 1,3-butadiene will persist in surface water or groundwater or adsorb to soil or sediment and does not persist on land, due to its physical and chemical properties (*i.e.*, gas form under ambient conditions, high volatility and reactivity, low sorption potential). Extensive ambient air monitoring data are available for 1,3-butadiene, which shows that 1,3-butadiene is prevalent in ambient air and confirms that air is a major 1,3-butadiene exposure pathway. However, EPA did not conduct a quantitative analysis on this pathway for aquatic or terrestrial species.

7.2.1 Populations and Exposures EPA Assessed for the Environment

EPA quantitatively determined 1,3-butadiene concentrations for ambient air pathway based on the physical and chemical properties, and concentrations reported from databases and scientific literature for the general population. Furthermore, the Agency qualitatively assessed environmental exposures for surface water and sediment pathway as well as drinking water and soil. This qualitative analysis was based on the low amounts of releases and high frequencies of non-detects reported in databases and scientific literature. EPA has robust confidence in the overall characterization of environmental media concentrations for 1,3-butadiene as it relies upon databases that are publicly available and reviewed with quality control and assurance protocols. such as AMTIC, WQP, and UCMR, and extracted data from peer-reviewed literature that received medium to high-quality ratings from EPA's systematic review process.

7.2.2 Summary of Environmental Effects

EPA qualitatively assessed environmental exposures of 1,3-butadiene in air, water, and soil. Based on these assessments, the preliminary findings are as follows:

- 1,3-Butadiene releases in air are expected to be the predominant pathway of environmental exposure.

- 1,3-Butadiene is not expected to be present in surface water given minimal releases to surface water, rapid biodegradation, and volatilization. Additionally, 1,3-butadiene has low sorption potential and is not expected to be present in sediment.
- 1,3-Butadiene is not released to soil, and air to soil deposition is not expected due to the physical and chemical properties (high volatility and reactivity and low sorption to organic material).

Extensive ambient air monitoring data are available for 1,3-butadiene and confirms that air is the primary exposure pathway. Although these data demonstrate 1,3-butadiene concentrations in ambient air, the sources are unknown. Concentrations of 1,3-butadiene in ambient air is likely from a combination of non-point sources (*e.g.*, forest fires, mobile exhaust).

7.2.3 Basis for Risk of Injury to the Environment

Based on the pathways evaluated in the draft risk evaluation for 1,3-butadiene, EPA did not identify risk of injury to the environment that would contribute significantly to the unreasonable risk determination for 1,3-butadiene. EPA is preliminarily determining that there is no significant risk of injury to the environment to aquatic organisms as 1,3-butadiene is not appreciably released to, and does not persist in, surface water and exposure is not expected based on the physical and chemical properties of 1,3-butadiene. Additionally, EPA is preliminarily determining that there is no significant risk of injury to the environment to terrestrial organisms through soil exposure as 1,3-butadiene does not partition, deposit, or persist in or on land and exposure is not expected. Although exposure of 1,3-butadiene to terrestrial organisms is expected via ambient air, exposures will be transient due to the reactive nature of 1,3-butadiene. Because 1,3-butadiene exposure in ambient air cannot be attributed to a specific TSCA use and there is no available hazard data for 1,3-butadiene in terrestrial organisms, environmental risk to terrestrial organisms via ambient air was not assessed and a preliminary risk cannot be determined for this pathway.

7.3 Additional Information Regarding the Basis for the Unreasonable Risk Determination

Table 7-1 summarizes the basis for this draft unreasonable risk determination of injury to human health for occupational COUs, presented in this draft risk evaluation for those COUs with a qualitative evaluation. Table 7-2 summarizes the basis for this draft unreasonable risk determination of injury to human health for consumer COUs, presented in this draft risk evaluation. In these tables, a checkmark (✓) indicates how the COU significantly contributes to the unreasonable risk by identifying the type of effect (*e.g.*, non-cancer for human health). Inhalation was the only exposure route assessed. Dermal exposures are not expected due to the volatility and transport method of the chemical. As explained in Section 7, for this draft unreasonable risk determination, EPA considered the effects of 1,3-butadiene to human health at the central tendency and high-end.

2538 **Table 7-1. Supporting Basis for the Draft Unreasonable Risk Determination for Human Health (Occupational COUs, Inhalation**
2539 **Exposure Route)**

Life Cycle Stage	Category	Subcategory	Population/SEG	Intermediate Non-cancer	Chronic Non-cancer	Cancer
Manufacturing	Domestic manufacturing	Domestic manufacturing	Infrastructure/ Distribution Operations	✓	–	–
			Infrastructure/ Distribution Operations – Nonroutine	✓	–	–
			Instrument and Electrical	✓	–	–
			Instrument and Electrical – Nonroutine	–	–	–
			Instrument and Electrical – Turnaround	–	–	–
			Laboratory Technician	✓	–	–
			Laboratory Technician – Nonroutine	✓	✓	✓
			Machinery and Specialists	✓	–	–
			Machinery and Specialists – Turnaround	–	–	–
			Maintenance	✓	✓	✓
			Maintenance – Nonroutine	✓	–	–
			Maintenance – Turnaround	✓	–	–
			Operations Onsite	✓	–	–
			Operations Onsite – Nonroutine	–	–	–
			Operations Onsite – Turnaround	–	–	–
			Safety Health and Engineering	✓	–	–
			ONU	–	–	–
	Importing	Importing	Worker	✓	✓	✓
			ONU	✓	✓	✓

Life Cycle Stage	Category	Subcategory	Population/SEG	Intermediate Non-cancer	Chronic Non-cancer	Cancer
Processing	Processing as a reactant	Intermediate in: adhesive manufacturing; all other basic organic chemical manufacturing; fuel binder for solid rocket fuels; organic fiber manufacturing; petrochemical manufacturing; petroleum refineries; plastic material and resin manufacturing; propellant manufacturing; synthetic rubber manufacturing; paint and coating manufacturing; wholesale and retail trade	Infrastructure/ Distribution Operations	✓	–	–
			Infrastructure/ Distribution Operations – Nonroutine	✓	–	–
			Instrument and Electrical	✓	–	–
			Instrument and Electrical – Nonroutine	–	–	–
			Instrument and Electrical – Turnaround	–	–	–
			Laboratory Technician	✓	–	–
			Laboratory Technician – Nonroutine	✓	✓	✓
			Machinery and Specialists	✓	–	–
			Machinery and Specialists – Turnaround	–	–	–
			Maintenance	✓	✓	✓
			Maintenance – Nonroutine	✓	–	–
			Maintenance – Turnaround	✓	–	–
			Operations Onsite	✓	–	–
			Operations Onsite – Nonroutine	–	–	–
			Operations Onsite – Turnaround	–	–	–
			Safety Health and Engineering	✓	–	–
			ONU	–	–	–
	Processing as a reactant	Monomer used in polymerization process in: synthetic rubber manufacturing; plastic material and resin manufacturing	Worker	✓	–	–
			ONU	✓	–	–

Life Cycle Stage	Category	Subcategory	Population/SEG	Intermediate Non-cancer	Chronic Non-cancer	Cancer
Processing	Processing –incorporation into formulation, mixture, or reaction product	Processing aids, not otherwise listed in: petrochemical manufacturing; monomers used in: plastic product manufacturing; synthetic rubber manufacturing	Infrastructure/ Distribution Operations	✓	–	–
			Infrastructure/ Distribution Operations – Nonroutine	✓	–	–
			Instrument and Electrical	✓	–	–
			Instrument and Electrical – Nonroutine	–	–	–
			Instrument and Electrical – Turnaround	–	–	–
			Laboratory Technician	✓	–	–
			Laboratory Technician – Nonroutine	✓	✓	✓
			Machinery and Specialists	✓	–	–
			Machinery and Specialists – Turnaround	–	–	–
			Maintenance	✓	✓	✓
			Maintenance – Nonroutine	✓	–	–
			Maintenance – Turnaround	✓	–	–
			Operations Onsite	✓	–	–
			Operations Onsite – Nonroutine	–	–	–
			Operations Onsite – Turnaround	–	–	–
			Safety Health and Engineering	✓	–	–
			ONU	–	–	–
	Processing – incorporation into formulation, mixture, or reaction product	Other: adhesive manufacturing, paints and coatings manufacturing, petroleum lubricating oil and grease manufacturing, and all other chemical product and preparation manufacturing	Infrastructure/ Distribution Operations	✓	–	–
			Infrastructure/ Distribution Operations – Nonroutine	✓	–	–
			Instrument and Electrical	✓	–	–
			Instrument and Electrical – Nonroutine	–	–	–
			Instrument and Electrical – Turnaround	–	–	–
			Laboratory Technician	✓	–	–

Life Cycle Stage	Category	Subcategory	Population/SEG	Intermediate Non-cancer	Chronic Non-cancer	Cancer
Processing	Processing – incorporation into formulation, mixture, or reaction product	Other: adhesive manufacturing, paints and coatings manufacturing, petroleum lubricating oil and grease manufacturing, and all other chemical product and preparation manufacturing	Laboratory Technician – Nonroutine	✓	✓	✓
			Machinery and Specialists	✓	–	–
			Machinery and Specialists – Turnaround	–	–	–
			Maintenance	✓	✓	✓
			Maintenance – Nonroutine	✓	–	–
			Maintenance – Turnaround	✓	–	–
			Operations Onsite	✓	–	–
			Operations Onsite – Nonroutine	–	–	–
			Operations Onsite – Turnaround	–	–	–
			Safety Health and Engineering	✓	–	–
			ONU	–	–	–
Processing	Processing – incorporation into article	Other: polymer in: rubber and plastic product manufacturing	Worker	✓	–	–
			ONU	–	–	–
	Repackaging	Intermediate in: wholesale and retail trade; monomer in: synthetic rubber manufacturing	Worker	✓	✓	✓
			ONU	✓	✓	✓
	Recycling	Recyling	Infrastructure/ Distribution Operations	✓	–	–
			Infrastructure/ Distribution Operations – Nonroutine	✓	–	–
			Instrument and Electrical	✓	–	–
			Instrument and Electrical – Nonroutine	–	–	–
			Instrument and Electrical – Turnaround	–	–	–
			Laboratory Technician	✓	–	–
			Laboratory Technician – Nonroutine	✓	✓	✓
			Machinery and Specialists	✓	–	–
			Machinery and Specialists – Turnaround	–	–	–
			Maintenance	✓	✓	✓

Life Cycle Stage	Category	Subcategory	Population/SEG	Intermediate Non-cancer	Chronic Non-cancer	Cancer
Processing	Recycling	Recyling	Maintenance – Nonroutine	✓	–	–
			Maintenance – Turnaround	✓	–	–
			Operations Onsite	✓	–	–
			Operations Onsite – Nonroutine	–	–	–
			Operations Onsite – Turnaround	–	–	–
			Safety Health and Engineering	✓	–	–
			ONU	–	–	–
Distribution in Ccommerce	Distribution in commerce	Distribution in commerce (*e.g.*, Sold to a trader; Sold to re-sellers for petroleum fuel and petrochemical industry in: petrochemical manufacturing)	Worker	–	–	–
			ONU	–	–	–
Industrial Use	Adhesives and sealants	Adhesives and sealants, including epoxy resins	Worker	–	–	–
			ONU	–	–	–
Commercial Use	Fuels and related products	Fuels and related products	Worker	–	–	–
			ONU	–	–	–
	Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	Worker	–	–	–
			ONU	–	–	–
	Toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard)	Toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard)	Worker	–	–	–
			ONU	–	–	–
	Synthetic Rubber	Synthetic Rubber (*e.g.*, rubber tires)	Worker	–	–	–
			ONU	–	–	–
	Furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles	Furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles	Worker	–	–	–
			ONU	–	–	–
	Packaging (excluding food packaging), including rubber	Packaging (excluding food packaging), including rubber	Worker	–	–	–
			ONU	–	–	–

Life Cycle Stage	Category	Subcategory	Population/SEG	Intermediate Non-cancer	Chronic Non-cancer	Cancer
Commercial Use	articles; plastic articles (hard); plastic articles (soft)	articles; plastic articles (hard); plastic articles (soft)				
	Automotive care products	Automotive care products	Worker	–	–	–
			ONU	–	–	–
	Other use	Laboratory chemicals	Laboratory Technician	✓	–	–
			Laboratory Technician – Nonroutine	✓	✓	✓
			ONU	✓	–	–
	Paints and coatings	Paints and coatings, including aerosol spray paint	Worker	–	–	–
			ONU	–	–	–
	Adhesives and sealants	Adhesives and sealants, including epoxy resins	Worker	–	–	–
			ONU	–	–	–
Disposal	Disposal	Disposal	Worker	✓	✓	✓
			ONU	✓	✓	✓

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Table 7-2. Supporting Basis for the Draft Unreasonable Risk Determination for Human Health (Consumer COUs, Inhalation Exposure Route)

Life Cycle Stage	Category	Subcategory	Population/SEG	Intermediate Non-cancer	Chronic Non-cancer	Cancer
Consumer Use	Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	Worker	–	–	–
Consumer Use	Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	ONU	–	–	–
Consumer Use	Toys intended for children’s use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard)	Toys intended for children’s use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard)	Worker	–	–	–
Consumer Use	Toys intended for children’s use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard)	Toys intended for children’s use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard)	ONU	–	–	–
Consumer Use	Synthetic Rubber	Synthetic rubber (*e.g.*, rubber tires)	Worker	–	–	–
Consumer Use	Synthetic Rubber	Synthetic rubber (*e.g.*, rubber tires)	ONU	–	–	–
Consumer Use	Furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles	Furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles	Worker	–	–	–
Consumer Use	Furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles	Furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles	ONU	–	–	–
Consumer Use	Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft)	Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft)	Worker	–	–	–
Consumer Use	Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft)	Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft)	ONU	–	–	–

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APPENDICES

Appendix A KEY ABBREVIATIONS AND ACRONYMS

ABS	Acrylonitrile butadiene styrene resin plastics
ACC	American Chemistry Council
ACGIH	American Conference of Governmental Industrial Hygienists
ADAF	Age-Dependent Adjustment Factor
AEGL	Acute Exposure Guideline Level
ATSDR	Agency for Toxic Substances and Disease Registry
BCF	Bioconcentration factor
CAA	Clean Air Act
CASRN	Chemical Abstracts Service Registry Number
CBI	Confidential Business Information
CCL	Contaminant Candidate List
CDR	Chemical Data Reporting
CEPA	Canadian Environmental Protection Act
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
COU	Condition of use
CSCL	Chemical Substances Control Law
ECB	European Chemicals Bureau
ECHA	European Chemicals Agency
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ESD	Emission Scenario Document
GACT	Generally Available Control Technology
ECEL	Existing Chemical Exposure Limit
EU	European Union
EV	Exposure Value
GS	Generic Scenario
HAP	Hazardous Air Pollutant
HEC	Human Equivalent Concentration
IIOAC	Integrated Indoor-Outdoor Air Calculator
IMAP	Inventory Multi-Tiered Assessment and Prioritization
(I)UR	(Inhalation) Unit Risk
IRIS	Integrated Risk Information System
ISHA	Industrial Safety and Health Act
K_{OA}	Octanol: Air partition Coefficient
K_{OC}	Organic Carbon: Water Partition Coefficient
K_{OW}	Octanol: Water partition Coefficient
LADC	Lifetime Average Daily Concentration
LCD	Life Cycle Diagram
MACT	Maximum Achievable Control Technology
MOA	Mode of action
MOE	Margin of exposure
NAICS	North American Industry Classification System
NEI	National Emissions Inventory
NICNAS	National Industrial Chemicals Notification and Assessment Scheme (Australia)

NIOSH	National Institute for Occupational Safety and Health
NPL	National Priorities List
NPRI	National Pollutant Release Inventory
NTP	National Toxicology Program
OCSPP	Office of Chemical Safety and Pollution Prevention
OECD	Organisation for Economic Co-operation and Development
OEL	Occupational exposure limits
OES	Occupational exposure scenario
ONU	Occupational non-user
OPPT	Office of Pollution Prevention and Toxics
OSHA	Occupational Safety and Health Administration
PBZ	Personal breathing zone
PEL	Permissible Exposure Limit
PECO	Populations, exposures, comparators, and outcomes
PESS	Potentially exposed or susceptible subpopulations
POD	Point of departure
POTW	Publicly owned treatment works
PV	Production volume
PWS	Public water system
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals (European Union)
SARA	Superfund Amendments and Reauthorization Act
SBR	Styrene-butadiene rubber
SDS	Safety data sheet
SDWA	Safe Drinking Water Act
SEG	Similarly exposed group
STEL	Short-Term Exposure Limit
TSCA	Toxic Substances Control Act
TLV	Threshold limit value
TRI	Toxics Release Inventory
TWA	Time-weighted average
UCMR	Unregulated Contaminants Monitoring Rule
UF	Uncertainty factor
VOC	Volatile organic compound
WWT	Wastewater treatment

Appendix B REGULATORY AND ASSESSMENT HISTORY

The chemical substance, 1,3-butadiene, is subject to federal and state laws and regulations in the United States (Sections B.1 and B.2). Regulatory actions by other governments, tribes, and international agreements applicable to 1,3-butadiene are listed in Sections B.3 and the governmental assessment history is presented in Section B.4.

B.1 Federal Laws and Regulations

Table_Apx B-1. Federal Laws and Regulations

Statutes/Regulations	Description of Authority/Regulation	Description of Regulation
Toxic Substances Control Act (TSCA) – Section 6(b)	EPA is directed to identify high-priority chemical substances for risk evaluation; and conduct risk evaluations on at least 20 high priority substances no later than three and one-half years after the date of enactment of the Frank R. Lautenberg Chemical Safety for the 21st Century Act.	1,3-Butadiene is one of the 20 chemicals EPA designated as a High-Priority Substance for risk evaluation under TSCA (84 FR 71924, December 30, 2019). Designation of 1,3-butadiene as a high-priority substance constitutes the initiation of the risk evaluation on the chemical.
Toxic Substances Control Act (TSCA) – Section 8(a)	The TSCA section 8(a) CDR Rule requires manufacturers (including importers) to give EPA basic exposure-related information on the types, quantities, and uses of chemical substances produced domestically and imported into the United States.	1,3-Butadiene manufacturing (including importing), processing, and use information is reported under the CDR rule (85 FR 20122, April 2, 2020).
Toxic Substances Control Act (TSCA) – Section 8(b)	EPA must compile, keep current, and publish a list (the TSCA Inventory) of each chemical substance manufactured (including imported) or processed in the United States.	1,3-Butadiene was on the initial TSCA Inventory and therefore was not subject to EPA's new chemicals review process under TSCA section 5 (60 FR 16309, March 29, 1995).
Toxic Substances Control Act (TSCA) – Section 8(e)	Manufacturers (including importers), processors, and distributors must immediately notify EPA if they obtain information that supports the conclusion that a chemical substance or mixture presents a substantial risk of injury to health or the environment.	20 risk reports received for 1,3-butadiene (2017, 2011, 2008-2007, 2005, 2002-1997, 1995-1994, 1992, 1990) (U.S. EPA, ChemView, Accessed April 8, 2019).
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	1,3-Butadiene is a listed substance subject to reporting requirements under 40 CFR 372.65, effective as of January 01, 1987.

Statutes/Regulations	Description of Authority/Regulation	Description of Regulation
	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).	
Clean Air Act (CAA) – Section 112(b)	Defines the original list of 189 hazardous air pollutants (HAPs). Under 112(c) of the CAA, EPA must identify and list source categories that emit HAPs and then set emission standards for those listed source categories under CAA Section 112(d). CAA Section 112(b)(3)(A) specifies that any person may petition the Administrator to modify the list of HAPs by adding or deleting a substance. Since 1990, EPA has removed two pollutants from the original list leaving 187 at present.	1,3-Butadiene is listed as a HAP (42 U.S. Code Section 7412).
Clean Air Act (CAA) – Section 112(d)	Directs EPA to establish, by rule, NESHAPs for each category or subcategory of listed major sources and area sources of HAPs (listed pursuant to Section 112(c)). For major sources, the standards must require the maximum degree of emission reduction that EPA determines is achievable by each particular source category. This is generally referred to as maximum achievable control technology (MACT). For area sources, the standards must require generally achievable control technology (GACT) though may require MACT.	EPA has established NESHAPs for a number of source categories that emit 1,3-butadiene to air.
Clean Air Act (CAA) - Sections 112(d) and 112(f)	Risk and technology review (RTR) of Section 112(d) national emission standards for hazardous air pollutants (NESHAP). Section 112(f)(2) requires EPA to conduct risk assessments for each source category subject to Section 112(d) NESHAP that require maximum achievable control technology (MACT), and to determine if additional standards are needed to reduce remaining risks. Section 112(d)(6) requires EPA to review and revise the emission standards, as necessary, taking into account developments in practices, processes and control technologies.	EPA has promulgated a number of RTR NESHAP and will do so, as required, for the remaining source categories with NESHAP.
Clean Air Act (CAA) - Section 183(e)	Section 183(e) requires EPA to list the categories of consumer and commercial products that account for at least 80% of all VOC emissions in areas that violate the National Ambient Air Quality Standards (NAAQS) for ozone and to issue standards for these categories that require "best available controls." In lieu of regulations, EPA may	1,3-Butadiene is listed under the National Volatile Organic Compound Emission Standards for Aerosol Coatings (40 CFR part 59, subpart E). 1,3-Butadiene has a reactivity factor of 13.58 g O3/g VOC.

Statutes/Regulations	Description of Authority/Regulation	Description of Regulation
	issue control techniques guidelines if the guidelines are determined to be substantially as effective as regulations.	
Safe Drinking Water Act (SDWA) – Section 1412(b)	Every 5 years, EPA must publish a list of contaminants that: (1) are currently unregulated, (2) are known or anticipated to occur in public water systems (PWSs) and (3) may require regulations under SDWA. EPA must also determine whether to regulate at least five contaminants from the list every 5 years.	1,3-Butadiene was identified on both the Third (2009) and Fourth (2016) Contaminant Candidate Lists (CCL) (74 FR 51850, October 8, 2009) (81 FR 81099, November 17, 2016).
Safe Drinking Water Act (SDWA) – Section 1445(a)	Every 5 years, EPA must issue a new list of no more than 30 unregulated contaminants to be monitored by PWSs. The data obtained must be entered into the National Drinking Water Contaminant Occurrence Database.	1,3-Butadiene was identified in the Third Unregulated Contaminant Monitoring Rule (UCMR3), issued in 2012 (77 FR 26071, May 2, 2012).
Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) – Sections 102(a) and 103	Authorizes EPA to promulgate regulations designating as hazardous substances those substances which, when released into the environment, may present substantial danger to the public health or welfare or the environment. EPA must also promulgate regulations establishing the quantity of any hazardous substance the release of which must be reported under Section 103. Section 103 requires persons in charge of vessels or facilities to report to the National Response Center if they have knowledge of a release of a hazardous substance above the reportable quantity threshold.	1,3-Butadiene is a hazardous substance under CERCLA. Releases of 1,3-butadiene in excess of 10 lb must be reported (40 CFR 302.4).
Superfund Amendments and Reauthorization Act (SARA)	Requires the Agency to revise the hazardous ranking system and update the National Priorities List of hazardous waste sites, increases state and citizen involvement in the superfund program and provides new enforcement authorities and settlement tools.	1,3-Butadiene is listed on SARA, an amendment to CERCLA and the CERCLA Priority List of Hazardous Substances. This list includes substances most commonly found at facilities on the CERCLA National Priorities List (NPL) that have been deemed to pose the greatest threat to public health.
Other federal statutes/regulations		
Occupational Safety and Health Act (OSHA)	Requires employers to provide their workers with a place of employment free from recognized hazards to safety and health, such as exposure to toxic chemicals, excessive noise levels, mechanical dangers, heat or cold stress or unsanitary conditions (29 U.S.C Section 651 et seq.).	OSHA established a PEL for 1,3-butadiene of 1 ppm / 5 ppm short-term exposure limit (STEL) as an 8-hour, TWA (29 CFR 1910.1051).

Statutes/Regulations	Description of Authority/Regulation	Description of Regulation
	Under the Act, OSHA can issue occupational safety and health standards including such provisions as Permissible Exposure Limits (PELs), exposure monitoring, engineering and administrative control measures, and respiratory protection.	

B.2 State Laws and Regulations

Table_Apx B-2. State Laws and Regulations

State Actions	Description of Action
State Air Regulations	Allowable Ambient Levels: New Hampshire (Env-A 1400: Regulated Toxic Air Pollutants). Rhode Island (Air Pollution Regulation No. 22).
State PELs	California (PEL of 1 ppm and a STEL of 5) (Cal Code Regs. Title 8, § 5155) Hawaii PEL: 1 ppm (Hawaii Administrative Rules Section 12-60-50).
State Right-to-Know Acts	Massachusetts (105 Code Mass. Regs. § 670.000 Appendix A), New Jersey (N.J.A.C. 7:1G) and Pennsylvania (P.L. 734, No. 159 and 34 Pa. Code § 323).
Chemicals of High Concern to Children	Two states have adopted reporting laws for chemicals in children's products containing 1,3-butadiene, including Maine (38 MRSA Chapter 16-D) and Minnesota (Toxic Free Kids Act Minn. Stat. 116.9401 to 116.9407).
Other	California listed 1,3-butadiene on Proposition 65 in 1998 due to cancer, and in 2004 due to developmental toxicity and female/male reproductive toxicity (Cal Code Regs. Title 27, § 27001). 1,3-Butadiene is listed as a Candidate Chemical under California's Safer Consumer Products Program established under Health and Safety Code § 25252 and 25253 (California, Candidate Chemicals List, Accessed April 15, 2019). California lists 1,3-butadiene as a designated priority chemical for biomonitoring under criteria established by California SB 1379 (Biomonitoring California, Priority Chemicals, February 2019). 1,3-Butadiene is on the MA Toxic Use Reduction Act (TURA) list of 2019 (301 CMR 41.00).

B.3 International Laws and Regulations

Table_Apx B-3. International Laws and Regulations

Country/ Tribe/ Organization	Requirements and Restrictions
Canada	1,3-Butadiene is on the Canadian List of Toxic Substances (CEPA 1999 Schedule 1). Other regulations include: Canada's National Pollutant Release Inventory (NPRI) Part 1A as a VOC.
European Union	1,3-Butadiene is registered for use in the EU with no restrictions CoRAP (Final). 1,3-Butadiene was evaluated under the 2014 Community rolling action plan (CoRAP) under regulation European Commission (EC) No1907/2006. -

Country/ Tribe/ Organization	Requirements and Restrictions
	REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals). European Chemical Agency (ECHA) database, Accessed April 10, 2019.
Australia	1,3-Butadiene was assessed under Human Health Tier II of the Inventory Multi-Tiered Assessment and Prioritisation (IMAP). Uses reported include: • Producing synthetic rubber (used to manufacture automotive tires and tire products); • Producing plastics such as acrylics, high impact polystyrene and acrylonitrile butadiene styrene (ABS) resin plastics, nylon and neoprene; • Producing resins; • Processing petroleum; • As a chemical intermediate in producing some fungicides; and • In manufacturing latex adhesives and paints (NICNAS, 2013, Human Health Tier II assessment for 1,3-butadiene, Accessed April 16, 2019).
Japan	1,3-Butadiene is regulated in Japan under the following legislation: Act on the Evaluation of Chemical Substances and Regulation of Their Manufacture, etc. (Chemical Substances Control Law; CSCL) Act on Confirmation, etc. of Release Amounts of Specific Chemical Substances in the Environment and Promotion of Improvements to the Management Thereof Industrial Safety and Health Act (ISHA) Air Pollution Control Law (Accessed April 10, 2019.)
Basel Convention	Solid Plastic Waste is listed as a category of waste under the Basel Convention. Although the United States is not currently a party to the Basel Convention, this treaty still affects U.S. importers and exporters.
Australia, Austria, Belgium, Canada, Denmark, European Union, Finland, France, Germany, Hungary, Ireland, Latvia, New Zealand, People's Republic of China, Poland, Romania, Singapore, South Korea, Spain, Sweden, Switzerland, The Netherlands, United Kingdom	Occupational exposure limits for 1,3-butadiene (GESTIS International limit values for chemical agents (Occupational exposure limits, OELs database, Accessed April 16, 2019).

B.4 Government Assessment History

Only governmental assessments published since 2000 are included in the below table. This list represents prominent assessments referenced either directly or indirectly by this risk evaluation or supporting documents and others identified through the systematic review process. It does not include private organizational or academic assessments and may not be inclusive of every single national or international governmental assessment.

Table_Apx B-4. Assessment History of 1,3-Butadiene

Authoring Organization	Publication
EPA publications	
U.S. EPA, Office of Pollution Prevention and Toxics (OPPT)	TSCA Work Plan for Chemical Assessments: 2014 Update (U.S. EPA, 2014b)
U.S. EPA, Office of Research and Development (ORD)	Health Assessment of 1,3-Butadiene (U.S. EPA, 2002b)
Other U.S. agencies	
Agency for Toxic Substances and Disease Registry (ATSDR)	Toxicological Profile for 1,3-Butadiene (ATSDR, 2012)
U.S. States	
California, California Environmental Protection Agency, Office of Environmental Health Hazard Assessments	1,3-Butadiene Reference Exposure Levels (OEHHA, 2013)
Texas, Texas Commission on Environmental Quality	A Chronic Reference Value for 1,3-Butadiene Based on an Updated Noncancer Toxicity Assessment (Grant et al., 2010)
International	
Australia, Australian Department of Health, National Industrial Chemicals Notification and Assessment Scheme (NICNAS)	1,3-Butadiene: Human health tier II assessment (NICNAS, 2013)
International Agency for Research on Cancer (IARC), IARC monograph	Chemical agents and related occupations: A review of human carcinogens (IARC, 2012)
Netherlands, National Institute for Public Health and the Environment	Environmental risk limits for 1,3-butadiene (RIVM, 2009)
European Union, European Chemicals Bureau, Institute for Health and Consumer Protection	European Union risk assessment report: 1,3-Butadiene (ECB, 2002)
World Health Organization (WHO)	1,3-Butadiene: Human health aspects (WHO, 2001)
Canada, Environment Canada, Health Canada	Priority Substances List Assessment Report: 1,3-Butadiene (Health Canada, 2000)

Appendix C LIST OF TECHNICAL SUPPORT DOCUMENTS

The below list indicates all technical support documents associated with this risk evaluation. These include discipline-specific assessments, systematic review results, risk calculations, modeling outputs, public communication documents, etc. Files are numbered corresponding with the filenames uploaded to the docket: https://www.regulations.gov/docket/EPA-HQ-OPPT-2024-0425

2. *Draft Charge Questions to the SACC for 1,3-Butadiene*

Associated **Technical Support Documents** – Provide additional details and information on physical chemistry, fate, exposure, hazard, and risk assessments.

3. *Draft Physical Chemistry, Fate, and Transport Assessment for 1,3-Butadiene* (U.S. EPA, 2024z)
4. *Draft Environmental Release and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2024y)
5. *Draft Environmental Media Concentrations for 1,3-Butadiene* (U.S. EPA, 2024p)
6. *Draft General Population Exposure for 1,3-Butadiene* (U.S. EPA, 2024r)
7. *Draft Human Health Hazard Assessment for 1,3-Butadiene* (U.S. EPA, 2024t)

Associated **Systematic Review Protocol and Data Quality Evaluation and Data Extraction** Documents – Provide additional detail and information on systematic review methodologies used as well as the data quality evaluations and extractions criteria and results.

8. *Draft Systematic Review Protocol for 1,3-Butadiene* (U.S. EPA, 2024ac) – In lieu of an update to the *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances*, also referred to as the "2021 Draft Systematic Review Protocol" (U.S. EPA, 2021a), this systematic review protocol for the Draft Risk Evaluation for 1,3-Butadiene describes some clarifications and different approaches that were implemented than those described in the 2021 Draft Systematic Review Protocol in response to (1) SACC comments, (2) public comments, or (3) to reflect chemical-specific risk evaluation needs. This supplemental file may also be referred to as the "1,3-Butadiene Systematic Review Protocol."

9. *Draft Data Quality Evaluation and Data Extraction Information for Physical and Chemical Properties for 1,3-Butadiene* (U.S. EPA, 2024l) – Provides a compilation of tables for the data extraction and data quality evaluation information for 1,3-butadiene. Each table shows the data point, set, or information element that was extracted and evaluated from a data source that has information relevant for the evaluation of physical and chemical properties. This supplemental file may also be referred to as the "1,3-Butadiene Data Quality Evaluation and Data Extraction Information for Physical and Chemical Properties."

10. *Draft Data Quality Evaluation and Data Extraction Information for Environmental Fate and Transport for 1,3-Butadiene* (U.S. EPA, 2024j) – Provides a compilation of tables for the data extraction and data quality evaluation information for 1,3-butadiene. Each table shows the data point, set, or information element that was extracted and evaluated from a data source that has information relevant for the evaluation for Environmental Fate and Transport. This supplemental file may also be referred to as the "1,3-Butadiene Data Quality Evaluation and Data Extraction Information for Environmental Fate and Transport."

11. *Draft Data Quality Evaluation and Data Extraction Information for Environmental Release and Occupational Exposure for 1,3-Butadiene* (U.S. EPA, 2024k) – Provides a compilation of tables for

the data extraction and data quality evaluation information for 1,3-butadiene. Each table shows the data point, set, or information element that was extracted and evaluated from a data source that has information relevant for the evaluation of environmental release and occupational exposure. This supplemental file may also be referred to as the "1,3-Butadiene Data Quality Evaluation and Data Extraction Information for Environmental Release and Occupational Exposure."

12. *Draft Data Quality Evaluation Information for General Population, Consumer, and Environmental Exposure for 1,3-Butadiene* (U.S. EPA, 2024m) – Provides a compilation of tables for the data extraction for 1,3-butadiene. Each table shows the data point, set, or information element that was extracted from a data source that has information relevant for the evaluation of general population, consumer, and environmental exposure. This supplemental file may also be referred to as the "1,3-Butadiene Data Extraction Information for General Population, Consumer, and Environmental Exposure."

13. *Draft Data Extraction Information for General Population, Consumer, and Environmental Exposure for 1,3-Butadiene* (U.S. EPA, 2024h) – Provides a compilation of tables for the data quality evaluation information for 1,3-butadiene. Each table shows the data point, set, or information element that was evaluated from a data source that has information relevant for the evaluation of general population, consumer, and environmental exposure. This supplemental file may also be referred to as the "1,3-Butadiene Data Quality Evaluation Information for General Population, Consumer, and Environmental Exposure."

14. *Draft Data Further Filtering Results for Human Health Hazard Animal Toxicology and Epidemiology for 1,3-Butadiene* (U.S. EPA, 2024q) – Provides a compilation of tables for study-wide summary information for 1,3-butadiene human health hazard studies. This information was used to "filter" studies that met PECO criteria to determine which studies should undergo data evaluation and extraction based on whether they could potentially support dose-response analysis. This supplemental file may also be referred to as the "1,3-Butadiene Further Filtering Results for Human Health Hazard."

15. *Draft Data Quality Evaluation Information for Human Health Hazard Epidemiology for 1,3-Butadiene* (U.S. EPA, 2024o) – Provides a compilation of tables for the data quality evaluation information for DIDP. Each table shows the data point, set, or information element that was evaluated from a data source that has information relevant for the evaluation of epidemiological information. This supplemental file may also be referred to as the "1,3-Butadiene Data Quality Evaluation Information for Human Health Hazard Epidemiology."

16. *Draft Data Quality Evaluation Information for Human Health Hazard Animal Toxicology for 1,3-Butadiene* (U.S. EPA, 2024n) – Provides a compilation of tables for the data quality evaluation information for 1,3-butadiene. Each table shows the data point, set, or information element that was evaluated from a data source that has information relevant for the evaluation of human health hazard animal toxicity information. This supplemental file may also be referred to as the "1,3-Butadiene Data Quality Evaluation Information for Human Health Hazard Animal Toxicology."

17. *Draft Data Extraction Information for Human Health Hazard Animal Toxicology and Epidemiology for 1,3-Butadiene* (U.S. EPA, 2024i) – Provides a compilation of tables for the data extraction for 1,3-butadiene. Each table shows the data point, set, or information element that was extracted from a data source that has information relevant for the evaluation human health hazard animal toxicology and epidemiology information. In contrast with other risk evaluations, this file

contains dose-response information for every assessed endpoint within each animal toxicology study. This supplemental file may also be referred to as the "1,3-Butadiene Data Extraction Information for Environmental Hazard and Human Health Hazard Animal Toxicology and Epidemiology."

Associated **Quantitative Analysis** Supplemental Documents:

18. *Draft EPI Suite Modeling Results Supporting Fate Assessment for 1,3-Butadiene* (U.S. EPA, 2024af)

19. *Draft Ambient Monitoring Technology Information Center (AMTIC) Monitoring Data 2016 to 2021 for 1,3-Butadiene* (U.S. EPA, 2024f)

20. *Draft Water Quality Portal (WQP) Monitoring Data 2011 to 2023 for 1,3-Butadiene* (U.S. EPA, 2024ad)

21. *Draft Land Releases for 1,3-Butadiene* (U.S. EPA, 2024v)

22. *Draft Water Releases for 1,3-Butadiene* (U.S. EPA, 2024ae)

23. *Draft Air Releases (TRI) for 1,3-Butadiene* (U.S. EPA, 2024e)

24. *Draft Air Releases (NEI 2017) for 1,3-Butadiene* (U.S. EPA, 2024c)

25. *Draft Air Releases (NEI 2020) for 1,3-Butadiene* (U.S. EPA, 2024d)

26. *Draft Adhesives and Sealants Release Model for 1,3-Butadiene* (U.S. EPA, 2024b)

27. *Draft Number of Sites for 1,3-Butadiene* (U.S. EPA, 2024x)

28. *Draft Benchmark Dose Modeling Results for 1,3-Butadiene* (U.S. EPA, 2024g)

29. *Draft Lifetable Analysis of Leukemia and Bladder Cancer for 1,3-Butadiene* (U.S. EPA, 2024w)

30. *Modified Lifetable Analysis of Leukemia and Bladder Cancer for 1,3-Butadiene* (U.S. EPA, 2024ag)

31. *Draft Risk Calculator for Occupational Exposures for 1,3-Butadiene* (U.S. EPA, 2024aa)

32. *Draft Integrated Indoor Outdoor Air Calculator (IIOAC) TRI 2016-2021 Exposure and Risk Analysis for 1,3-Butadiene* (U.S. EPA, 2024u)

33. *Draft Human Exposure Model (HEM) TRI 2016-2021 Exposure and Risk Analysis for 1,3-Butadiene* (U.S. EPA, 2024s)

34. *1,3-Butadiene: Corrected Lifetable Analyses for Leukemia and Bladder Cancer* (U.S. EPA, 2024a)

35. *Draft Supplemental Information on the Human Exposure Modeling Results for 1,3-Butadiene* (U.S. EPA, 2024ab)

36. *Draft Nontechnical Summary for 1,3-Butadiene*

Appendix D UPDATES TO THE 1,3-BUTADIENE CONDITIONS OF USE TABLES

After the final scope, EPA received updated submissions under the 2020 Chemical Data Reporting (CDR) reported data. Therefore, EPA is amending the description of certain 1,3-butadiene COUs based on the new submissions, expanding subcategories to accurately represent EPA's understanding of the use, and consolidating categories already covered in the COU table. Also, EPA is amending an error to a COU in the final scope document.

Table_Apx D-1. Additions and Name Changes to Categories and Subcategories of Conditions of Use Based on CDR Reporting and Stakeholder Engagement

Life Cycle Stage and Category	Original Subcategory in the Final Scope Document	Occurred Change	Revised Subcategory in the 2024 Draft Risk Evaluation
Processing; incorporation into formulation, mixture, or reaction product	Other: Paints and coatings manufacturing	Expanded category and associated subcategory to more accurately represent EPA's understanding of the use and based on public comments. Added "Intermediate in: Paint and coating manufacturing"	Processing – Incorporation into formulation, mixture, or reaction product – Other (paint and coating manufacturing) And Processing – Processing as a reactant – Intermediate (paint and coating manufacturing)
Processing; repackaging	N/A	Added subcategory to reflect updates from 2020 CDR reporting cycle.	Processing – Repackaging – Monomer (synthetic rubber manufacturing)
Industrial Use; Processing aids, specific to petroleum production	Hydraulic fracturing fluids	Removed "Hydraulic fracturing fluids" 1,3-butadiene is not used for hydraulic fracturing for oil and gas.	N/A
Commercial Use	Plastic and rubber products not covered elsewhere, including rubber tires	Replaced "plastic and rubber products not covered elsewhere" with new subcategories based on updates to CDR reporting and the 2020 CDR reporting cycle.	Commercial use – Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard); Commercial use – Toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard); Commercial use – Synthetic Rubber (*e.g.*, rubber tires); Commercial use – Furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles; And

Life Cycle Stage and Category	Original Subcategory in the Final Scope Document	Occurred Change	Revised Subcategory in the 2024 Draft Risk Evaluation
			Commercial use – Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft)
Commercial Use	Other: Monomer used in polymerization process	Consolidated category and associated subcategory under "Processing as a reactant; Intermediate" EPA believes this use is already covered, this is not a commercial use, and is consolidating to avoid duplication.	Processing – Processing as a reactant – Intermediate
Consumer Use	Plastic and rubber products not covered elsewhere	Replaced "plastic and rubber products not covered elsewhere" with new subcategories based on updates to CDR reporting and the 2020 CDR reporting cycle.	Consumer Use – Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard); Consumer Use – Toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard); Consumer Use – Synthetic Rubber (*e.g.*, rubber tires); Consumer Use – Furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles; And Consumer Use – Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft)

As indicated in the Table_Apx D-1, the changes are based on close examination of the CDR reports, including the 2020 CDR reports that were received after the scope was completed, additional research on the conditions of use, additional comments from stakeholders, and overall systematic review of the use information.

In addition, EPA did further analysis of the following conditions of use, which resulted in the changes presented on the table which warrant further explanation because these COUs were changed significantly between the final scope and the draft risk evaluation:

- *"Processing; Processing as a reactant – Intermediate in: Paint and coating manufacturing"* – EPA expanded this paint and coating manufacturing use to include both "incorporation into formulation, mixture, or reaction product" and "processing as a reactant." The original COU represented in the scope document, "incorporation into formulation, mixture, or reaction product," was included based on public comments. A commenter stated that manufacturers note residual amounts of 1,3-butadiene in architectural paints and coatings (EPA-HQ-OPPT-2018-

0451-0005) However, "processing as a reactant - Intermediate in: paint and coating manufacturing" more accurately represent 1,3 butadiene's function in these uses. Although 1,3-butadiene monomer is not directly incorporated into paints and coatings, rather a 1,3-butadiene polymer, residual 1,3-butadiene may be present.

- "*Industrial Use – Processing aids, specific to petroleum production – Hydraulic fracturing fluids"*– Hydraulic Fracturing was added to the COU table in response to a public comment EPA- HQ-2019-0131-0036. The commenters stated that since 1,3-butadiene is listed in EPA's Hydraulic fracturing for oil and gas: Impacts from the hydraulic fracturing water cycle on drinking water resources in the United States, 1,3-butadiene should be included in the COU table in the scope. On checking the source from EPA's hydraulic fracturing report, FracFocus, 1,3-butadiene is not listed, instead a different chemical, Benzene, ethenyl-, polymer with 2-methyl-1,3-butadiene, hydrogenated (CASRN 68648-89-5) was listed in the report. The 2020 CDR data also did not report the use of 1,3-butadiene in hydraulic fracturing fluid. As a result, hydraulic fracturing was removed from the COU table.

- *"Consumer Use; Plastic and rubber products not covered elsewhere"* – EPA updated the table to reflect the most recent CDR reporting codes. These COUs are broken up into five subcategories: "Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard);" "Toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard);" "Synthetic Rubber (*e.g.,* rubber tires);" "Furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles;" and "Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft)." In addition, these COUs were reported in 2020 CDR as commercial use, but not all were reported as consumer use. However, EPA is assuming that if these products are in commercial use they could also be available for consumer use.

Appendix E CONDITIONS OF USE DESCRIPTIONS

The following descriptions are intended to include examples of uses, so as not to exclude other activities that may also be included in the COUs of the chemical substance. To better describe the COU, EPA considered CDR submissions from the last two CDR cycles for 1,3-butadiene (CASRN 106-99-0) and the COU descriptions reflect what EPA identified as the best fit for that submission.

E.1 Manufacturing – Domestic Manufacturing

Domestic manufacture means to produce 1,3-butadiene within the United States. For purposes of the 1,3-butadiene risk evaluation, this includes the extraction of 1,3-butadiene from a previously existing chemical substance or complex combination of chemical substances, and loading/unloading and repackaging (but not transport) associated with the manufacturing and production of 1,3-butadiene.

1,3-Butadiene can be produced by three processes: catalytic dehydrogenation of n-butane and n-butene, oxidative dehydrogenation of n-butene, and in the process of the steam cracking of hydrocarbon streams for ethylene production. The most common method is as a co-product during ethylene production (Sun and Wristers, 2002). The process can use a variety of hydrocarbon feedstocks, the heavier fractions generally giving a higher yield of 1,3-butadiene/amount of ethylene produced (Miller and Villaume, 1978).

Examples of CDR Submissions

In the 2016 CDR, nine companies reported domestic manufacturing of 1,3-butadiene with all manufacturers producing a liquid or a gas/vapor. In the 2020 CDR, eight companies reported importing of 1,3-butadiene with all manufacturers producing a liquid or a gas/vapor.

E.2 Manufacturing – Importing

Import refers to the import of 1,3-butadiene into the customs territory of the United States. In general, chemicals may be imported into the United States in bulk via water, air, land, and intermodal shipments, and loading and repackaging (but not transport) associated with the import of 1,3-butadiene. These shipments take the form of oceangoing chemical tankers, railcars, tank trucks, and intermodal tank containers (U.S. EPA, 2021b). 1,3-Butadiene is primarily shipped in pressurized containers via railroads or tankers (Sun and Wristers, 2002). Other forms of transport include pipeline and barge (National Toxicology Program (NTP), 1999).

Examples of CDR Submissions

In the 2016 CDR, nine companies reported importing of 1,3-butadiene with all importing a liquid or gas/vapor. In the 2020 CDR, nine companies reported importing of 1,3-butadiene with all importing a liquid or gas/vapor.

E.3 Processing – Reactant – Intermediate in: Adhesive Manufacturing; All Other Basic Organic Chemical Manufacturing; Fuel Binder for Solid Rocket Fuels; Organic Fiber Manufacturing; Petrochemical Manufacturing; Petroleum Refineries; Plastic Material and Resin Manufacturing; Propellant Manufacturing; Synthetic Rubber Manufacturing; Paint and Coating Manufacturing, Wholesale and Retail Trade

Processing as a reactant includes the polymerization of 1,3-butadiene with itself or with other monomers

(Sun and Wristers, 2002). Some of the common polymers derived from the use of 1,3-butadiene as a monomer feedstock are:

- Polybutadiene
- Hydroxyl-terminated polybutadiene
- Styrene-butadiene rubber
- Styrene-butadiene latex
- Acrylonitrile-butadiene-styrene polymer

The general process at polymerization sites is unloading of 1,3-butadiene, a washing or purification step to remove polymerization inhibitors, then the different monomers are added to the reactor. After completion of reaction, the content of unreacted monomer may vary depending on the reactions and additives used. Typically, this may be followed with a butadiene monomer recovery system to recycle 1,3-butadiene back to feed into the reactor. Polymer production can be done either via emulsion polymerization or solution polymerization depending on the end product use. The final polymer products may be packaged to sale to downstream users (U.S. EPA, 1996). This polymerization product is incorporated into various rubber and plastic articles.

EPA received information on ways 1,3-butadiene is used as a chemical intermediate (EPA-HQ-OPPT-2018-0451-0021). One use is in the production of Nylon. In this process, 1,3-butadiene is subjected to direct hydrocyanation to form pentenitrile compounds and adiponitrile, which are further hydrocyanated to form hexamethylenediamine. This compound is polymerized to manufacture nylon resins. Another process in which 1,3-butadiene is used as a chemical intermediate is in the production of neoprene rubber which involves 1,3-butadiene being chlorinated to form chloroprene, which is then polymerized to form neoprene. 1,3-Butadiene is also used to produce 1,4-hexadiene (used to create ethylene-propylene terpolymer), sulfolane (an extraction solvent), and 1,5,9-cyclodecatriene (used in the production of nylon fibers and resins). Interagency and intra-agency comments indicate that 1,3-butadiene is also processed as a reactant in propellant manufacturing by the United States Department of Defense (DOD).

The CDR product category code for fuels and related products includes cooking and heating fuels, fuel additives, and vehicle and appliance fuels. EPA did not identify information on how 1,3-butadiene is used in fuels and related products. The National Library of Medicine's Hazardous Substance Databank (HSDB) confirms that polybutadiene (a polymer formed from the polymerization of 1,3-butadiene) is used as a matrix for rocket propellant as a binder, rather than the 1,3-butadiene monomer itself (NLM, 2003).

Examples of CDR Submissions

In the 2016 CDR, 13 companies reported processing as a reactant of 1,3-butadiene as an intermediate in: adhesive manufacturing, all other basic organic chemical manufacturing, fuel binder for solid rocket fuels; organic fiber manufacturing, petrochemical manufacturing, petroleum refineries, plastic material and resin manufacturing, propellant manufacturing, synthetic rubber manufacturing, and wholesale and retail trade. In the 2020 CDR, 10 companies for 1,3-butadiene reported processing as a reactant as an intermediate: for all other basic organic chemical manufacturing, organic fiber manufacturing, petrochemical manufacturing, petroleum refineries, plastic material and resin manufacturing, and synthetic rubber manufacturing. EPA is aware of one company reporting use of 1,3-butadiene as an "intermediate in non-incorporative activities: intermediate in wholesale and retail trade" in the 2020 CDR data. EPA is aware it was reported differently from the 2016 CDR data. However, based on EPA's understanding of 1,3-butadiene's use, EPA is keeping this COU as a reactant rather than an intermediate in non-incorporative activities.

E.4 Processing – Reactant – Monomer Used in Polymerization Process in: Synthetic Rubber Manufacturing; Plastic Material and Resin Manufacturing

As discussed previously, processing as a reactant includes the polymerization of 1,3-butadiene with itself or with other monomers (Sun and Wristers, 2002). 1,3-Butadiene is most commonly used as a monomer in polymerization processes, often to produce rubbers and plastics such as styrene-butadiene, polybutadiene, acrylonitrile-butadiene-styrene, and nitrile rubber (Sun and Wristers, 2002). During this process, dry solvent, initiator, other monomers, and 1,3-butadiene are loaded into a reactor until all monomers are depleted. Then, the chain ends are terminated, and the resulting polymer solution is pumped to a blend tank. These processes can be run in batch or continuous operation (EPA-HQ-OPPT-2018-0451-0022).

These polymers, such as acrylonitrile butadiene styrene (ABS), polybutadiene, and styrene-butadiene, are manufactured using 1,3-butadiene, and are often involved in compounding processes to produce final plastic and rubber products. Copolymers of styrene and butadiene containing over 45 percent 1,3-butadiene possess rubber like properties and copolymers containing over 45 percent styrene having plastic or latex like qualities (U.S. EPA, 1996). Unreacted 1,3-butadiene monomer is recovered and recycled during the process and according to public comments, synthetic rubber such as butadiene rubber (BR) and solution styrene butadiene rubber (SSBR) polymers contain less than 50 ppb of residual 1,3-butadiene monomer (EPA-HQ-OPPT-2018-0451-0027).

Examples of CDR Submissions

In the 2016 CDR, four companies reported processing as a reactant of 1,3-butadiene as a monomer used in polymerization process. In the 2020 CDR, six companies reported processing as a reactant of 1,3-butadiene as a monomer used in polymerization process. EPA is aware of one company reporting use of 1,3-butadiene as "Incorporation into a formulation, mixture, or reaction product – Monomers used in plastic product manufacturing; Synthetic rubber Manufacturing" in the 2020 CDR data. EPA is aware it was reported differently from the 2016 CDR data. However, based on EPA's understanding of 1,3-butadiene's chemical properties, EPA is keeping this COU as a reactant.

E.5 Processing – Incorporation into a Formulation, Mixture, or Reaction Product – Processing Aids, Not Otherwise Listed in: Petrochemical Manufacturing

This COU refers to the preparation of a product; that is, the incorporation of 1,3-butadiene into a formulation, mixture, or a reaction product which occurs when a chemical substance is added to a product (or product mixture) after its manufacture, for distribution in commerce. 1,3-Butadiene is used as processing aids and butadiene polymers are used in several petrochemical manufacturing operations (U.S. EPA, 2019b).

Examples of CDR Submissions

In the 2016 CDR, two companies reported use of 1,3-butadiene as a processing aid, not otherwise listed in petrochemical manufacturing. In the 2020 CDR, one company reported use of 1,3-butadiene as a processing aid, not otherwise listed in petrochemical manufacturing.

E.6 Processing – Incorporation into a Formulation, Mixture, or Reaction Product – Other: Adhesive Manufacturing, Paint and Coating Manufacturing, Petroleum Lubricating Oil and Grease Manufacturing, and All Other Chemical Product and Preparation Manufacturing

This COU refers to the preparation of a product; that is, the incorporation of 1,3-butadiene into a formulation, mixture, or a reaction product, which occurs when a chemical substance is added to a product (or product mixture) after its manufacture, for distribution in commerce. 1,3-Butadiene is used as a processing aid and butadiene polymers are used in several petrochemical manufacturing operations, adhesives, lubricants and in formulated paints and coatings (EPA-HQ-OPPT-2018-0451-0003; EPA-HQ-OPPT-2018-0451-0005; EPA-HQ-OPPT-2018-0451-0009; EPA-HQ-OPPT-2019-0131-0022).

This use was not reported to EPA in the 2016 or 2020 CDR reporting cycles.

E.7 Processing – Incorporation into Article – Other: Polymer in: Rubber and Plastic Product Manufacturing

This COU refers to the preparation of an article; that is, the incorporation of 1,3-butadiene into articles, meaning 1,3-butadiene becomes a component of the article, after its manufacture, for distribution in commerce. 1,3-Butadiene is used as a monomer or co-monomer in the manufacture of synthetic rubbers. These synthetic rubbers and latex are used to manufacture tires, other rubber components and plastic materials (U.S. EPA, 2019b). In plastic manufacturing, the final plastic article is produced in a conversion process that forms the compounded plastic into the finished products (U.S. EPA, 2014a; OECD, 2009). The converting process is different depending on whether the plastic is a thermoplastic or a thermosetting material (OECD, 2009). Thermoplastics converting involves the melting of the plastic material, forming it into a new shape and then cooling it (U.S. EPA, 2014a; OECD, 2009). The converting of thermoplastics may involve extrusion, injection molding, blow molding, rotational molding or thermoforming (U.S. EPA, 2014a; OECD, 2009).

Examples of CDR Submissions

In the 2016 CDR, one company reported incorporation into article – Other: Polymer in: Rubber and plastic product manufacturing. This use was not reported to the 2020 CDR reporting cycle.

E.8 Processing – Repackaging – Intermediate in: Wholesale and Retail Trade; Monomer in: Synthetic Rubber

Repackaging refers to the preparation of 1,3-butadiene for distribution in commerce in a different form, state, or quantity than originally received or stored by various industrial sectors, including chemical product and preparation manufacturing, wholesale and retail trade, and laboratory chemicals manufacturing. This COU includes the transferring of 1,3-butadiene from a bulk container into smaller containers. This COU would not apply to the relabeling or redistribution of a chemical substance without removing the chemical substance from the original container it was supplied in.

Examples of CDR Submissions

This use was not reported to the 2016 CDR reporting cycle. In the 2020 CDR, one company reported repackaging 1,3-butadiene as an intermediate in wholesale and retail trade and one company reported repackaging 1,3-butadiene as monomer in synthetic rubber manufacturing.

E.9 Processing – Recycling

This COU refers to the process of treating generated waste streams (*i.e.*, which would otherwise be disposed of as waste), containing1,3-butadiene, that are collected, either on-site or transported to a third-party site, for commercial purpose. Recovery and recycling of unreacted 1,3-butadiene from the various synthetic rubber manufacturing operations are common. 1,3-Butadiene and other monomers (such as styrene) are recovered and reused in rubber manufacturing to the extent possible (ECB, 2002). EPA notes that although 1,3-butadiene was not reported for recycling in the 2016 or 2020 CDR reporting periods, EPA is assuming that recycling waste streams could contain 1,3-butadiene.

There are multiple ways 1,3-butadiene can be recycled during its life cycle. First, when finished 1,3-butadiene does not meet commercial specifications, it is often combined with crude streams for energy recovery. Similarly, when ethylene manufacturers have excess butadiene supply, they can recycle the butadiene as a feedstock for the production of ethylene. In polymer production, unreacted butadiene-containing monomers are recycled back to the reactors to improve the process yield.

E.10Distribution in Commerce

For purposes of assessment in this risk evaluation, distribution in commerce consists of the transportation associated with the moving of 1,3-butadiene or 1,3-butadiene-containing products between sites manufacturing, processing, or recycling 1,3-butadiene or 1,3-butadiene-containing products, or to final use sites, or for final disposal of 1,3-butadiene or 1,3-butadiene-containing products. More broadly under TSCA, "distribution in commerce" and "distribute in commerce" are defined under TSCA section 3(5).

E.11 Industrial Use – Adhesives and Sealants, Including Epoxy Resins

This COU refers to 1,3-butadiene as it is used in various industrial sectors as a component of adhesive or sealant mixtures, meaning the use of 1,3-butadiene after it has already been incorporated into an adhesive and/or sealant product or mixture, as opposed to when it is used upstream, (*e.g.*, when 1,3-butadiene is processed into the adhesive and sealant formulation). Examples of applications for adhesive and sealant products that are used in aerospace industrial uses include: adhesives critical to electrical and circuit boards and pre-impregnated fiberglass or carbon reinforced fabrics and tapes, space vehicle propellants, and epoxy resin adhesive systems for bonding and sealing of glass to metal components (EPA-HQ-OPPT-2018-0451-0009).

Examples of CDR Submissions

In the 2016 CDR, one company reported use of 1,3-butadiene as an intermediate in adhesive manufacturing. This use was not reported to the 2020 CDR reporting cycle.

E.12 Commercial Use – Fuels and Related Products

This COU is referring to the commercial use of 1,3-butadiene in fuels and related products. 1,3 Butadiene is a byproduct in the refining process and in liquified petroleum gas as a result of butane contamination. The CDR product category code for fuels and related products includes cooking and heating fuels, fuel additives, and vehicle and appliance fuels. EPA did not identify information on how 1,3-butadiene is used in fuels and related products. Evidence was found, however, of 1,3-butadiene's presence within butane liquified petroleum gas (LPG) product, which is used as a fuel . The safety data sheet (SDS) for butane LPG states the product "is intended for use as a fuel in devices designed for combustion of butane, or for use in industrial processes." LPG can be used for the same domestic, commercial, and industrial applications as natural gas, with the largest market for LPG is the domestic/commercial market. Further, one of the main LPG uses is in rural areas for domestic cooking and heating. For commercial and industrial settings, LPG is used as a primary or backup fuel in small boilers and space heating equipment and is used to generate heat and process steam. Pressurized cylinder sizes will vary depending on the application (*i.e.*, larger cylinders would be used for industrial applications vs. smaller cylinders for consumer cooking).

Examples of CDR Submissions

In the 2016 CDR, one company reported use of 1,3-butadiene as commercial use in fuels and related products. In the 2020 CDR, one company reported the use of 1,3-butadiene as sold to re-sellers for petroleum fuel and petrochemical industry.

E.13Commercial Use – Other Articles with Routine Direct Contact During Normal Use Including Rubber Articles; Plastic Articles (Hard); Toys Intended for Children's Use (and Child Dedicated Articles), Including Fabrics, Textiles, and Apparel; or Plastic Articles (Hard); Synthetic Rubber (*e.g.*, Rubber Tires); Furniture & Furnishings Including Stone, Plaster, Cement, Glass and Ceramic Articles; Metal Articles; Or Rubber Articles; Packaging (Excluding Food Packaging), Including Rubber Articles; Plastic Articles (Hard); Plastic Articles (Soft)

This COU is referring to the commercial use of 1,3-butadiene already incorporated in plastic and rubber products not covered elsewhere. EPA understands examples of this COU could include tires, auto parts, the medical industry, footwear, industrial goods, the construction industry, appliances, lubricants, fabrics, wires and cables, and synthetic rubber in toys (EPA-HQ-OPPT-2018-0451-0003, EPA-HQ-OPPT-2019-0131-0012).

Examples of CDR Submissions

In the 2016 CDR, four companies reported commercial use of 1,3-butadiene in plastic and rubber products not covered elsewhere. After updates to the 2020 CDR reporting cycle, the subcategories changed from the 2016 CDR reporting cycle. In the 2020 CDR, three companies reported commercial use of 1,3-butadiene as other articles with routine direct contact during normal use including rubber articles; plastic articles (hard); one company reported commercial use of 1,3-butadiene in toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard); one company reported commercial use of 1,3-butadiene in synthetic rubber (*e.g.*, rubber tires); one company reported commercial use of 1,3-butadiene in furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles; one company reported commercial use of 1,3-butadiene in packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft).

E.14 Commercial Use – Automotive Care Products

This COU is referring to the commercial use of 1,3-butadiene in automotive care products. Meaning the use of 1,3-butadiene in automotive care products in a commercial setting, such as an automotive parts business or a worker driving a vehicle, as opposed to upstream use of 1,3-butadiene (*e.g.*, when 1,3-butadiene-containing products are used in the manufacturing of the automotive product) or use in an industrial setting. EPA understands that 1,3-butadiene has been used as part of a thermoplastic or as an elastomer/elastomeric compound and production parts of an automobile, such as console assembly, air brake valves, or seat set (EPA-HQ-OPPT-2019-0131-0022).

Examples of CDR Submissions

In the 2016 CDR, two companies reported commercial use of 1,3-butadiene in automotive care products. This use was not reported to the 2020 CDR reporting cycle.

E.15 Commercial Use – Other Use – Laboratory Chemicals

This COU is referring to the commercial use of 1,3-butadiene in laboratory chemicals. EPA understands 1,3-butadiene could be used as a product in analytical chemistry, research, equipment calibration, and sample preparation applications, including reference sample for analysis of terrestrial and extraterrestrial material samples. Additionally, 1,3-butadiene could be as a component of resin products that are used in research (EPA-HQ-OPPT-2018-0451-0039).

This use was not reported to EPA in the 2016 or 2020 CDR reporting cycles.

E.16 Commercial Use – Lubricants and Lubricant Additives

This COU is referring to the commercial use of 1,3-butadiene based polymers in lubricants and lubricant additives, including for use as lubricant additives and viscosity modifiers (EPA-HQ-OPPT-2018-0451-0003; EPA-HQ-OPPT-2019-0131-0022)

This use was not reported to EPA in the 2016 or 2020 CDR reporting cycles.

E.17 Commercial Use – Paint and Coatings

This COU is referring to the commercial use of 1,3-butadiene in paints and coatings. EPA understands 1,3-butadiene to be present in architectural paints and coatings (EPA-HQ-OPPT-2018-0451-0005).

This use was not reported to EPA in the 2016 or 2020 CDR reporting cycles.

E.18 Commercial Use – Adhesives and Sealants

This COU is referring to the commercial use of 1,3-butadiene in adhesives and sealants, including epoxy resins (EPA-HQ-OPPT-2018-0451-0003; EPA-HQ-OPPT-2018-0451-0009; EPA-HQ-OPPT- 2019-0131-0022).

This use was not reported to EPA in the 2016 or 2020 CDR reporting cycles.

E.19 Consumer Use – Other Articles with Routine Direct Contact During Normal Use Including Rubber Articles; Plastic Articles (Hard); Toys Intended for Children's Use (and Child Dedicated Articles), Including Fabrics, Textiles, and Apparel; or Plastic Articles (Hard); Synthetic Rubber (*e.g.*, Rubber Tires); Furniture & Furnishings Including Stone, Plaster, Cement, Glass and Ceramic Articles; Metal Articles; or Rubber Articles; Packaging (Excluding Food Packaging), Including Rubber Articles; Plastic Articles (Hard); Plastic Articles (Soft)

This COU is referring to the consumer use of 1,3-butadiene in plastic rubber products not covered elsewhere, including rubber tires. It is estimated that more than 3 million metric tons of natural and synthetic rubber are used annually. Half of this use volume is expected to be from the use of styrene-butadiene-rubber (SBR). Half of this SBR is used to make tires (Burgess, 1991). In addition, plastics containing 1,3-butadiene were identified in electronic appliances, furniture and furnishings, toys and recreational products, housewares, packaging, automotive parts, building materials, and 3D-printing filament (Steinle, 2016; Pfäffli and Säämänen, 1993).

Examples of CDR Submission

In the 2016 CDR, two companies reported consumer use of 1,3-butadiene in plastic and rubber products not covered elsewhere. This use was not reported to the 2020 CDR reporting cycle.

E.20 Disposal

Each of the COUs of 1,3-butadiene may generate waste streams of the chemical. For purposes of the 1,3-butadiene risk evaluation, this COU refers to the 1,3-butadiene in a waste stream that is collected from facilities and households and are unloaded at and treated or disposed at third-party sites. This COU also encompasses 1,3-butadiene contained in wastewater or other wastes generated by consumer or occupational users and discharged to a POTW or other, non-public treatment works for treatment. TRI data indicate 1,3-butadiene may be land disposed, deep-well injected, or discharged to water following pretreatment (U.S. EPA, 2019e). Disposal may also include destruction and removal by incineration. Streams containing 1,3-butadiene may be combined with crude streams for energy recovery when finished 1,3-butadiene does not meet commercial specifications. Recycling of 1,3-butadiene and 1,3-butadiene-containing products is considered a different COU. Environmental releases from industrial sites are assessed in each COU.

Appendix F OCCUPATIONAL EXPOSURE VALUE DERIVATION AND ANALYTICAL METHODS USED TO DETECT 1,3-BUTADIENE

EPA has calculated an 8-hour time-weighted average (TWA) existing chemical occupational exposure value to summarize the occupational exposure scenario and sensitive health endpoints into a single value. This calculated value may be used to support risk management efforts for 1,3-butadiene under TSCA section 6(a), 15 U.S.C. 2605. EPA calculated the value rounded to 0.14 ppm (0.31 mg/m^3) for inhalation exposures to 1,3-butadiene as an 8-hour TWA and for consideration in workplace settings (see Appendix F.1 below) based on the chronic occupational unit risk (UR) for leukemia.

TSCA requires risk evaluations to be conducted without consideration of cost and other non-risk factors, and thus this most sensitive occupational exposure value represents a risk-only number. If risk management for 1,3-butadiene is implemented following the final risk evaluation, EPA may consider cost and other non-risk factors, such as technological feasibility, the availability of alternatives, and the potential for critical or essential uses. Any existing chemical exposure limit (ECEL) used for occupational safety risk management purposes could differ from the occupational exposure value presented in this appendix based on additional consideration of exposures and non-risk factors consistent with TSCA section 6(c).

This calculated value for 1,3-butadiene represents the exposure concentration below which exposed workers and occupational non-users are not expected to exhibit any appreciable risk of adverse toxicological outcomes. This value accounts for PESS. The value is derived based on the most sensitive human health effect (*i.e.*, leukemia) supported by the weight of scientific evidence. This value is expressed relative to benchmarks and standard occupational scenario assumptions of 8 hours per day, 5 days per week exposures for a total of 250 days exposure per year, and a 40-year working life.

All hazard values used in these calculations are based on the non-cancer intermediate POD and chronic occupational cancer UR from the *Draft Human Health Hazard Assessment for 1,3-Butadiene* (U.S. EPA, 2024t).

EPA expects that at the occupational exposure value of 0.14 ppm (0.31 mg/m^3) for lifetime exposure, workers and occupational non-users also would be protected against non-cancer health effects for acute, intermediate, and chronic durations. EPA has not separately calculated a short-term occupational exposure value (STEV) for 1,3-butadiene (see Section F.3 for details).

Of the identified occupational monitoring data for 1, 3-butadiene, there have been measured workplace air concentrations below the calculated exposure value. A summary table of available monitoring methods from the Occupational Safety and Health Administration (OSHA) and the National Institute for Occupational Safety and Health (NIOSH) is included in Appendix F.2. The table presents validated methods from governmental agencies and is not intended to be a comprehensive list of available air monitoring methods for 1,3-butadiene. The calculated occupational exposure value is above the limit of detection (LOD) and limit of quantification (LOQ) using at least one of the monitoring methods identified.

The Occupational Safety and Health Administration (OSHA) has set a permissible exposure limit (PEL) as an 8-hour TWA for 1,3-butadiene of 1 ppm and a short-term exposure limit (STEL) of 5 ppm at a duration of 15 minutes. However, as noted on OSHA's website, "OSHA recognizes that many of its permissible exposure limits (PELs) are outdated and inadequate for ensuring protection of worker health. Most of OSHA's PELs were issued shortly after adoption of the Occupational Safety and Health (OSH) Act in 1970 and have not been updated since that time." In addition, OSHA's PEL must undergo both risk assessment and feasibility assessment analyses before selecting a level that will substantially reduce risk under the Occupational Safety and Health Act. EPA's calculated exposure value is a lower value and is based on newer information and analysis from this risk evaluation.

Other governmental agencies and independent groups have also set recommended exposure limits established for 1, 3-butadiene. The American Conference of Governmental Industrial Hygienists (ACGIH) has set a Threshold Limit Value (TLV) at 2 ppm TWA. While this chemical does not have a NIOSH Recommended Exposure Limit (REL), NIOSH notes and identifies 1, 3-butadiene as a carcinogen and lists the following guidance: "reduce exposures to lowest feasible concentrations".

F.1 Occupational Exposure Value Calculations

This section presents the calculations used to estimate the occupational exposure values using inputs derived in this risk evaluation. Multiple values are presented below for hazard endpoints based on different exposure durations. For 1,3-butadiene, the most sensitive occupational exposure value is based on cancer following lifetime exposure and the resulting 8-hour TWA is rounded to 0.14 ppm. The human health hazard values (HECs, UR) used in the equations are derived in the risk evaluation draft risk evaluation and *Draft Human Health Hazard Assessment for 1,3-Butadiene* (U.S. EPA, 2024t).

Most Sensitive Occupational Exposure Value (Lifetime Cancer)

The EV_{cancer} is the concentration at which the extra cancer risk is equivalent to the benchmark cancer risk of $1x10^{-4}$: EPA notes that the occupational UR was corrected late in the draft risk evaluation process (U.S. EPA, 2024a). The corrected UR is 0.0049 per ppm (2.2×10^{-6} per µg/m^3), down from 0.0062 per ppm. The value below does not reflect the corrected occupational UR. The value for EV_{cancer} will be corrected to reflect the lower occupational UR in the *Risk Evaluation for 1,3-Butadiene.*

$$EV_{cancer} = \frac{Benchmark_{Cancer}}{UR} * \frac{AT_{IUR}}{ED*EF*WY} * \frac{\mathrm{IR_{resting}}}{\mathrm{IR_{workers}}} = \frac{1X10^{-4}}{6.2\times10^{-3}\ per\ ppm} * \frac{24\frac{h}{d}*\frac{365d}{y}*78y}{8\frac{h}{d}*\frac{250d}{y}*40y} * \frac{1.25\frac{m^3}{hr}}{1.25\frac{m^3}{hr}} = 0.14\ \mathrm{ppm}$$

$$\mathrm{EV_{cancer}}\left(\frac{\mathrm{mg}}{\mathrm{m^3}}\right) = \frac{EV\ ppm*MW}{Molar\ Volume} = \frac{0.14\ \mathrm{ppm}*54.0916\frac{g}{mol}}{24.45\frac{L}{mol}} = 0.31\ \frac{\mathrm{mg}}{\mathrm{m^3}}$$

Where:

Molar Volume	=	24.45 L/mol, the volume of a mole of gas at 1 atm and 25 °C
MW	=	Molecular weight of 1,3-butadiene (54.0916 g/mole)

Acute Non-cancer Occupational Exposure Value

EPA did not derive an acute POD for 1,3-butadiene. Therefore, no corresponding occupational exposure value is calculated.

Intermediate Non-cancer Occupational Exposure Value

The intermediate occupational exposure value ($EV_{intermediate}$) was calculated as the concentration at which the intermediate MOE would equal the benchmark MOE for intermediate occupational exposure using the following equation:

$$EV_{intermediate} = \frac{HEC_{intermediate}}{Benchmark\ MOE_{intermediate}} * \frac{AT_{HEC\ intermediate}}{ED*EF} * \frac{IR_{resting}}{IR_{workers}}$$

$$= \frac{2.5\text{ ppm}}{30} * \frac{24h/d * 30d}{8h/d * 22d} * \frac{0.6125\text{ m}^3/hr}{1.25\text{ m}^3/hr} = 0.17\text{ ppm}$$

$$EV_{intermediate}\left(\frac{\text{mg}}{\text{m}^3}\right) = \frac{EV\ ppm * MW}{Molar\ Volume} = \frac{0.17\text{ ppm} * 54.0916\frac{g}{mol}}{24.45\frac{L}{mol}} = 0.38\ \frac{\text{mg}}{\text{m}^3}$$

Chronic Non-cancer Occupational Exposure Value

The hazard value (an HEC of 2.5 ppm) is the same for the intermediate and chronic occupational exposure scenarios. The chronic occupational exposure value ($EV_{chronic}$) can be calculated as the concentration at which the chronic MOE would equal the benchmark MOE for exposures. However, EPA has determined that because the same critical health effect applies to both intermediate and chronic exposure contexts, the relevant averaging time should be considered equivalent across both exposure scenarios. Therefore, the resulting $EV_{chronic}$ would be the same as the $EV_{intermediate}$ based on intermediate exposures and EPA is presenting only the $EV_{intermediate}$.

The parameters used in the above equations are described here. Numerical values chosen for the parameters are described in relevant sections of this draft risk evaluation and *Draft Human Health Hazard Assessment for 1,3-Butadiene* (U.S. EPA, 2024t).

Where:

$AT_{HECintermediate}$	=	Averaging time for the POD/HEC used for evaluating non-cancer, intermediate occupational risk, based on study conditions and/or any HEC adjustments (24hrs/day for 30 days)
AT_{UR}	=	Averaging time for the cancer UR, based on study conditions and any adjustments (24 hrs/day for 365 days/yr) and averaged over a lifetime (78 yrs)
$Benchmark\ MOE_{intermediate}$	=	Intermediate non-cancer benchmark margin of exposure, based on the total uncertainty factor of 30
$\text{Benchmark}_{cancer}$	=	Benchmark for excess lifetime cancer risk
$EV_{intermediate}$	=	Draft occupational exposure value based on reduced fetal body weight
$EV_{chronic}$	=	Draft occupational exposure value based on reduced fetal body weight
EV_{cancer}	=	Draft occupational exposure value based on excess cancer risk
ED	=	Exposure duration (8 hrs/day)
EF	=	Exposure frequency 22 days/yr for intermediate, 250 days/yr for lifetime]
$HEC_{intermediate}$	=	Human equivalent concentration for acute, intermediate, or chronic occupational exposure scenarios
UR	=	Occupational unit risk (per mg/m^3 and per ppm)
IR	=	Inhalation rate (default is 1.25 m^3/hr for workers and 0.6125 m^3/hr for the general population at rest)
WY	=	Working years per lifetime at the 95th percentile (40 yrs)
Molar Volume	=	24.45 L/mol, the volume of a mole of gas at 1 atm and 25 °C
MW	=	Molecular weight of 1,3-butadiene (54.0916 g/mole)

Unit conversion:

1 ppm = 2.2 mg/m^3 (based on the molecular weight of 54.0916 g/mol for 1,3-butadiene)

F.2 Summary of Air Sampling Analytical Methods Identified

EPA conducted a search to identify relevant NIOSH, OSHA, and EPA analytical methods used to monitor for the presence of 1,3-butadiene in air (see Table_Apx F-1). This table presents validated methods from governmental agencies and is not intended to be a comprehensive list of available air monitoring methods for 1,3-butadiene. The sources used for the search included the following:

1) NIOSH Manual of Analytical Methods (NMAM); 5th Edition
   - URL: https://www.cdc.gov/niosh/nmam/default.html
2) NIOSH NMAM 4th Edition
   - URL: https://www.cdc.gov/niosh/docs/2003-154/default.html
3) OSHA Index of Sampling and Analytical Methods
   - URL: https://www.osha.gov/dts/sltc/methods/
4) EPA Environmental Test Method and Monitoring Information
   - URL: https://www.epa.gov/measurements-modeling/index-epa-test-methods

Table_Apx F-1. Limit of Detection (LOD) and Limit of Quantification (LOQ) Summary for Air Sampling Analytical Methods Identified

Air Sampling Analytical Methods	Year Published	LOD[a]	LOQ	Notes	Source
NIOSH Method 1024[b] OSHA Method 56	1994 (issue 2)	0.2–0.6 µg/sample (3.6–90 ppb)	N/A	NIOSH Method 1024 reports the LOD as 0.2 µg per sample and provides procedures for collecting air samples between 5 and 25 L with a flow rate of 0.01 to 0.5 L/min. Multiple media change- outs will be required in order to achieve the minimum LOD based on a maximum sampling volume of 25L. OSHA Method 56 recommends an air sample volume of 3L and lists a detection limit of the overall procedure as 90 ppb, which would make the LOD 0.6 µg per sample.	OSHA Index of Sampling and Analytical Methods NIOSH NMAM 4th Edition

ppm = parts per million; ppb = parts per billion; ppt = parts per trillion
[a] These sources cover a range of LODs both below and above the most sensitive occupational exposure value. This method provides the LOD based on sample size. For a sample size range of 0.5L to 15L, the LOD would be 0.67 mg/m^3 to 20 mg/m^3. However, the LOD listed in the table can be achieved through changes of media across an 8-hour period.
[b] It is common for laboratories to acquire updated equipment from the equipment used by NIOSH to develop Method 1003. Modern equipment can offer dramatically greater performance compared with the equipment available when NIOSH 1003 was published. This can result in significantly lower LOQ/LODs. However, NIOSH does not necessarily continually update the method because the labs are using the same general procedures with just modified/better equipment. Therefore, the lab is permitted to report their method as “modified NIOSH Method 1003”. The lab will include a record of how it modifies the method in their results.

F.3 Short-Term Occupational Exposure Value Derivation

According to *Current Intelligence Bulletin 69: NIOSH Practices in Occupational Risk Assessment* (NIOSH, 2020), a short-term occupational exposure value (described as a short-term exposure limit (STEL) in (NIOSH, 2020)) should be derived if there is a concern for effects following short-term exposure at 15-min concentrations. The 8-hour TWA most sensitive occupational exposure value would prevent 15-min exposures above 32× that value (based on 32 15-min periods in 8 hours), assuming only a single 15-min chemical exposure in one day. Therefore, if short-term health effects are expected and can be quantified with a derived short-term occupational exposure value (STEV) lower than 32× the most sensitive EV, implementing a short-term exposure value could be justified.

EPA did not derive an acute non-cancer hazard value for 1,3-butadiene because any options would have low confidence and be less protective than existing exposure limits. Therefore, EPA would default to the AEGL-1 value for determination of a STEV. The AEGL-1 value for 1,3-butadiene based on difficulty to focus is 670 ppm (NAC/AEGL, 2009). This value is significantly higher than the 15-min TWA occupational exposure equivalent value (Table_Apx F-2), and therefore the most sensitive occupational exposure value is already protective of any hazards specific to short-term exposure.

Table_Apx F-2. Comparison between Occupational Exposure Values for 1,3-Butadiene

Value Type	Most Sensitive Occupational Exposure Value (8-hour TWA)	Possible Short-term Occupational Exposure Value (15-minute value)	Most Sensitive Occupational Exposure Value (15-minute TWA)
Health Effect	Cancer	Difficulty to focus	Cancer
Exposure Value (ppm)	0.14	670	4.5

Appendix G POTENTIALLY EXPOSED OR SUSCEPTIBLE SUBPOPULATIONS CONSIDERED IN RISK EVALUATIONS

Considerations related to PESS can influence the selection of relevant exposure pathways, the sensitivity of derived hazard values, the inclusion of particular human populations, and the discussion of uncertainties throughout the assessment. Evaluation of the qualitative and quantitative evidence for PESS begins as part of the systematic review process, where any available relevant published studies and other data are identified. If adequate and complete, this evidence informs the derivation of exposure estimates and human health hazard endpoints/values that are protective of PESS.

EPA has identified a list of specific PESS factors that may contribute to a group having increased exposure or biological susceptibility, such as lifestage, occupational exposures, nutrition, and lifestyle activities. For 1,3-butadiene, the Agency identified how the risk evaluation addressed these factors as well as any remaining uncertainties in Section 5.3.5. The full list of PESS factors and representative examples of each are presented below in Table_Apx G-1.

Table_Apx G-1. PESS Factors Considered in the Risk Evaluation

PESS Factor	Examples[a]
Lifestage	Embryo/fetus, pregnant females, children, older adults
Pre-existing Disease	Obesity, cardiovascular disease, diabetes
Lifestyle Activities	Smoking, alcohol consumption, physical activity
Occupational Exposures	High end duration and frequency workers/ONUs;
Geography/Site-specific	Fenceline, residence/school location, historical releases
Sociodemographic Status	Race/ethnicity, socioeconomic status, sex/gender, education
Nutrition	Diet, malnutrition, subsistence fishing
Genetics/Epigenetics	Genetic polymorphisms
Unique Activities	Open burning, sweat lodge/purification ceremonies (tribal)
Aggregate Exposures	Multiple routes, multiple pathways, multiple COUs
Other Chemical and Non-chemical stressors	Stress, adverse childhood experiences, built environment, chemical co-exposures

ONU = occupational non-user
[a] Examples are not intended to be exhaustive but are illustrative of considerations for the risk evaluation.

Appendix H GENERAL POPULATION RISK

H.1 HEM Estimated 1,3-Butadiene Cancer Risks across Discrete Distances

Table_Apx H-1. 1,3-Butadiene Cancer Risks Based on HEM 95th Percentile Modeled Concentrations from 10 to 50,000 Meters

Life Cycle Stage	Category	Subcategory	OES	TRI Facilities		Estimated Cancer Risk using Maximum Concentration Across Facilities within OES by Distance from All Sources (m) (Based on 95th Percentile Modeled Concentrations)												
				Total	Risk Above 1E−06	10	30	30-60	60	100	100-1,000	1,000	2,500	5,000	1,0000	15,000	25,000	50,000
Manufacturing	Domestic manufacturing	Domestic manufacturing	Manufacturing	40	32	5.3E−04	9.1E−04	7.2E−04	5.1E−04	3.5E−04	6.0E−05	2.1E−05	6.1E−06	2.4E−06	9.0E−07	5.0E−07	2.4E−07	8.7E−08
Processing	Processing as a reactant	Other: monomer used in polymerization process in: plastic material and resin manufacturing; manufacturing synthetic rubber and plastics	Plastics and rubber compounding	33	29	1.3E−03	1.7E−03	1.2E−03	8.4E−04	4.1E−04	3.2E−05	9.4E−06	2.2E−06	7.4E−07	2.5E−07	1.3E−07	5.8E−08	1.9E−08
Processing	Processing – incorporation into article	Other: polymer in: rubber and plastic product manufacturing	Plastics and rubber converting	1	0	1.3E−17	1.3E−12	1.6E−12	1.8E−12	2.3E−12	6.5E−13	1.9E−13	8.3E−14	3.7E−14	1.6E−14	9.1E−15	4.4E−15	1.6E−15
Processing	Processing – incorporation into formulation, mixture, or reaction product	Processing aids, not otherwise listed in: petrochemical manufacturing	Processing – incorporation into formulation, mixture, or reaction product	53	25	6.8E−05	1.7E−04	1.5E−04	1.1E−04	7.6E−05	2.9E−05	1.4E−05	3.8E−06	1.5E−06	5.3E−07	2.9E−07	1.3E−07	4.9E−08

Life Cycle Stage	Category	Subcategory	OES	TRI Facilities		Estimated Cancer Risk using Maximum Concentration Across Facilities within OES by Distance from All Sources (m) (Based on 95th Percentile Modeled Concentrations)												
				Total	Risk Above 1E−06	10	30	30-60	60	100	100-1,000	1,000	2,500	5,000	1,0000	15,000	25,000	50,000
Processing	Processing as a reactant	Intermediate in: adhesive manufacturing; all other basic organic chemical manufacturing; fuel binder for solid rocket fuels; organic fiber manufacturing; petrochemical manufacturing; petroleum refineries; plastic material and resin manufacturing; propellant manufacturing; synthetic rubber manufacturing; wholesale and retail trade	Processing as a reactant	57	43	3.7E−04	5.5E−04	4.9E−04	3.2E−04	1.4E−04	1.3E−05	3.5E−06	8.1E−07	2.7E−07	9.4E−08	5.0E−08	2.2E−08	8.1E−09
Disposal	Disposal	Disposal	Recycling	11	6	6.0E−06	1.0E−05	8.7E−06	6.4E−06	3.1E−06	3.8E−07	9.8E−08	2.4E−08	9.2E−09	3.2E−09	1.6E−09	6.6E−10	2.4E−10
Manufacturing	Import	Import	Repackaging	23	13	2.75E−04	4.14E−04	2.94E−04	1.87E−04	9.03E−05	1.08E−05	2.28E−06	5.35E−07	1.83E−07	6.35E−08	3.37E−08	1.53E−08	5.27E−09
Processing	Repackaging	Intermediate in: wholesale and retail trade																
Disposal	Disposal	Disposal	Waste handling, disposal, treatment, and recycling	7	1	2.2E−06	3.2E−06	2.7E−06	1.7E−06	7.9E−07	9.2E−08	3.1E−08	8.9E−09	3.4E−09	1.2E−09	6.4E−10	3.0E−10	1.1E−10
			Total	**225**	**149**													

3634 **Table_Apx H-2. 1,3-Butadiene Cancer Risks Based on HEM 50th Percentile Modeled Concentrations from 10 to 50,000 Meters**

Life Cycle Stage	Category	Subcategory	OES	TRI Facilities		Estimated Cancer Risk using Maximum Concentration across Facilities within OES by Distance from All Sources (m) (Based on 50th Percentile Modeled Concentrations)												
				Total	Risk Above 1E−06	10	30	30-60	60	100	100-1,000	1,000	2,500	5,000	1,0000	15,000	25,000	50,000
Manufacturing	Domestic Manufacturing	Domestic Manufacturing	Manufacturing	40	29	2.1E−04	5.1E−04	3.5E−04	2.6E−04	1.4E−04	1.3E−05	7.5E−06	2.4E−06	9.1E−07	3.5E−07	1.9E−07	9.6E−08	3.5E−08
Processing	Processing as a reactant	Other: monomer used in polymerization process in: plastic material and resin manufacturing; manufacturing synthetic rubber and plastics	Plastics and rubber compounding	33	28	2.7E−04	4.7E−04	3.3E−04	2.4E−04	1.2E−04	6.6E−06	3.6E−06	9.2E−07	3.2E−07	1.2E−07	6.2E−08	2.9E−08	1.0E−08
Processing	Processing – incorporation into article	Other: polymer in: rubber and plastic product manufacturing	Plastics and rubber converting	1	0	6.7E−18	1.5E−14	2.8E−13	4.4E−13	9.0E−13	2.4E−13	1.6E−13	5.1E−14	1.9E−14	7.9E−15	3.9E−15	1.5E−15	5.8E−16
Processing	Processing – incorporation into formulation, mixture, or reaction product	Processing aids, not otherwise listed in: petrochemical manufacturing	Processing – incorporation into formulation, mixture, or reaction product	53	15	3.1E−05	6.2E−05	4.3E−05	3.3E−05	1.7E−05	1.6E−06	1.3E−06	5.5E−07	2.4E−07	9.1E−08	5.0E−08	2.3E−08	8.2E−09
Processing	Processing as a reactant	Intermediate in: adhesive manufacturing; all other basic organic chemical manufacturing; fuel binder for solid rocket fuels; organic fiber manufacturing; petrochemical manufacturing; petroleum refineries; plastic material and resin manufacturing; Propellant	Processing as a reactant	57	30	8.8E−05	2.5E−04	1.6E−04	1.0E−04	4.5E−05	2.1E−06	1.1E−06	3.4E−07	1.3E−07	4.9E−08	2.7E−08	1.2E−08	4.4E−09

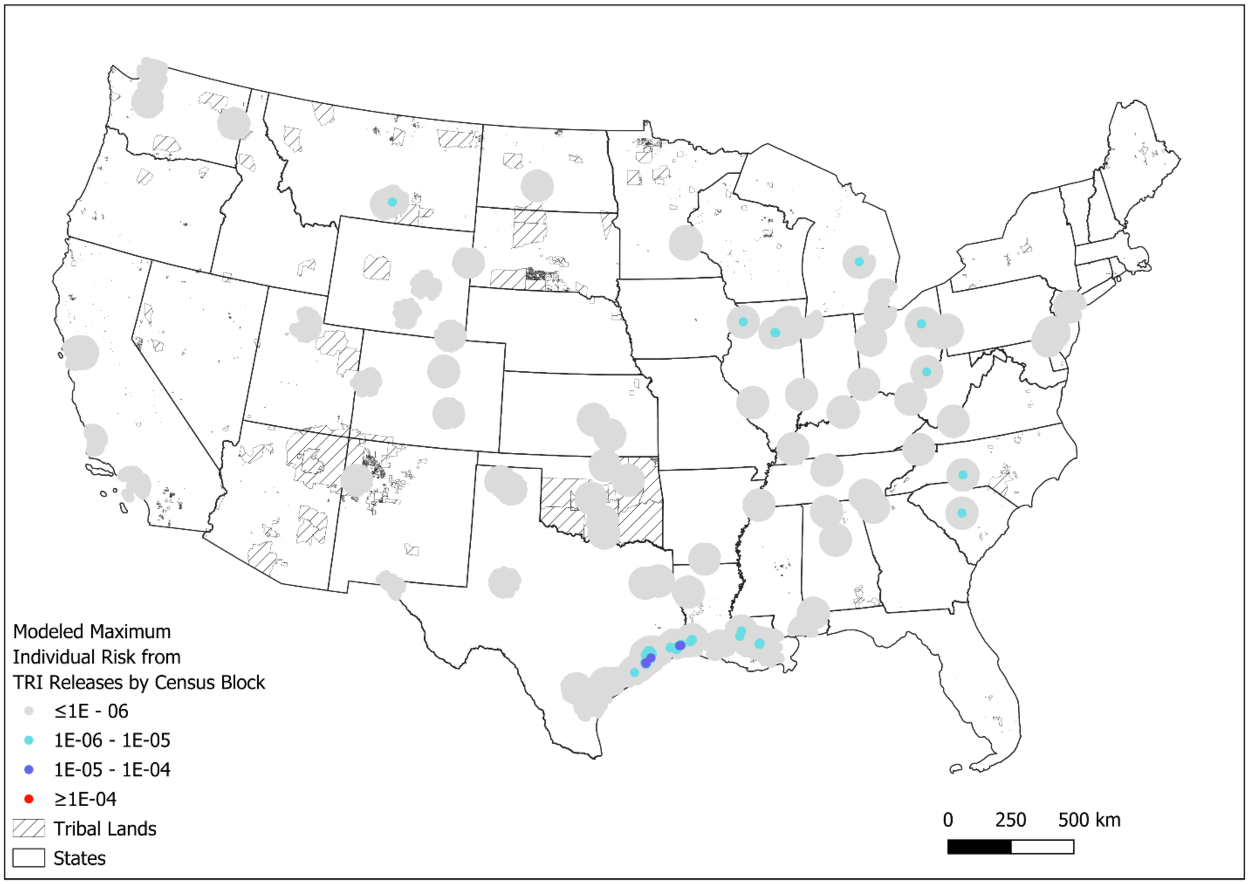
Life Cycle Stage	Category	Subcategory	OES	TRI Facilities		Estimated Cancer Risk using Maximum Concentration across Facilities within OES by Distance from All Sources (m) (Based on 50th Percentile Modeled Concentrations)												
				Total	**Risk Above 1E−06**	**10**	**30**	**30-60**	**60**	**100**	**100-1,000**	**1,000**	**2,500**	**5,000**	**1,0000**	**15,000**	**25,000**	**50,000**
		manufacturing; Synthetic rubber manufacturing; Wholesale and retail trade																
Disposal	Disposal	Disposal	Recycling	11	3	1.7E−06	5.8E−06	4.7E−06	3.4E−06	1.4E−06	6.3E−08	3.4E−08	7.8E−09	2.6E−09	8.7E−10	4.6E−10	2.1E−10	7.4E−11
Manufacturing	Import	Import	Repackaging	23	8	6.55E−05	1.51E−04	1.05E−04	7.78E−05	3.75E−05	1.92E−06	9.93E−07	2.43E−07	8.32E−08	2.9E−08	1.53E−08	7.05E−09	2.56E−09
Processing	Repackaging	Intermediate in: Wholesale and retail trade																
Disposal	Disposal	Disposal	Waste handling, disposal, treatment, and recycling	7	0	6.0E−08	1.8E−07	1.2E−07	8.4E−08	7.8E−08	2.0E−08	1.1E−08	3.5E−09	1.4E−09	5.4E−10	3.0E−10	1.4E−10	4.8E−11
			Total	**225**	**113**													

Table_Apx H-3. 1,3-Butadiene Cancer Risks Based on HEM 10th Percentile Modeled Concentrations from 10 to 50,000 Meters

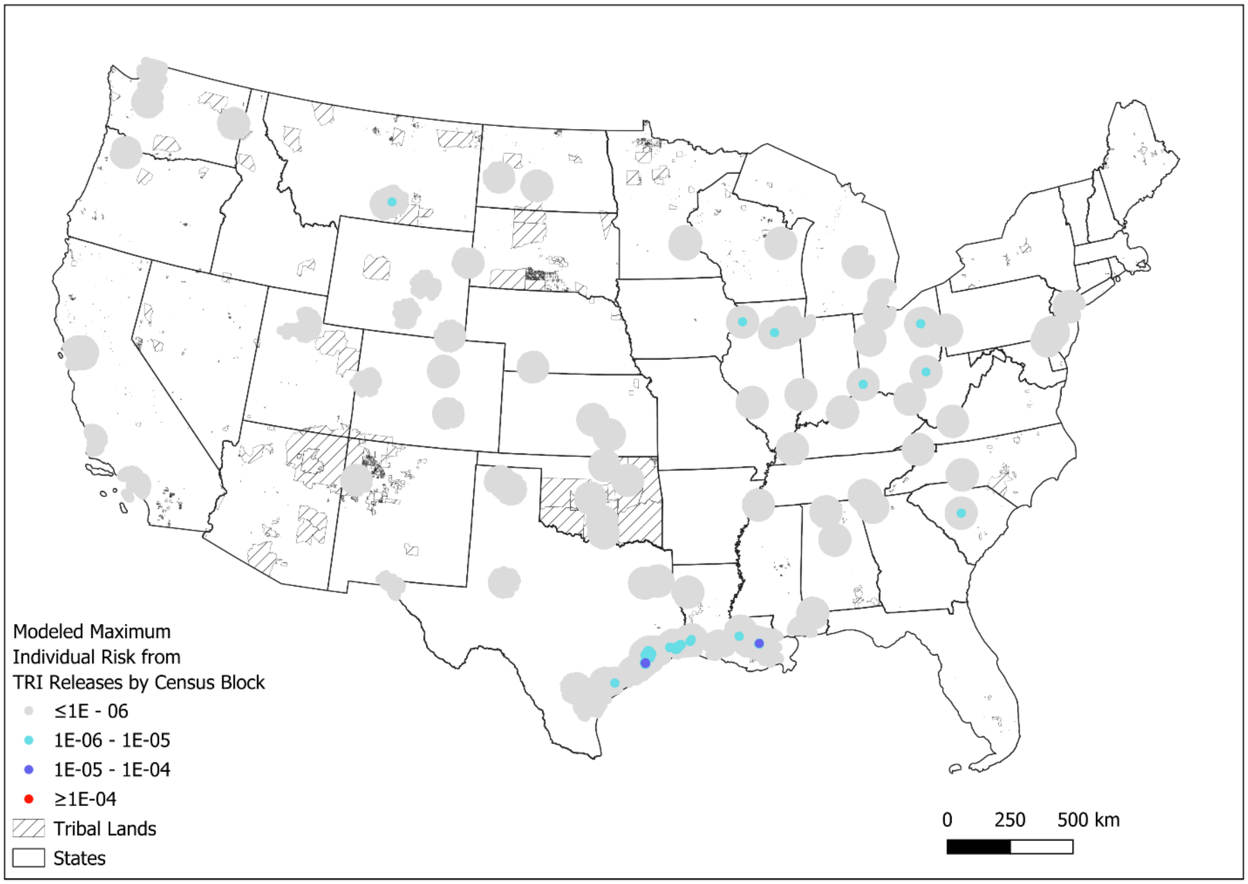
Life Cycle Stage	Category	Subcategory	OES	TRI Facilities		Estimated Cancer Risk using Maximum Concentration across Facilities within OES by Distance from All Sources (m) (Based on 10th Percentile Modeled Concentrations)												
				Total	Risk Above 1E−06	10	30	30-60	60	100	100-1,000	1,000	2,500	5,000	1,0000	15,000	25,000	50,000
Manufacturing	Domestic Manufacturing	Domestic Manufacturing	Manufact-uring	40	24	5.6E−05	2.4E−04	1.8E−04	1.4E−04	6.6E−05	4.6E−06	3.3E−06	9.6E−07	3.8E−07	1.5E−07	8.5E−08	4.2E−08	1.7E−08
Processing	Processing as a reactant	Other: monomer used in polymerization process in: plastic material and resin manufacturing; manufacturing synthetic rubber and plastics	Plastics and rubber compound -ing	33	24	1.3E−04	2.7E−04	2.0E−04	1.4E−04	7.1E−05	2.9E−06	1.9E−06	5.2E−07	1.9E−07	6.5E−08	3.5E−08	1.7E−08	5.7E−09
Processing	Processing – incorporation into article	Other: Polymer in: Rubber and plastic product manufacturing	Plastics and rubber converting	1	0	4.4E−19	6.9E−15	4.3E−14	3.1E−13	5.9E−13	1.6E−13	1.4E−13	4.1E−14	1.5E−14	4.3E−15	2.6E−15	1.0E−15	3.9E−16
Processing	Processing – incorporation into formulation, mixture, or reaction product	Processing aids, not otherwise listed in: Petrochemical manufacturing	Process-ing – Incorporation into formul-ation, mixture, or reaction product	53	7	5.8E−06	2.3E−05	1.6E−05	1.2E−05	5.8E−06	3.6E−07	2.3E−07	8.3E−08	3.7E−08	1.5E−08	8.4E−09	3.4E−09	1.3E−09
Processing	Processing as a reactant	Intermediate in: adhesive manufacturing; all other basic organic chemical manufacturing; fuel binder for solid rocket fuels; organic fiber manufacturing; petrochemical manufacturing; petroleum refineries; plastic material	Process-ing as a reactant	57	22	1.3E−05	8.4E−05	5.9E−05	4.5E−05	2.2E−05	8.0E−07	5.3E−07	1.9E−07	7.5E−08	2.9E−08	1.6E−08	7.6E−09	2.8E−09

Life Cycle Stage	Category	Subcategory	OES	TRI Facilities		Estimated Cancer Risk using Maximum Concentration across Facilities within OES by Distance from All Sources (m) (Based on 10th Percentile Modeled Concentrations)												
				Total	**Risk Above 1E−06**	**10**	**30**	**30-60**	**60**	**100**	**100-1,000**	**1,000**	**2,500**	**5,000**	**1,0000**	**15,000**	**25,000**	**50,000**
		and resin manufacturing; propellant manufacturing; synthetic rubber manufacturing; wholesale and retail trade																
Disposal	Disposal	Disposal	Recycling	11	2	1.1E−07	4.1E−06	3.1E−06	2.4E−06	6.3E−07	3.3E−08	2.3E−08	5.4E−09	1.7E−09	5.3E−10	2.8E−10	1.1E−10	4.1E−11
Manufacturing	Import	Import	Repack-aging	23	4	2.56E−06	9.84E−05	6.23E−05	5.03E−05	2.28E−05	7.54E−07	5.06E−07	1.16E−07	3.85E−08	1.27E−08	6.66E−09	2.98E−09	1.08E−09
Processing	Repackaging	Intermediate in: wholesale and retail trade																
Disposal	Disposal	Disposal	Waste handling, disposal, treatment, and recycling	7	0	3.0E−09	5.3E−08	3.6E−08	2.7E−08	3.0E−08	5.7E−09	3.7E−09	1.3E−09	5.2E−10	1.9E−10	1.1E−10	5.3E−11	2.1E−11
			Total	**225**	**83**													

H.2 General Population Cancer Risk Maps Based on HEM Modeled Census Blocks



Figure_Apx H-1. Map of Contiguous United States with HEM Model Results for Cancer Risks Aggregated and Summarized by Census Block for the 2020 TRI Reporting Year



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3646 **Figure_Apx H-2. Map of Contiguous United States with HEM Model Results for Cancer Risks**
3647 **Aggregated and Summarized by Census Block for the 2018 TRI Reporting Year**