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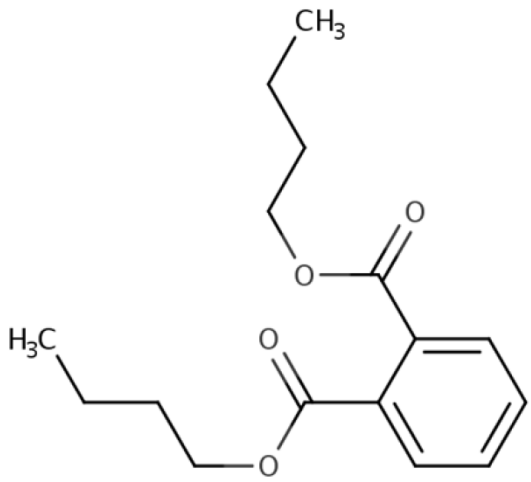
Draft Consumer and Indoor Exposure Assessment for Dibutyl Phthalate (DBP)

Technical Support Document for the Draft Risk Evaluation

CASRN 84-74-2



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KEY ABBREVIATIONS AND ACRONYMS

ADR	Acute dose rate
CADD	Chronic average daily dose
CASRN	Chemical Abstracts Service Registry Number
CDC	Centers for Disease Control and Prevention (U.S.)
CDR	Chemical Data Reporting
CEM	Consumer Exposure Model
CPSC	Consumer Product Safety Commission
CPSIA	Consumer Product Safety Improvement Act
COU	Condition of use
DBP	Dibutyl phthalate, Di-(2-ethylhexyl) phthalate
DIY	Do-it-yourself
EPA	Environmental Protection Agency (U.S.)
HPCDS	High Priority Chemicals Data System
MCCEM	Multi-Chamber Concentration and Exposure Model
OCSPP	Office of Chemical Safety and Pollution Prevention
OPPT	Office of Pollution Prevention and Toxics
PVC	Polyvinyl chloride
SDS	Safety data sheet
SVOC	Semi-volatile organic compound
TSCA	Toxic Substances Control Act
TSD	Technical support document
U.S.	United States

SUMMARY

This technical support document (TSD) accompanies the *TSCA Draft Risk Evaluation for Dibutyl Phthalate (DBP)* (U.S. EPA, 2025c). It provides detailed descriptions of DBP consumer uses and indoor exposure assessments. DBP is a phthalate ester with Chemical Abstracts Service Registry Number (CASRN) 84-74-2. DBP is primarily used as a plasticizer in consumer, commercial, and industrial applications—though it is also used in adhesives, sealants, paints, coatings, rubbers, polyvinyl chloride (PVC) plastics, and non-PVC plastics, as well as for other applications. It is added to make plastic soft and flexible, like shower curtains, vinyl fabrics and textiles, and flooring. This draft assessment considers human exposure to DBP in consumer products resulting from conditions of use (COUs) as defined under the Toxic Substances Control Act (TSCA). The major routes of DBP exposure considered were ingestion via mouthing, ingestion of suspended dust, ingestion of settled dust, inhalation, and dermal exposure. The exposure durations considered were acute, intermediate, and chronic. Acute exposures are for an exposure duration of 1 day, chronic exposures are for an exposure duration of 1 year, and intermediate exposures are for an exposure duration of 30 days.

For inhalation and ingestion exposures, EPA (or "the Agency") used the Consumer Exposure Model (CEM) to estimate acute and chronic exposures to consumer users and bystanders. Intermediate exposures were calculated from the CEM daily exposure outputs for applicable scenarios (U.S. EPA, 2025a) outside of CEM because the exposure duration for intermediate scenarios is outside the 60-day modeling period CEM uses. For each scenario, high-, medium-, and low-intensity use exposure scenarios were developed in which values for duration of use, frequency of use, and surface area were determined based on reasonably available information and professional judgment (see Section 2.2 for CEM parameterization and input selection). Overall, confidence in the estimates were robust or moderate depending on product or article scenario (see Section 5.1). Briefly, CEM default scenarios were selected for mass of product used, duration of use, and frequency of use. Generally, when using CEM defaults EPA has robust confidence. When no CEM default was available or applicable for some products, manufacturer instructions and online retailers provided details on recommended use of the product; for example, mass of product used during product application (see Section 2.2.3.2).

Most inhalation and ingestion product use patterns overall confidence were robust because the supporting evidence provided product-specific information. For articles, key parameters that control DBP emission rates from articles in CEM models are weight fraction of DBP in the material, density of article material, article surface area, and surface layer thickness. For articles that do not have default CEM inputs, EPA's *Exposure Factors Handbook* or professional judgment was used to select the duration of use and article surface area for the low, medium, and high exposure scenario levels for most articles. The overall confidence for most inhalation and ingestion article use patterns was rated robust because (1) the source of the information was the Handbook, or (2) when using professional judgment the Agency based selection of inputs on online article descriptions for article surface area (see Section 2.2.3.1). EPA has a moderate confidence in ingestion via mouthing estimates due to uncertainties about professional judgment inputs regarding mouthing durations for adult toys and synthetic leather furniture for children. In addition, the chemical migration rate input parameter has a moderate confidence due to the large variability in the empirical data used in this assessment and unknown correlation between chemical migration rate and DBP concentration in articles.

Dermal exposures for both liquid products and solid articles were calculated outside of CEM; see the *Draft Consumer Exposure Analysis for Dibutyl Phthalate (DBP)* (U.S. EPA, 2025a) for calculations and inputs. CEM dermal modeling assumes infinite DBP migration from product to skin without considering saturation, which result in overestimations of dose and subsequent risk (see Section 2.3 for a detailed explanation). Low-, medium-, and high-intensity use exposure scenarios were developed for each

product and article scenario by varying values for duration of dermal contact and area of exposed skin. Confidence in the dermal exposure estimates were moderate depending on uncertainties associated with input parameters. The flux-limited screening dermal absorption approaches for liquid and solid products and articles assumes an excess of DBP in contact with the skin independent of DBP concentration in the article/product. The flux-limited screening approach provides an upper-bound of dermal absorption of DBP and likely results in some overestimations; see Section 5.1 for detailed discussion on limitations, strengths, and confidence in dermal estimates. Briefly, inputs for duration of dermal contact were either from the *Exposure Factors Handbook* or professional judgment based on product and article manufacturer use descriptions. For products, manufacturer instructions provide details on recommended use of the product (*e.g.*, adhesives and sealants). However, for articles, typically such data is not available from manufactures. Sometimes inputs can be found in the Handbook (*e.g.*, vinyl flooring contact duration), other times professional judgment is used (*e.g.*, length of time an individual spends sitting on a couch per day for medium-and low-intensity use scenarios).

For young teens, teenagers and young adults aged 11 to 20 years old as well as adults (21+ years), dermal contact was a strong driver of exposure to DBP, with the dose received being generally higher than or similar to the dose received from exposure via inhalation or ingestion. The largest acute dose estimated was for dermal exposure to adhesives, sealers, coatings, and waxes for young teens to adults. The largest chronic dose estimated was for dermal and inhalation exposure to metal coatings for young teens to adults, followed by dermal exposure to adhesives, footwear, and waxes. It is noteworthy that the dermal screening analysis used a flux-limited approach, which has larger uncertainties than inhalation dose results; see Section 5.1 for a detailed discussion of uncertainties within approaches, inputs, and overall estimate confidence.

Among the younger lifestages, infant to 10 years, the pattern was less clear as these ages were not designated as product users and therefore not modeled for dermal contact with any of the liquid products assessed that resulted in larger dermal doses for the older lifestages. Key differences in exposures among lifestages include (1) designation as a product user or bystander; (2) behavioral differences such as hand to mouth contact times and time spent on the floor; and (3) dermal contact expected from touching specific articles that may not be appropriate for some lifestages.

1 INTRODUCTION

DBP is a phthalate ester (CASRN 84-74-2) and properties used to support product flexibility and softness. DBP is primarily used as a plasticizer in consumer, commercial, and industrial applications such as adhesives, sealants, paints, coatings, rubbers, PVC plastics, and non-PVC plastics as well as for other applications. Some consumer DBP-containing solid article examples are car mats, synthetic leather clothing, footwear, furniture components and textiles, vinyl flooring, wallpaper, shower curtains and children's toys; liquid products including adhesives, sealants, and paints; and coatings for metal and wood building materials. Under the Consumer Product Safety Improvement Act (CPSIA) of 2008 (CPSIA section 108(a), 15 U.S.C. § 2057c(a);16 C.F.R. § 1307.3(a)), Congress permanently prohibited the sale of children's toys or childcare articles containing concentrations of more than 0.1 percent DBP. However, it is possible that some individuals may still have children's toys in the home that were produced before statutory and regulatory limitations. EPA assembled reasonably available information from 2016 and 2020 data reported in the Chemical Data Reporting (CDR) database and consulted a variety of other sources, including published literature, company websites, and government and commercial trade databases to identify products and articles under the defined COUs of DBP for inclusion in the risk evaluation, see Table 1-1 for consumer-specific COUs. Consumer products and articles were identified and matched to COUs. Weight fractions of DBP in specific items were then gathered from a variety of sources, such as safety data sheets (SDSs), databases, and peer-reviewed publications. These data were used in this assessment in a tiered approach as described in Section 2.1.

The migration of DBP from consumer products and articles has been identified as a potential mechanism of exposure. However, the relative contribution of various consumer goods to overall exposure to DBP has not been well characterized. The identified uses can result in exposures to consumers and bystanders (non-product users that are incidentally exposed to the product). For all the DBP containing consumer products identified, the approach involves addressing the inherent uncertainties by modeling high-, medium-, and low-intensity use exposure scenarios. Due to the lack of comprehensive data on various parameters and the expected variability in exposure pathways, EPA used conservative screening approaches to obtain exposure doses associated with DBP across COUs and various age groups.

Because PVC products are ubiquitous in modern indoor environments, and since DBP can leach, migrate, or evaporate (to a lesser extent based on physical and chemical properties) into indoor air and concentrate in household dust. Exposure to compounds through dust ingestion, dust inhalation, and dermal absorption is a particular concern for young children between the ages of 6 months and 2 years. This is because they crawl on the ground and pull up on ledges, which increases hand-to-dust contact, and place their hands and objects in their mouths. Therefore, estimated exposures were assessed and compared for children below and above 2 years of age.

Table 1-1. Consumer Conditions of Use Table

Life-Cycle Stage [a]	Category [b]	Subcategory [c]	Reference(s)
Consumer	Automotive, fuel, agriculture, outdoor use products	Automotive care products	(U.S. EPA, 2020a)
	Construction, paint, electrical, and metal products	Adhesives and sealants	(MEMA, 2019; U.S. EPA, 2019b)
		Paints and coatings	(NLM, 2024; U.S. EPA, 2020a, 2019b; GoodGuide, 2011; Streitberger et al., 2011)
	Furnishing, cleaning, treatment care products	Fabric, textile, and leather products	(WSDE, 2023; U.S. EPA, 2020c, 2019b)
		Floor coverings; construction and building materials covering large surface areas including stone, plaster, cement, glass and ceramic articles; fabrics, textiles, and apparel	(U.S. EPA, 2020a, 2019b)
		Cleaning and furnishing care products	(NLM, 2024; U.S. EPA, 2019b; GoodGuide, 2011)
	Packaging, paper, plastic, hobby products	Ink, toner, and colorant products	(U.S. EPA, 2019b)
		Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft); other articles with routine direct contact during normal use, including rubber articles; plastic articles (hard)	(NLM, 2024; U.S. EPA, 2019b)
		Toys, playground and sporting equipment	(U.S. EPA, 2019a, c)
	Other uses	Automotive articles	(MEMA, 2019)
		Chemiluminescent light sticks	(U.S. EPA, 2020b)
		Lubricants and lubricant additives	(MEMA, 2019)
		Novelty articles	(Sipe et al., 2023; Stabile, 2013)
Disposal	Disposal	Disposal	(U.S. EPA, 2019b)

[a] Life Cycle Stage Use Definition (40 CFR 711.3) for "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.
[b] These categories of conditions of use appear in the Life Cycle Diagram, reflect CDR codes, and broadly represent conditions of use of DBP in industrial and/or commercial settings.
[c] These subcategories represent more specific activities within the life cycle stage and category of the COUs of DBP.

2 CONSUMER EXPOSURE APPROACH AND METHODOLOGY

The main steps in performing a consumer exposure assessment are summarized below:

1. Identification and mapping of product and article examples following the consumer COU table (Table 1-1), product and article identification.
2. Compilation of manufacturer use instructions for products and articles to determine patterns of use.
3. Selection of exposure routes and exposed populations according to product/article use descriptions.
4. Identification of data gaps and further search to fill gaps with studies, chemical surrogates or product and article proxies, or professional judgment.
5. Selection of appropriate modeling tools based on available information and chemical properties.
6. Gathering of input parameters per exposure scenario.
7. Parameterization of selected modeling tools.

Consumer products or articles containing DBP were matched with TSCA COUs appropriate for the anticipated use of the item. Table 2-1 summarizes the consumer exposure scenarios by COU for each product example(s), the relevant exposure routes, an indication of scenarios also used in the indoor dust assessment, and whether the analysis was done qualitatively or quantitatively. The indoor dust assessment uses consumer product information for selected articles with the goal of recreating the indoor environment. The consumer articles included in the indoor dust assessment were selected for their potential to have large surface area for dust collection.

A quantitative analysis was conducted when the exposure route was deemed relevant based on product or article use description and there was sufficient data to parameterize the model. The qualitative analysis is a discussion of exposure potential based on physical and chemical properties, and/or available monitoring data, if available. When a quantitative analysis was conducted, exposure from the consumer COUs was estimated by modeling. Each product or article was individually assessed to determine whether all or some exposure routes were applicable, and approaches were developed accordingly.

Exposure via inhalation and ingestion routes were modeled using EPA's CEM Version 3.2 (U.S. EPA, 2023). All exposure estimates for tire crumb rubber were calculated using a computational framework implemented within a spreadsheet as described in Section 2.4 because CEM does not have capabilities to model exposure to chemicals in particulate matter other than indoor dust. Dermal exposure to DBP-containing consumer products was estimated using a computational framework implemented within a spreadsheet. Refer to Dermal Modeling Approach in Section 2.3 for a detailed description of dermal approaches, rationale for analyses conducted outside CEM, and consumer specific dermal parameters and assumptions for exposure estimates. For each exposure route, EPA used the 10th percentile, average, and 95th percentile value of an input parameter (*e.g.*, weight fraction, surface area, etc.) to characterize low, medium, and high exposure, where possible and according to condition of use. If only a range was reported, EPA used the minimum and maximum of the range as the low and high values, with the average of the minimum and maximum used for the medium scenario. See Section 2.1 for details about the identified weight fraction data and statistics used in the low, medium, and high exposure scenarios. All CEM and dermal spreadsheet calculations inputs, sources of information, assumptions, and exposure scenario descriptions are available in the *Draft Risk Evaluation for Dibutyl Phthalate (DBP) - Supplemental Information File: Consumer Exposure Analysis* (U.S. EPA, 2025a). High-, medium-, and low-intensity use exposure scenarios serve as a two-pronged approach. First, it provides a sensitivity analysis with insight on the impact of the main modeling input parameters (*e.g.*, skin contact area, duration of contact, frequency of contact) in the doses and risk estimates. And second, the high-intensity

use exposure scenarios are used first to screen for potential risks at the upper-bound of possible exposures, and to refine if needed.

Based on reasonably available information from the systematic review on consumer COUs and indoor dust studies, inhalation of DBP is possible through DBP emitted from products and articles and DBP sorbed to indoor dust and particulate matter. A detailed discussion of indoor dust references, sources, and concentrations is available in Section 4. Due to DBP's low volatility, 1.81×10^{-6} atm·m^3/mol at 25 °C, there is expected to be negligible or very small gas-phase inhalation exposures. However, DBP's physical and chemical properties—such as low vapor pressure, low solubility, and high K_{oa}—suggest a high affinity for organic matter that is typically present in household dust. See *Draft Physical Chemistry and Fate and Transport Assessment for Dibutyl Phthalate (DBP)* TSD (U.S. EPA, 2024a) for further description of physical chemical properties. The likelihood of sorption to suspended and settled dust is supported by indoor monitoring data. Section 4.2 reports concentrations of DBP in settled dust from indoor environments. Due to the presence of DBP in indoor dust, inhalation and ingestion of suspended dust, and ingestion of settled dust, are both considered as exposure routes in this consumer assessment.

Oral exposure to DBP is also possible through incidental ingestion during product use, transfer of chemical from hand-to-mouth, or mouthing of articles. Dermal exposure may occur via direct contact with liquid products and solid articles during use. Based on these potential sources and pathways of exposures that may result from the conditions of use identified for DBP, oral and dermal exposures to consumers were assessed.

Qualitative analyses describing low exposure potential are discussed in Section 2.1 and mainly based on physical and chemical properties or product and article use descriptions. For example, given the low volatility of DBP, emissions to air from solid articles are expected to be relatively low. As such, articles with a small surface area (less than ≈1 m^2) and articles used outdoors were not assessed for inhalation exposure. For items with small surface area for emissions and dust collection, the potential for emission to air and dust is further reduced. To verify this assumption, a CEM test run for a generic 1 m^2 item with 30 percent DBP content by weight was performed. The combined doses from inhalation and dust ingestion were four orders of magnitude less than the point of departure (POD) used to assess human health risk in this draft assessment and are likely to be negligeable as compared to potential exposure by dermal and mouthing routes, which were assessed as appropriate, see *Draft DBP Risk Evaluation for Dibutyl Phthalate* (U.S. EPA, 2025c). Similarly, solid articles not expected to be mouthed (*e.g.*, building materials, outdoor furniture, etc.) were not assessed for mouthing exposure. Furthermore, because DBP is a low volatility solid that is used primarily as a plasticizer in manufacturing, potential take-home exposures are likely small in comparison to the exposures from scenarios considered in this assessment. Thus, take-home exposures were not further explored.

EPA assessed acute, chronic, and intermediate exposures to DBP from consumer COUs. For the acute dose rate calculations, an averaging time of 1 day is used to represent the maximum time-integrated dose over a 24-hour period in which the exposure event occurs. The chronic dose rate is calculated iteratively at a 30-second interval during the first 24 hours and every hour after that for 60 days and averaged over 1 year. Professional judgment and product use descriptions were used to estimate number of events per day and per month for each product, for use in the calculation of the intermediate dose. Whenever professional judgment was used, EPA provided a rationale and description of selected parameters.

2.1 Products and Articles with DBP Content

The preferred data sources for DBP content in U.S. consumer goods were safety data sheets (SDSs) for specific products or articles with reported DBP content, peer-reviewed literature providing

measurements of DBP in consumer goods purchased in the United States, and government reports originating in the United States with manufacturer-reported concentrations. In instances where these data from preferred sources were not available, DBP contents in specific products and articles provided in peer-reviewed literature and government reports originating from Canada and the European Union were used. Because manufacturing practices and regulations for DBP in consumer goods are comparable between these regions and the United States, it is reasonable to assume that similarly formulated products may be available across these regions. DBP weight fractions reported in the CDR database were not used as they may pertain to a finished good in the product category reported, or it could represent a chemical additive that will be added to other components during the manufacturing process of the finished good.

EPA further evaluated the products and articles identified to ensure that data was representative of items that may expose U.S. consumers to DBP. Where possible, SDSs were cross-checked with company websites to ensure that each product could reasonably be purchased by consumers. In instances where a product or article could not be purchased by a consumer, EPA did not evaluate the item in a do-it-yourself (DIY) or application scenario but did determine whether consumers might reasonably be exposed to the specific item as part of a purchased good, including homes and automobiles. For data reported in literature and government reports, recent regulations for DBP content in specific items was considered when determining whether data was likely to be relevant to the current U.S. consumer market. For solid articles with enacted limits on DBP content (*e.g.*, children's toys, childcare items), it was considered reasonable that consumers might be exposed to older items with DBP content higher than current limits via secondhand purchases or long-term use. For these items, exposures from new and legacy toys were considered separately.

In addition to DBP weight fractions, EPA obtained additional information about physical characteristics and potential uses of specific products and articles from technical specifications, manufacturer websites, and vendor websites. These data were used in the assessment to define exposure scenarios. The following section provides a summary of specific products and articles with DBP content identified for each item, and Table 2-1 provides a summary of TSCA COUs determined for each item and exposure pathways modeled.

2.1.1 Solid Articles

While DBP is known to be used in a large variety of solid articles, weight fraction data for solid articles sold in the United States were limited. Consumer product data were obtained from the Washington State Department of Ecology Consumer Product Monitoring Database (WSDE, 2023), which includes children's items. Additionally, some information was obtained from the High Priority Chemicals Data System (HPCDS, (WSDE, 2020)), a database compiling manufacturer reporting requirements from 2017 to 2024 per Washington and Oregon safe children's product regulations. However, HPCDS does not identify specific products or articles, only generic categories (*e.g.*, toys/games). DBP reporting in HPCDS dates from 2017 to 2024.

As data for DBP content in solid items not specific to children were lacking for U.S. consumer goods, a large amount of data was taken from monitoring studies of phthalates in consumer goods carried out in European countries, and these values are assumed to be similar to contents in comparable items sold in the U.S. In particular, a large amount of data was available for phthalates in consumer goods published across several studies carried out by the Danish EPA. For articles that did not have U.S. data, it is unclear if DBP is not present in U.S.-sold items or if these materials are not captured in U.S. monitoring efforts. As such, EPA assessed these items under the assumption that the weight fractions reported by the Danish EPA are representative of DBP content that could be present in items sold in the U.S.

Given the high molecular weight (278.35 g/mol) and low vapor pressure (2.01×10^{-5} mmHg) of DBP, partitioning into air and overlying dust from solid articles is expected to be limited. See *Draft Physical Chemistry and Fate and Transport Assessment for Dibutyl Phthalate (DBP)* TSD (U.S. EPA, 2024a) for further description of physical chemical properties. Consequently, inhalation and dust ingestion exposure for items with small surface area of emissions (<1 m^2, for example a kitchen counter or single cushion chair) or those items used outdoors are expected to be insignificant as compared to exposure by mouthing and dermal contact. As such, inhalation and dust ingestion were not assessed for these items. For articles assessed for mouthing and/or dermal contact the weight fraction data is used to confirm the presence of DBP in the article but these data are not used in the dermal and mouthing modeling, see Sections 2.2.3.1 (mouthing) and 2.3 (dermal). Furthermore, dermal, and mouthing exposure assessments include high-, medium-, and low-intensity use scenarios for each article using a range of modeling input parameters described in the corresponding sections, such as dermal absorption-related parameters and chemical migration rates (mouthing).

Adult Toys

Adult toys, also known as intimacy and sex toys, are objects that people use to increase or facilitate sexual pleasure. Examples of adult toys include vibrators, dildos, sleeves, *etc*. These articles were assessed for DBP exposure by mouthing and dermal routes. Vaginal and anal exposures were not assessed due to a lack of use patterns information and modeling tools to calculate exposure for articles with vaginal and anal use needed to complete a risk assessment. DBP was reported at 1.06×10^{-5} w/w in an adult toy sample purchased in the United States (Sipe et al., 2023).

Car Mats

Car floor mats were assessed for DBP exposure by inhalation, dust ingestion, and dermal pathways. The only available data for DBP content in car mats was one car mat set purchased from an internet vendor in Denmark, with reported DBP weight fraction of 1.4×10^{-4} w/w (Danish EPA, 2020). As data specific to the U.S. market are lacking, this weight fraction value was used in the low, medium, and high exposure scenarios.

Children's Toys

Children's toys were assessed for DBP exposure by inhalation, dust ingestion, dermal and mouthing routes of exposure. Under the Consumer Product Safety Improvement Act (CPSIA) of 2008 (CPSIA section 108(a), 15 U.S.C. § 2057c(a);16 C.F.R. § 1307.3(a)), Congress permanently prohibited the sale of children's toys or childcare articles containing concentrations of more than 0.1 percent DBP. However, it is possible that some individuals may still have children's toys in the home that were produced before statutory and regulatory limitations. A recent survey by the Danish EPA of PVC products purchased from foreign online retailers found that DBP content in a toy bath duck of 1.7 percent exceeded the current Danish regulatory limit of 0.1 percent DBP (Danish EPA, 2020).

In the U.S. market, among the data for children's items from the Washington State database (WSDE, 2023), three toys had detectable concentrations of DBP; however, none toys had DBP content above the statutory and regulatory limit of 0.1 percent (WSDE, 2023). The HPCDS database contained data for DBP measurements in 96 toy/game items with reporting dates from 2017 to 2024. Although there is some uncertainty about the materials these items are manufactured from, based on the limited descriptions in the database, EPA determined that these items are likely composed primarily of plastic and rubber components. For example, some of the descriptions provided for toys were dolls, puppets, action figures, board games, toy vehicles, soft toys, and more specific descriptions were toy soldiers, glow in the dark plastic bugs, waterproof pouches, pink plastic recorder, yellow bendy man. DBP content was reported to be <100 ppm (<0.0001 w/w) in 42 items, 100 to 500 ppm (0.0001–0.0005 w/w)

in 44 items, 500 to 1,000 ppm (0.0005–0.001 w/w) in 9 items, and 5,000 to 10,000 ppm (0.005–0.01 w/w) in one item. This last item with DBP content over the statutory and regulatory limit of 0.1 percent was listed as a non-ride toy vehicle (WSDE, 2020).

EPA assessed exposure to DBP in children's toys under two scenarios. In the first exposure scenario, new toys produced for the U.S. market are assumed to comply with statutory and regulatory limits and were therefore assessed with DBP weight fractions of 0.001 w/w in low, medium, and high exposure scenarios. In the second scenario, legacy toys are assessed with weight fractions reported in the HPCDS database, (WSDE, 2020), that are above the statutory and regulatory limit of 0.001 w/w. Based on the reported data, the weight fractions of DBP used in low, medium, and high exposure scenarios were 0.005 w/w, 0.0075 w/w, and 0.01 w/w. One new toy in the HPCDS database tested 8 or more years after the CPSIA had components with DBP content above the statutory and regulatory limit of 0.01 percent (WSDE, 2020). The legacy toys scenario is more representative of any new toys with weight fractions above the CPSIA statutory and regulatory limit.

Clothing

Clothing was assessed for DBP exposure by dermal contact only, but a different approach was taken for adults and children based on anticipated contact with specific garments. DBP content was reported in components of two adult sized garments by the Danish EPA. This included measurements of 0.00087 w/w in the outer layer of a raincoat (Danish EPA, 2020) and 0.0012 w/w in a jacket reflector (Danish EPA, 2009). DBP has also been reported in synthetic leather materials sampled from furniture items (see coated textiles description below). It is reasonable to assume that these materials may be used in synthetic leather clothing as well, which is expected to have a greater potential for dermal exposure as it may be worn more often than raincoats, has direct dermal contact, and may have a larger area of dermal contact. As such, synthetic leather clothing was chosen as the representative clothing item for modeling dermal exposure to DBP in adults and teens. Based on this data, the weight fraction of DBP is used to confirm DBP in article and identified data range from 2×10^{-6} to 7.2×10^{-4} w/w.

In the U.S. market, the Washington State database reported measurable DBP content in the outside facing print, not in direct dermal contact, of four children's garments and in the exterior component of a hat/mitten set. The DBP concentrations in these items ranged from 5.3×10^{-6} to 1.30×10^{-4} w/w (WSDE, 2020). Given the low concentrations of DBP and limited dermal contact arising from its use on the outside layer of clothing, DBP exposure from these, or similar items is not expected to be significant. In addition, infants and children are not anticipated to wear synthetic leather clothing. As such, dermal exposure to DBP from clothing was not modeled explicitly for infants and children; however, the potential for dermal contact with these items is captured under the scenario "PVC articles with the potential for semi-routine dermal exposure" outlined below.

Coated Textiles

Coated textiles were assessed for DBP exposure via inhalation, dust ingestion, mouthing, and dermal uptake. The Danish EPA reported DBP measurements of 2×10^{-6} to 7.2×10^{-4} w/w in 11 synthetic leather furniture samples (Danish EPA, 2011). Synthetic leather is expected to have many potential applications, including furniture, clothing, and accessory items such as belts and handbags. Exposure to coated textiles was assessed as two representative articles expected to capture the highest exposure by inhalation, dermal uptake, and ingestion due to large surface area of emissions and long dermal contact times. To that end, consumer exposure to DBP from coated textiles was modeled in scenarios for furniture and adult clothing. The low, medium, and high exposure scenarios for BBP in synthetic leather used the minimum, average, and maximum reported weight fractions of 2×10^{-6}, 1.5×10^{-4}, and 7.2×10^{-4} w/w, respectively.

Footwear

Footwear components were assessed for DBP exposure by dermal contact only. DBP content was reported by the Danish EPA in two footwear items including one flip-flop sandal at 0.297 w/w (Danish EPA, 2020) and one rubber clog at 0.026 w/w (Danish EPA, 2009). In the U.S. market, DBP was reported in the Washington State database at 2.1×10^{-5} w/w in one flip-flop sandal (WSDE, 2020). Based on the reported data, the weight fractions of DBP used to confirm presence of DBP in article and range of identified data from 0.26 to 0.3 w/w.

PVC Articles with Potential for Semi-Routine Dermal Exposure

DBP has been measured in a variety of consumer goods that are not expected to (1) be mouthed, (2) to result in significant inhalation exposure due to their small size and/or outdoor only use, (3) result in significant dermal exposures due to short and/or infrequent dermal contact events. However, EPA recognizes that while dermal uptake of DBP from contact with these individual items is not expected to be significant, given the widespread nature of the items, an individual could have significant daily contact with some combination of these items and/or with other similar items that have not been measured during monitoring campaigns. As such, these items have been grouped together for modeling but represent a variety of TSCA COUs. It is likely that real world exposures to these types of items would occur as a result of dermal contact with articles belonging to multiple COUs. However, the contribution of individual COUs to exposure from these types of items is expected to vary at an individual level due to differences in lifestyle and habits. As such, while this scenario encompasses items from more than one COU, it may be viewed as an upper boundary for exposure to any of the COUs included. Weight fractions of DBP are not used in dermal exposure calculations, they are provided below only to demonstrate the broad range of the product types, formulations, and DBP content, which may be captured in this model scenario.

In the U.S. market from the Washington State database, (WSDE, 2020), arts and crafts items including pencil cases, stickers, vinyl liner, and a Halloween kit were identified with DBP content ranging from 5.4×10^{-6} to 2.1×10^{-4} w/w. Additionally, 1 bib contained DBP content of 1.19×10^{-5} w/w, 1 light-up jewelry item contained DBP content of 2.5×10^{-5} w/w, 20 packaging products contained DBP content from 9×10^{-6} to 0.002 w/w, and 4 bag/pouch articles contained DBP content from 6.1×10^{-6} to 2×10^{-4} w/w (WSDE, 2020). Additionally in the U.S. market from a 2012 study on consumer products, one dryer sheet was identified with DBP content of 0.001 w/w (Dodson et al., 2012).

In two studies, the Danish EPA reported measurable DBP content in several articles. Two hobby cutting board samples had reported DBP of 0.0032 w/w, one chew toy for pets had reported DBP of 6.0×10^{-5} w/w, two tape samples had reported DBP of 0.068 w/w and 0.072 w/w, one garden house had reported DBP of 0.052 w/w, one glove had reported DBP of 2×10^{-5} w/w, one football had a reported DBP of 3×10^{-5} w/w (Danish EPA, 2020), and one balance ball had reported DBP of 2.5×10^{-5} w/w (Danish EPA, 2011).

Chemiluminescent light sticks, commonly called “glow sticks,” consist of a chemical solution within a plastic tube or other container. The Danish EPA reported DBP in two glow stick samples at 0.078 and 0.45 w/w (Danish EPA, 2013). Glow sticks may be used during entertainment and play; within military and police operations; and for recreational activities such as diving, fishing, and camping. It is unclear from the provided data if DBP is present as part of the chemical solution or as part of the flexible plastic tube. Exposure to DBP in the liquid component of glow sticks is expected to occur rarely after accidental or intentional misuse of the item that results in breaking the outer casing and releasing the interior liquid. Depending upon use patterns, dermal contact with the exterior housing occurs but is still not expected to occur on a routine basis.

Shower Curtains

Shower curtains were assessed for DBP exposure by inhalation, dust ingestion, and dermal exposure routes. The Danish EPA reported DBP in one shower curtain sample at 6.3×10^{-5} w/w (Danish EPA, 2011). This weight fraction was applied for low, medium, and high exposure scenarios.

Vinyl Flooring

Vinyl flooring was assessed for DBP exposure by inhalation, dust ingestion, and dermal exposure. DBP content was reported by the Danish EPA in vinyl coverings at 1.3×10^{-4} w/w (Danish EPA, 2011). This weight fraction was applied for low, medium, and high exposure scenarios.

Wallpaper

Wallpaper was assessed for DBP exposure by inhalation, dust ingestion, and dermal exposure routes. DBP was reported by the Danish EPA for three wallpaper samples (Danish EPA, 2011). The minimum, mean, and maximum weight fractions of DBP were 9.0×10^{-6}, 1.7×10^{-5}, and 3.0×10^{-5} w/w; these values were used in low, medium, and high exposure scenarios.

2.1.2 Liquid, Paste, and Powder Products

Consumable products with DBP content were largely identified by manufacturer safety data sheets (SDSs). Products with similar DBP content and expected use patterns were grouped together for modeling as described below. Some products were not assessed for inhalation exposure due to the small volume of the product that is expected to be used, short durations of use and thus a shorter duration for emissions to air to occur (*e.g.*, adhesives with short working times [less than a few minutes] until solidification and liquids poured directly into a reservoir that is capped after product addition), and/or products used in outdoor conditions where air exchange rates are high and product application are not expected to generate aerosols. Note that for liquid and paste products assessed only for dermal exposure, DBP content is provided here for context only as it is not used directly in exposure calculations for these routes (see Sections 2.3.2 and 2.3.3 for details).

Adhesives and Sealants

One all-purpose adhesive used for small repairs was identified with DBP content. The reported DBP content was less than 3 percent (Walmart, 2019), and this weight fraction of 0.03 w/w was used to confirm DBP presence in product. Because small volumes of this adhesive are expected to be used and the working time is short (<5 minutes), this product was evaluated for dermal exposure only.

One metal bonding adhesive used for small to moderately sized automotive repairs was identified with DBP content of 1 to less than 3 percent (Ford Motor Company, 2015). This product was modeled for dermal and inhalation exposure with DBP weight fractions of 0.01, 0.015, and 0.03 w/w in low, medium, and high exposure scenarios.

Two adhesive products for home repair or construction bonding were identified with DBP content. One anchoring adhesive used for anchoring metal rebar into cured concrete and masonry was reported to have a DBP content of 0.1 to 5 percent (ITW Red Head, 2016), and one paste designed to watertight details in construction was reported to have a DBP content of 10 to 30 percent (Vaproshield, 2018). Both products are used outdoors in relatively small quantities and not applied in a manner expected to generate significant aerosols. As such, these products were modeled for dermal exposure only.

Cleaning and Furnishing Care Products

Two cleaning and furnishing care products with DBP content were identified from a 2012 study on U.S. consumer products (Dodson et al., 2012). Due to the different format and application, these items were

modeled separately. One spray cleaning product used for tub and tile cleaning was identified with a reported DBP content of 0.0001 w/w, which was applied for low, medium, and high exposure scenarios. This product was assessed for inhalation, ingestion, and dermal contact. One polish/wax used for floors and furniture was identified with a reported DBP content of 0.001 w/w, which was applied for low, medium, and high exposure scenarios. This product was assessed for inhalation and dermal exposure.

Coatings

Several types of coating products were identified with DBP content. These items were grouped for modeling according to expected consumer use patterns.

Six waterproofing coating products for roofs, decks, and walkway applications were identified with DBP content. Three products had reported DBP content of 0.1 to 1 percent (GAF, 2018, 2017, 2016), two products had reported DBP content of 2 to 3 percent (Structures Wood Care, 2016a, b), and one product had reported DBP content of 0.05 to 10 percent (Lanco Mfg. Corp, 2016). Based on this data, the weight fractions of 0.0005 w/w, 0.017 w/w, and 0.1 w/w were used for low, medium, and high exposure scenarios. Though these products are for outdoor only use, inhalation exposure may be significant due to relatively large volumes of product used and aerosol generation during spray application. As such, these products were modeled for both inhalation and dermal exposures.

Two wood floor finish or coating products were identified with DBP content and were assessed for inhalation and dermal contact. The products were reported to have DBP content of <2 percent (Franklin Cleaning Technology, 2011) and 1 percent (Daly's Wood Finishing Products, 2015). Based on this data, the weight fractions of 0.01, 0.015, and 0.02 w/w were used in low, medium, and high exposure scenarios.

Two metal coating products were assessed for inhalation and dermal contact as application may occur indoors (garage). One anti-fouling boat coating was identified with 2.5 to 10 percent DBP content (Rust-Oleum Corporation, 2015), and one aluminum primer was identified with 1 to 2.5 percent DBP content (Rust-Oleum Corporation, 2016). Based on this data, the weight fractions of 0.01 w/w, 0.04 w/w, and 0.1 were used for low, medium, and high exposure scenarios.

Rifle Powder

DBP was identified in several rifle powders manufactured by Western Powders, Inc. and the reported DBP content was 0 to 10 percent (Western Powders Inc, 2015). Exposure to DBP in gunpowder was qualitatively assessed as exposure is expected to be minimal. Exposure was considered in both DIY bullet making and firing range scenarios. In DIY bullet making, exposure to DBP is limited due to the precision required in measuring and handling the gunpowder. Exact quantities are critical to ensure safe and effective ammunition, which necessitates the use of a powder measure - a device that dispenses specific amounts of powder into each cartridge case. The powder measure typically consists of a hopper, where the gunpowder is stored, and an adjustable measuring chamber that dispenses the powder without manual contact. This process minimizes direct handling of the gunpowder, as the hopper only needs to be refilled intermittently, significantly reducing the risk of both dermal and inhalation exposure to DBP. The controlled, small-scale nature of powder dispensing also limits potential inhalation exposure. At firing ranges, no data were available for DBP concentrations in air or particulate matter. However, the exposure risk from DBP in these environments is expected to be minimal due to the small quantities involved and the dispersion of these residues in the environment.

664 **Table 2-1. Summary of Consumer COUs, Exposure Scenarios, and Exposure Routes**

Consumer Condition of Use Category	Consumer Condition of Use Subcategory	Product/Article	Exposure Scenario and Route	Evaluated Routes				
						Ingestion		
				Inhalation [a]	Dermal	Suspended Dust	Settled Dust	Mouthing
Automotive, fuel, agriculture, outdoor use products	Automotive care products	See automotive adhesives	Use of product in DIY small-scale auto repair and hobby activities. Direct contact during use; inhalation of emissions during use	✓	✓	✗	✗	✗
Construction, paint, electrical, and metal products	Adhesives and sealants	Adhesive for small repairs	Direct contact during use	✗	✓	✗	✗	✗
Construction, paint, electrical, and metal products	Adhesives and sealants	Automotive adhesives	Use of product in DIY small-scale auto repair and hobby activities. Direct contact during use; inhalation of emissions during use	✓	✓	✗	✗	✗
Construction, paint, electrical, and metal products	Adhesives and sealants	Construction adhesives	Direct contact during use	✗	✓	✗	✗	✗
Construction, paint, electrical, and metal products	Paints and coatings	Metal coatings	Use of product in DIY home repair and hobby activities. Direct contact during use; inhalation of emissions during use	✓	✓	✗	✗	✗
Construction, paint, electrical, and metal products	Paints and coatings	Sealing and refinishing sprays (indoor use)	Application of product in house via spray. Direct contact during use; inhalation of emissions during use	✓	✓	✗	✗	✗
Construction, paint, electrical, and metal products	Paints and coatings	Sealing and refinishing sprays (outdoor use)	Application of product outdoors via spray. Direct contact during use; inhalation of emissions during use	✓	✓	✗	✗	✗
Furnishing, cleaning, treatment care products	Fabric, textile, and leather products	Synthetic leather clothing	Direct contact during use	✗	✓	✗	✗	✗
Furnishing, cleaning, treatment care products	Fabric, textile, and leather products	Synthetic leather furniture	Direct contact during use; inhalation of emissions / ingestion of airborne particulate; ingestion by mouthing	✓ [b]	✓	✓ [b]	✓ [b]	✓
Furnishing, cleaning, treatment/care products	Cleaning and furnishing care products	Spray cleaner	Application of product in house via spray. Direct contact during use; inhalation of emissions during use	✓	✓	✗	✗	✗

Consumer Condition of Use Category	Consumer Condition of Use Subcategory	Product/Article	Exposure Scenario and Route	Evaluated Routes				
						Ingestion		
				Inhalation [a]	Dermal	Suspended Dust	Settled Dust	Mouthing
Furnishing, cleaning, treatment/care products	Cleaning and furnishing care products	Waxes and polishes	Application of product in house via spray. Direct contact during use; inhalation of emissions during use	✓	✓	✗	✗	✗
Furnishing, cleaning, treatment/care products	Floor coverings; construction and building materials covering large surface areas including stone, plaster, cement, glass and ceramic articles; fabrics, textiles, and apparel	Vinyl flooring	Direct contact, inhalation of emissions / ingestion of dust adsorbed chemical	✓ [b]	✓	✓ [b]	✓ [b]	✗
Furnishing, cleaning, treatment/care products	Floor coverings; construction and building materials covering large surface areas including stone, plaster, cement, glass and ceramic articles; fabrics, textiles, and apparel	Wallpaper	Direct contact during installation (teenagers and adults) and while in place; inhalation of emissions / ingestion of dust adsorbed chemical	✓ [b]	✓	✓ [b]	✓ [b]	✗
Other uses	Novelty articles	Adult toys	Direct contact during use; ingestion by mouthing	✗	✓	✗	✗	✓
Other uses	Automotive articles	Synthetic leather seats. see synthetic leather furniture	Direct contact during use; inhalation of emissions / ingestion of airborne particulate; ingestion by mouthing	✓ [b]	✓	✓ [b]	✓ [b]	✗
Other uses	Automotive articles	Car mats	Direct contact during use; inhalation of emissions / ingestion of airborne particulate; ingestion by mouthing	✓ [b]	✓	✓ [b]	✓ [b]	✗
Other uses	Chemiluminescent light sticks	Small articles with semi routine contact; glow sticks	Direct contact during use	✗	✓	✗	✗	✗
Other uses	Lubricants and lubricant additives	No consumer products identified. See adhesives for small repairs	Current products were not identified. Foreseeable uses were matched with the adhesives for small repairs because similar use patterns are expected.	✗	✓	✗	✗	✗
Packaging, paper, plastic, hobby products	Ink, toner, and colorant products	No consumer products identified. See adhesives for small repairs	Current products were not identified. Foreseeable uses were matched with the adhesives for small repairs because similar use patterns are expected.	✗	✓	✗	✗	✗
Packaging, paper, plastic, hobby products	Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles	Footwear	Direct contact during use	✗	✓	✗	✗	✗

Consumer Condition of Use Category	Consumer Condition of Use Subcategory	Product/Article	Exposure Scenario and Route	Evaluated Routes				
				Inhalation [a]	Dermal	Ingestion		
						Suspended Dust	Settled Dust	Mouthing
	(soft); other articles with routine direct contact during normal use, including rubber articles; plastic articles (hard)							
Packaging, paper, plastic, hobby products	Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft); other articles with routine direct contact during normal use, including rubber articles; plastic articles (hard)	Shower curtains	Direct contact during use; inhalation of emissions / ingestion of dust adsorbed chemical while hanging in place	✓ [b]	✓	✓ [b]	✓ [b]	✗
Packaging, paper, plastic, hobby products	Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft); other articles with routine direct contact during normal use, including rubber articles; plastic articles (hard)	Small articles with semi routine contact; miscellaneous items including a pen, pencil case, hobby cutting board, costume jewelry, tape, garden hose, disposable gloves, and plastic bags/pouches	Direct contact during use	✗	✓	✗	✗	✗
Packaging, paper, plastic, hobby products	Toys, playground, and sporting equipment	Children's toys (legacy)	Collection of toys; direct contact during use; inhalation of emissions / ingestion of airborne PM; ingestion by mouthing	✓ [b]	✓	✓ [b]	✓ [b]	✓
Packaging, paper, plastic, hobby products	Toys, playground, and sporting equipment	Children's toys (new)	Collection of toys; direct contact during use; inhalation of emissions / ingestion of airborne particulate; ingestion by mouthing	✓ [b]	✓	✓ [b]	✓ [b]	✓
Packaging, paper, plastic, hobby products	Toys, playground, and sporting equipment	Small articles with semi routine contact; miscellaneous items including a football, balance ball, and pet toy	Direct contact during use	✗	✓	✗	✗	✗
Packaging, paper, plastic, hobby products	Toys, playground, and sporting equipment	Tire crumb and artificial turf	Direct contact during use (particle ingestion via hand-to-mouth)	✓	✓	✓ [c]		

Consumer Condition of Use Category	Consumer Condition of Use Subcategory	Product/Article	Exposure Scenario and Route	Evaluated Routes				
						Ingestion		
				Inhalation [a]	Dermal	Suspended Dust	Settled Dust	Mouthing
Disposal	Disposal	Down the drain products and articles	Down the drain and releases to environmental media	✘	✘	✘	✘	✘
Disposal	Disposal	Residential end-of-life disposal, product demolition for disposal	Product and article end-of-life disposal and product demolition for disposal	✘	✘	✘	✘	✘

DIY = Do-it-yourself

[a] Inhalation scenarios consider suspended dust and gas-phase emissions.

[b] Scenario used in Indoor Dust Exposure Assessment in Section 4. These indoor dust articles scenarios consider the surface area from multiple articles such as toys, while furniture and flooring already have large surface areas. For these articles dust can deposit and contribute to significantly larger concentration of dust than single small articles

[c] The tire crumb and artificial turf ingestion route assessment considers all three types of ingestions, settled dust, suspended dust, and mouthing altogether, but results cannot be provided separately has it was done for all other articles and products.

✓ Quantitative consideration

✘ Qualitative consideration

Qualitative Assessments

EPA performed qualitative assessments of the COU summarized in Table 2-2. A qualitative discussion using physical and chemical properties and monitoring data for environmental media was performed to support conclusions about down-the-drain and disposal practices and releases to the environment.

Table 2-2. COUs and Products or Articles Without a Quantitative Assessment

Consumer Use Category	Consumer Use Subcategory	Product/Article	Comment
Disposal	Disposal	Down the drain products and articles	Qualitative assessment done due to limited information on source attribution of the consumer COUs in drain water or wastewater.
Disposal	Disposal	Residential end-of-life disposal, product demolition for disposal	Qualitative assessment done due to limited information on source attribution of the consumer COUs in landfills.

Environmental releases may occur from consumer products and articles containing DBP via the end-of-life disposal and demolition of consumer products and articles in the built environment or landfills, as well as from the associated down-the-drain release of DBP. It is difficult for EPA to quantify these end-of-life and down-the-drain exposures due to limited information on source attribution of the consumer COUs. In previous assessments, the Agency has considered down-the-drain analyses for consumer product scenarios where it is reasonably foreseen that the consumer product would be discarded directly down-the-drain. For example, adhesives, sealants, paints, coatings, cleaner, waxes, and polishes can be disposed down-the-drain while users wash their hands, brushes, sponges, and other product applying tools. Although EPA acknowledges that there may be DBP releases to the environment via the cleaning and disposal of adhesives, sealants, paints, coatings, and cleaning and furnishing care products, the Agency did not quantitatively assess these products and instead provides a qualitative assessment.

DBP-containing products can be disposed when users no longer have use for them, or when they have reached the product shelf life and are taken to landfills. All other solid products and articles in Table 2-1 can be disposed in landfills, or other waste handling locations that properly manage the disposal of products like adhesives, sealants, paints, and coatings. Section 3.2 in the *Draft Environmental Media and General Population and Environmental Exposure for Dibutyl Phthalate (DBP)* (U.S. EPA, 2025b) summarizes DBP monitoring data identified for landfills. Briefly, no studies were identified that reported the concentration of DBP in landfills or in the surrounding areas in the United States, but DBP was identified in sludge in wastewater plants in China, Canada, and the United States. DBP is expected to have a high affinity to particulate (log K_{OC} = 3.14–3.94) and organic media (log K_{OW} = 4.5) that would limit leaching to groundwater. Because of its high hydrophobicity and high affinity for soil sorption, it is unlikely that DBP will migrate from landfills via groundwater infiltration. Nearby surface waters, however, may be susceptible to DBP contamination via surface water runoff if DBP is not captured before interacting with surface water.

2.2 Inhalation and Ingestion Modeling Approaches

The CEM Version 3.2 (U.S. EPA, 2023) was selected for the consumer exposure modeling as the most appropriate model based on the type of input data available for DBP-containing consumer products. The advantages of using CEM to assess exposures to consumers and bystanders are as follows:

- CEM model has been peer-reviewed (ERG, 2016);

- CEM accommodates the distinct inputs available for the products and articles containing DBP, such as weight fractions, product density, room of use, frequency and duration of use (see Section 2.2.3 for specific product and article scenario inputs); and
- CEM uses the same calculation engine to compute indoor air concentrations as the higher-tier Multi-Chamber Concentration and Exposure Model (MCCEM) but does not require measured chamber emission values (which are not available for DBP).

CEM has capabilities to model exposure to DBP from both products and articles containing the chemical. Products are generally consumable liquids, aerosols, or semi-solids that are used a given number of times before they are exhausted. Articles are generally solids, polymers, foams, metals, or woods, which are present within indoor environments for the duration of their useful life and may be several years.

CEM 3.2 estimates acute dose rates and chronic average daily doses for inhalation, ingestion, and dermal exposures of consumer products and articles. However, for the purpose of this assessment, EPA performed dermal calculations outside of CEM, see Section 2.3 for approach description and input parameters. CEM 3.2 acute exposures are for an exposure duration of 1 day while chronic exposures are for an exposure duration of 1 year. The model provides exposure estimates for various lifestages. EPA made some adjustments to match CEM's lifestages to those listed in the U.S. Centers for Disease Control and Prevention (CDC) guidelines (CDC, 2021) and EPA's *A Framework for Assessing Health Risks of Exposures to Children* (U.S. EPA, 2006). CEM lifestages are re-labeled from this point forward as follows:

- Adult (21+ years) → Adult
- Youth 2 (16–20 years) → Teenager and Young Adult
- Youth 1 (11–15 years) → Young Teen
- Child 2 (6–10 years) → Middle Childhood
- Child 1 (3–5 years) → Preschooler
- Infant 2 (1–2 years) → Toddler
- Infant 1 (<1 year) → Infant

Exposure inputs for these various lifestages are provided in the EPA's CEM Version 3.2 Appendices.

2.2.1 Inhalation and Ingestion Modeling for Products

The calculated emission rates are then used in a deterministic, mass balance calculation of indoor air concentrations. CEM employs different models for products and articles. For products, CEM 3.2 uses a two-zone representation of the building of use when predicting indoor air concentrations. Zone 1 represents the room where the consumer product is used. Zone 2 represents the remainder of the building. Each zone is considered well-mixed. The model allows for further division of Zone 1 into a near- and far-field component to accommodate situations where a higher concentration of product is expected very near the product user during the period of use. Zone 1 – near-field represents the breathing zone of the user at the location of the product use, while Zone 1 –far-field represents the remainder of the Zone 1 room. The modeled concentrations in the two zones are a function of the time-varying emission rate in Zone 1, the volumes of Zones 1 and 2, the air flows between each zone and outdoor air, and the air flows between the two zones. Following product use, the user and bystander may follow one of three pre-defined activity patterns: full-time worker, part-time worker, and stay-at-home. The activity use pattern determines which zone is relevant for the user and bystander and the duration of the exposures. The user and bystander inhale airborne concentrations within these zones, which can vary over time, resulting in the overall estimated exposure for each individual.

The stay-at-home activity pattern assumes that occupants are inside the home a total of 21 hours per day, in an automobile 1 hour per day, and outside 2 hours per day. Of the hours spent in the home, 10 hours are in the bedroom, 7 hours are in the living room, 2 hours are in the kitchen, and 1 hour in both the utility room and bathroom. However, normal activity patterns are overridden by the selection of product users; any age group selected as a user remains in Zone 1 (or near-field if specified) for the duration of product use.

CEM default air exchange rates for the building are from the *Exposure Factors Handbook* (U.S. EPA, 2011c). The default interzonal air flows are a function of the overall air exchange and volume of the building as well as the openness of the room, which is characterized in a regression approach for closed rooms and open rooms (U.S. EPA, 2023). See Section 2.2.3 for product scenario specific selections of environment such as living room versus whole house, or indoor vs. outdoor and the air exchange rate used per environment selection. Kitchens, living rooms, and the garage area are considered more open, with an interzonal ventilation rate of 109 m^3/hour. Bedrooms, bathrooms, laundry rooms, and utility rooms are considered less open, and an interzonal ventilation rate of 107 m^3/hour is applied. In instances where the whole house is selected as the room of use, the entire building is considered Zone 1, and the interzonal ventilation rate is therefore equal to the negligible value of 1×10^{-30} m^3/hour. In instances where a product might be used in several rooms of the house, air exchange rate was considered in the room of use to ensure that effects of ventilation were captured.

2.2.2 Inhalation and Ingestion Modeling for Articles

For articles, the model comprises an air compartment (including gas phase, suspended particulates) and a floor compartment (containing settled particulates). Semi-volatile organic compounds (SVOCs) emitted from articles partition between indoor air, airborne particles, settled dust, and indoor sinks over time. Multiple articles can be incorporated into one room over time by increasing the total exposed surface area of articles present within a room. CEM 3.2 models exposure to SVOCs emitted from articles via inhalation of airborne gas- and particle-phase SVOCs, ingestion of previously inhaled particles, dust ingestion via hand-to-mouth contact, and ingestion exposure via mouthing. Abraded particles are first emitted to the air and thereafter may deposit and resuspend from the surfaces. Abraded particles, like suspended and settled particulate, are subject to cleaning and ventilation losses. Abraded particles, both in the suspended and settled phases, are not assumed to be in equilibrium with the air phase. Thus, the chemical transfer between particulates and the air phase is kinetically modeled in terms of the two-phase mass transfer theory. In addition, abraded particles settled on surfaces are assumed to have a hemispherical area available for emission, whereas those suspended in the air have a spherical area available for emission.

In the inhalation scenarios where DBP is released from an article into the gas-phase, the article inhalation scenario tracks chemical transport between the source, air, airborne and settled particles, and indoor sinks by accounting for emissions, mixing within the gas phase, transferring to particulates by partitioning, removal due to ventilation, removal due to cleaning of settled particulates and dust to which DBP has partitioned, and sorption or desorption to/from interior surfaces. The emissions from the article were modeled with a single exponential decay model. This means that the chronic and acute exposure duration scenarios use the same emissions/air concentration data based on the weight fraction of the chemical in the article but have different averaging times. The acute data uses concentrations for a 24-hour period at the peak of the simulated emissions, while the chronic data was averaged over the entire 1-year period. Because air concentrations for most of the year are significantly lower than the peak value, the air concentrations used in chronic dose calculations are usually lower than that used to calculate an acute dose.

2.2.3 CEM Modeling Inputs and Parameterization

The COUs that were evaluated for DBP consisted of both products and articles. The embedded models within CEM 3.2 that were used for DBP are listed in Table 2-3. As dermal exposure was modeled separately, only inhalation and ingestion routes were evaluated using CEM.

Table 2-3. CEM 3.2 Model Codes and Descriptions

Model Code	Description
E1	Emission from Product Applied to a Surface Indoors Incremental Source Model
E2	Emission from Product Applied to a Surface Indoors Double Exponential Model
E3	Emission from Product Sprayed
E6	Emission from Article Placed in Environment
A_INH1	Inhalation from Article Placed in Environment
A_ING1	Ingestion After Inhalation
A_ING2	Ingestion of Article Mouthed
A_ING3	Incidental Ingestion of Dust
P_ING1	Ingestion of Product Swallowed
P_INH2	Inhalation of Product Used in an Environment

Table 2-4 presents a crosswalk between the COU subcategories with either a predefined or generic scenario. Models were generated to reflect specific use conditions as well as physical and chemical properties of identified products and articles. In some cases, one COU mapped to multiple scenarios, and in other cases one scenario mapped to multiple COUs. Table 2-4 provides data on emissions model and exposure pathways modeled for each exposure scenario. Emissions models were selected based upon physical and chemical properties of the product or article and application use method for products. Exposure pathways were selected to reflect the anticipated use of each product or article. The article model Ingestion of Article Mouthed (A_ING2) was only evaluated for the COUs where it was anticipated that mouthing of the product could occur. For example, it is unlikely that a child would mouth flooring or wallpaper, hence the A_ING2 Model was deemed inappropriate for estimating exposure for these COUs. Similarly, solid articles with small surface area are not anticipated to contribute significantly to inhalation or ingestion of DBP sorbed to dust/PM and were therefore not modeled for these routes (A_ING1, A_ING3). Note that products and articles not assessed in CEM (adhesives for small repairs, construction adhesives, footwear, synthetic leather clothing, small articles with potential for semi-routine contact) are not listed in this table; modeling for these items was performed outside of CEM as described in Sections 2.3 and 2.5.

Table 2-4. Crosswalk of COU Subcategories, CEM 3.2 Scenarios, and Relevant CEM 3.2 Models Used for Consumer Modeling

Consumer COU	Sub-COU	Product/Article	Emission Model and Exposure Pathway(s)	CEM Saved Analysis
Other	Novelty products	Adult toys	A_ING2	Rubber articles: with potential for routine contact (baby bottle nipples, pacifiers, toys)
Construction, paint, electrical, and metal products	Adhesives and sealants, including fillers and putties	Automotive adhesives	E1, P_INH2 (near-field, users), P_INH1 (bystanders)	Glue and adhesives (small scale)
Other use	Automotive products, other than fluids	Car mats	E6, A_INH1, A_ING1, A_ING3	Rubber articles: with potential for routine contact (baby bottle nipples, pacifiers, toys)
Packaging, paper, plastic, hobby products	Toys, playground, and sporting equipment	Children's toys (legacy)	E6, A_INH1, A_ING1, A_ING2, A_ING3	Rubber articles: with potential for routine contact (baby bottle nipples, pacifiers, toys)
Packaging, paper, plastic, hobby products	Toys, playground, and sporting equipment	Children's toys (new)	E6, A_INH1, A_ING1, A_ING2, A_ING3	Rubber articles: with potential for routine contact (baby bottle nipples, pacifiers, toys)
Construction, paint, electrical, and metal products	Paints and coatings	Metal coatings	Generic P3 E3	E3, P_INH2 (Near-field, users), P_INH1 (bystanders)
Construction, paint, electrical, and metal products	Paints and coatings	Sealing and refinishing sprays (indoor use)	Generic P3 E3	E3, P_INH2 (Near-field, users), P_INH1 (bystanders)
Construction, paint, electrical, and metal products	Paints and coatings	Sealing and refinishing sprays (outdoor use)	Generic P3 E3	E3, P_INH2 (Near-field, users), P_INH1 (bystanders)
Packaging, paper, plastic, hobby products	Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft)	Shower curtains	E6, A_INH1, A_ING1, A_ING3	Plastic articles: other objects with potential for routine contact (toys, foam blocks, tents)
Furnishing, cleaning, treatment care products	Fabric, textile, and leather products	Synthetic leather furniture	E6, A_INH1, A_ING1, A_ING2, A_ING3	Leather Furniture
Furnishing, cleaning, treatment/care products	Cleaning and furnishing care products	Tub and tile cleaner	All-purpose spray cleaner	E3, P_INH2 (Near-field, users), P_INH1 (bystanders)

Consumer COU	Sub-COU	Product/Article	Emission Model and Exposure Pathway(s)	CEM Saved Analysis
Furnishing, cleaning, treatment/care products	Floor coverings; construction and building materials covering large surface areas including stone, plaster, cement, glass, and ceramic articles; fabrics, textiles, and apparel	Vinyl flooring	E6, A_INH1, A_ING1, A_ING3	Plastic articles: vinyl flooring
Furnishing, cleaning, treatment/care products	Floor coverings; construction and building materials covering large surface areas including stone, plaster, cement, glass, and ceramic articles; fabrics, textiles, and apparel	Wallpaper (in place)	E6, A_INH1, A_ING1, A_ING3	Fabrics: curtains, rugs, wall coverings
Furnishing, cleaning, treatment/care products	Cleaning and furnishing care products	Waxes and polishes	All-purpose waxes and polishes (furniture, floor, etc.)	E3, P_INH2 (Near-field, users), P_INH1 (bystanders)

In total, the specific products representing 11 COUs for DBP were mapped to 20 scenarios, 14 of which were modeled in CEM. Relevant consumer behavioral pattern data (*i.e.*, use patterns) and product-specific characteristics were applied to each of the CEM scenarios and are summarized in Sections 2.2.3.1 and 2.2.3.2.

2.2.3.1 Key Parameters for Articles Modeled in CEM

Key input parameters for articles vary based on the exposure pathway modeled. For inhalation and dust ingestion, higher concentrations of DBP in air and dust result in increased exposure. This may occur due to article specific characteristics that allow for higher emissions of DBP to air and/or environment specific characteristics such as smaller room volume and lower ventilation rates. Key parameters that control DBP emission rates from articles in CEM 3.2 models are weight fraction of DBP in the material, density of article material (g/cm^3), article surface area (m^2), and surface layer thickness (cm); an increase in any of these parameters results in increased emissions and greater exposure to DBP. A detailed description of derivations of key parameter values used in CEM 3.2 models for articles is provided below, and a summary of values can be found in Table 2-5. Note that articles not modeled for inhalation exposure in CEM (clothing, footwear components, tire crumb rubber, and small articles with potential for semi-routine dermal contact) are not described here or included in the table. However, tire crumb rubber was assessed for inhalation exposure outside of CEM to accommodate use of empirical data for concentrations of DBP in air; details of this approach are provided in Section 2.4.

Weight fractions of DBP were calculated for each article as outlined in Section 2.1.1. Material density was assumed to be a standard value for PVC of 1.4 g/cm^3 in all articles. Values for article surface layer thickness were taken from CEM default values for scenarios with emissions from the same or similar solid material. CEM default values for parameters used to characterize the environment (use volume, air exchange rate, and interzonal ventilation rate) were used for all models. Due to the high variability and uncertainty of article surface areas, high, medium, and low values were generally estimated for each item with the goal of capturing a reasonable range of values for this parameter. Assumptions for surface area estimates are outlined below.

Car Mats

Based on a survey of car mat sets available on manufacturers websites, there was little variability in surface area and mats were sold in sets with two front mats approximately 30 inches × 20 inches and two back floor mats approximately 20 inches × 20 inches. Based on these dimensions the total surface area modeled was 1.29 m^2. As there was little observed variation in dimensions, this value was used in the low, medium, and high scenarios.

Children's Toys

Children's toys generally have a small surface area for an individual item, but consumers may have many of the same type of item in a home. As phthalates are ubiquitous in PVC material, it is reasonable to assume that in a collection of toys all of the items may have DBP content. As such, surface area for these items was estimated by assuming that a home has several of these items rather than one. The surface area of new and legacy toys was varied for the low, medium, and high exposure scenarios based on EPA's professional judgment of the number and size of toys present in a bedroom. The low-intensity use scenario was based on 5 small toys measuring 15 cm × 10 cm × 5 cm, the medium intensity use scenario was based on 20 medium toys measuring 20 cm ×15 cm × 8 cm, and the high intensity use scenario was based on 30 large toys measuring 30 cm × 25 cm × 15 cm.

Synthetic Leather Furniture

For textile furniture components, each scenario consisted of a couch and loveseat set, with the surface area varied in low, medium, and high exposure scenarios to reflect the variability observed in standard sizes available for purchase. The low, medium, and high surfaces areas, respectively, are based on prisms measuring 60 inches × 30 inches × 25 inches, 80 inches × 36 inches × 30 inches, and 100 inches × 42 inches × 35inches for a couch and 48inches × 30inches × 25inches, 60 inches × 36 inches × 30 inches, and 72 inches × 42 inches × 35 inches for a loveseat. The measurements were compiled from furniture retail store descriptions. EPA added the low surface areas for a couch and loveseat together to estimate exposures to smaller furniture in the low-end scenario, and similarly for the medium and high estimates. EPA assumes the bottom side of the furniture is not covered with the same material.

Shower Curtains

Based on a survey of shower curtains available on manufacturers' websites, there was little variability in surface area. EPA used manufacturer specifications for a shower curtain's dimensions (1.83 m × 1.78 m) to estimate surface area and multiplied by 2 to account for both sides. As there was little variability for this item, this surface area value was used in the low, medium, and high exposure scenarios.

Vinyl Flooring

To estimate surface areas for flooring materials, it was assumed that the material was used in 100, 50, and 25 percent of the total floor space. The value for whole house floor space was back calculated from the CEM house volume (492 m^3) and an assumed ceiling height of 8 ft, and the resulting values were applied in high, medium, and low exposure scenarios.

Wallpaper

The surface area of wallpaper in a residence was varied for the low, medium, and high exposure scenarios. The medium value of 100 m^2 is based on *Exposure Factors Handbook* Table 9-13 (U.S. EPA, 2011b). This value was scaled to 200 and 50 m^2 for the high and low exposure scenarios based on professional judgment.

Table 2-5. Summary of Key Parameters for Inhalation and Dust Ingestion Exposure to DBP from Articles Modeled in CEM 3.2

Article	Exposure Scenario Level	Weight Fraction [a]	Density (g/cm^3) [b]	Article Surface Area (m^2) [c]	Surface Layer Thickness (cm) [d]	Use Environment [e]	Use Environ Volume (m^3) [d]	Interzone Ventilation Rate (m^3/h) [d]
Car mats	High	0.00014	1.4	1.29	0.01	Automobile	2.4	9.5
	Medium	0.00014						
	Low	0.00014						
Children's toys (legacy) [f]	High	0.001	1.4	9.45	0.01	Bedroom	36.0	107.01
	Medium	0.001		2.32				
	Low	0.001		0.28				
Children's toys (new) [g]	High	0.01	1.4	9.45	0.01	Bedroom	36.0	107.01
	Medium	0.0075		2.32				
	Low	0.005		0.28				
Synthetic leather furniture	High	0.0007	1.4	17	0.01	Living room	50.0	108.98
	Medium	0.0001		12				
	Low	0.0001		7.9				
Shower curtains	High	0.0173	1.4	6.5	0.01	Bathroom	15.0	107.01
	Medium	0.011						
	Low	0.0064						
Vinyl flooring	High	0.000129	1.4	202	0.01	Whole house	492.0	1.0E−30
	Medium	0.000129		101				
	Low	0.0001		50.5				
Wallpaper (In place)	High	0.000030	1.4	200	0.01	Whole house	492.0	1.0E−30
	Medium	0.000017		100				
	Low	0.000009		50				

[a] See Section 2.1.1 for weight fraction sources and discussion.
[b] Used density of PVC from various sources, see *DBP Draft Consumer Exposure Analysis Spreadsheet* (U.S. EPA, 2025a).
[c] See text related to article in this section.
[d] CEM default for the emission scenario and saved analysis.
[e] Professional judgment based on likeliness of article presence.
[f] Legacy toys scenarios consider weight fractions in toys that are not limited to 0.1% and may be older than the 2017 CSPC phthalate rule, 16 CFR part 1307.
[g] New toys scenarios consider the application of the U.S. CSPC final phthalates rule established in 2017 (16 CFR Part 1307) that bans children's toys and childcare articles from containing more than 0.1% of five phthalates, including DBP. The identified weight fractions in the legacy toys scenario were not limited to 0.1%.

Environmental Parameters

The room of use selected for modeling affects the time occupants spend in the environment while products are actively emitting BBP, the total volume of air in the room, and ventilation rates. Default values are provided in CEM for use environment and ventilation rates in each room, which may be modified by the user. Time spent in each use environment is defined by activity patterns as described in Section 2.2. EPA used CEM defaults for the articles assessed.

Mouthing Exposure

For mouthing exposure, key parameters include the rate of chemical migration from the article to saliva (µg/cm^2/h), surface area mouthed (cm^2), and duration of mouthing (min/day). Derivation of these inputs is outlined below.

Chemical Migration Rate: Phthalates added to plastic products are not chemically-bound to the polymer matrix, allowing for migration through the material and release into saliva during mouthing. The rate of phthalate migration and release to saliva depends upon several factors, including physicochemical properties of the article polymer matrix, phthalate concentration in the polymer, physical mechanics of the individual's mouth during mouthing (*e.g.*, sucking, chewing, biting, etc), and chemical composition of saliva. In addition, physicochemical properties of the specific phthalate such as size, molecular weight, and solubility have a strong impact on migration rate to saliva.

Chemical migration rates of phthalates to saliva may be measured by *in vitro* or *in vivo* methods. While measurement assays may be designed to mimic mouthing conditions, there is not a consensus on what constitutes standard mouthing behavior. As a result, there is considerable variability in assay methods, which is expected to affect the results. Because of the aggregate uncertainties arising from variability in physical and chemical composition of the polymer, assay methods for *in vitro* measurements, and physiological and behavioral variability in *in vivo* measurements, migration rates observed in any single study were not considered adequate for estimating this parameter. The chemical migration rate of DBP was estimated based on data compiled in a review published by the Denmark EPA in 2016 (Danish EPA, 2016). For that review, data were gathered from existing literature for *in vitro* migration rates from soft PVC to artificial sweat and artificial saliva, as well as *in vivo* tests when such studies were available. The authors used 23 values taken from 3 studies (Danish EPA, 2010; Niino et al., 2003; Niino et al., 2001) for chemical migration rates of DBP to saliva from a variety of consumer goods measured with varying mouthing approaches methods. These values were then subdivided into mild, medium, and harsh categories based on the mouthing approach method used to estimate migration. Harsh mouthing method is used for vigorous chewing of an article relative to mild mouthing approaches. There is considerable variability in the measured migration rates, but there was not a clear correlation between weight fraction of DBP and chemical migration rate.

As such, the same chemical migration rates were applied to all articles regardless of DBP weight fraction. As no values were reported for DBP chemical migration rate using medium assay conditions, mean values under mild and harsh assay conditions were used in the low and high exposure scenarios, respectively and the midpoint between the two values was used in the medium exposure scenario. DBP chemical migration rate values used in low, medium, and high exposure scenarios were 0.17, 24.3, and 48.5 µg/cm^2-h, respectively; these values are expected to capture the range of reasonable values for this parameter, see Table 2-6. EPA calculated a high-intensity use of adult toys using harsh mouthing approaches as part of the screening approach; however, recognizing that this highly conservative use pattern is very unlikely behavior, it is not to be used to estimate risk. The Agency did not identify use pattern information regarding adult toys.

Table 2-6. Chemical Migration Rates Observed for DBP Under Mild, Medium, and Harsh Extraction Conditions

Mouthing Approach	Migration Rate (µg/cm²/h) [a]		
	Min	Mean (Standard Deviation)	Max
Mild	0.04	0.17 [b] (1.39)	5.8
Medium	–	24.3 [b c]	–
Harsh	–	48.5 [b]	–

[a] Information from Tables 17, 18, and 19 in (Danish EPA, 2016).
[b] Selected values for assessment.
[c] Calculated from the average of the mild and harsh means.

Mouthing Surface Area

The parameter "mouthing surface area" refers to the specific area of an object that comes into direct contact with the mouth during a mouthing event. A standardized value of 10 cm² for mouthing surface area is commonly used in studies and a default in CEM to estimate mouthing exposure in children (Danish EPA, 2010; Niino et al., 2003; Niino et al., 2001). This standard value is based on empirical data reflecting typical mouthing behavior in young children, providing a reliable basis for estimating exposure levels and potential health risks associated with mouthing activities. The value of 10 cm² was thus chosen for all mouthing exposure models for children.

Mouthing of adult toys was only modeled for adults and teenagers. Object mouthing is not commonly observed behavior in adults and teens, and as such there are not standard values for mouthing surface area. Although mouthing is uncommon for adults and teenagers, EPA assessed this potential behavior for adult toys only to consider associated exposures for selected individuals who may exhibit this behavior. The Agency did not identify adult toys use information with regards to surface area. To determine a reasonable value for mouthing surface area for adults and teens, EPA identified two studies that reported the surface area of the entire oral cavity in adults (Assy et al., 2020; Collins and Dawes, 1987). The mean surface area reported in Collins et al. (1987) was 215 cm^2, and the mean value reported in Assy et al. (2020) was 173 cm^2. Based on these data, EPA assumes approximately 200 cm^2 is a reasonable estimate for the total surface area in the oral cavity. However, this value accounts for all surface area—including teeth, gums, the ventral surface of the tongue, and mouth floor—which is a significant overestimation of surface area which would be in contact with an object. As such, it was assumed that 50 percent of the total surface area might reasonably represent mouthing surface area, and a value of 100 cm^2 was used for this parameter. This corresponds approximately with a one-ended cylinder having a radius of 2 cm and length of 7 cm. This value is similar, though slightly lower than the value of 125 cm^2 used for adult toy mouthing area in an European Chemicals Agency assessment (ECHA, 2013).

Mouthing Duration

Mouthing durations were obtained from EPA' *Exposure Factors Handbook* Table 4-23 (U.S. EPA, 2011c), which provides mean mouthing durations for children between 1 month and 5 years of age, broken down by age groups expected to be behaviorally similar. Values are provided for toys, pacifiers, fingers, and other objects. For this assessment, values for toys were used for legacy and new children's toys. Values for other object were used for all other items assessed for mouthing by children (*i.e.*, synthetic leather furniture). The data provided in the Handbook were broken down into more age groups than CEM. For example, it provides different mouthing durations for infants 12 to 15, 15 to 18, 18 to 21, and 21 to 24 months of age; CEM, in contrast, has only one age group for infants under 1 year of age.

To determine the mouthing duration in CEM, all relevant data in the *Exposure Factors Handbook* table (U.S. EPA, 2011b) were considered together. The minimum value by item type within each age group was used in the low exposure scenario, maximum value was used in the high exposure scenario, and the mean value (average across the age groups provided in the Handbook) was used in the medium exposure scenario as shown in Table 2-7. For mouthing of adult toys, values of 60, 30, and 15 minutes per day were used in the high, medium, and low exposure scenarios, respectively. As there were no available data for these values, they were chosen to encompass the range of expected mouthing durations based on professional judgment.

Table 2-7. Mouthing Durations for Children for Toys and Other Objects

	Estimated Mean Daily Mouthing Duration Values from Table 4-23 in *Exposure Factors Handbook* (minutes/day)				**Mouthing Durations for CEM Age Groups (minutes/day)**		
Item Mouthed	Reported Age Group				CEM Age Group: Infants <1 Year		
	1–3 Months	3–6 Months	6–9 Months	9–12 Months	High Exposure Scenario	Med. Exposure Scenario	Low Exposure Scenario
Toy	1.0	28.3	39.2	23.07	39.2	22.9	1.0
Other Object	5.2	12.5	24.5	16.42	24.5	14.7	5.2
Item Mouthed	Reported Age Group				CEM Age Group: Infants 1–2 Years		
	12–15 Months	15–18 Months	18–21 Months	21–24 Months	High Exposure Scenario	Med. Exposure Scenario	Low Exposure Scenario
Toy	15.3	16.6	11.1	15.8	16.6	14.7	11.1
Other Object	12.0	23.0	19.8	12.9	23.0	16.9	12.0
Item Mouthed	Reported Age Group				CEM Age Group: Small Child 3–5 Yars		
	2 Years	3 Years	4 Years	5 Years	High Exposure Scenario	Med. Exposure Scenario	Low Exposure Scenario
Toy	12.4	11.6	3.2	1.9	12.4	7.3	1.9
Other Object	21.8	15.3	10.7	10.0	21.8	14.4	10.0

2.2.3.2 Key Parameters for Liquid and Paste Products Modeled in CEM

CEM models for liquid and paste products only evaluated exposure by inhalation. Higher concentrations of DBP in air result in increased inhalation exposure. This may occur due to product formulation or use patterns that allow for higher emissions of DBP to air and/or environment specific characteristics such as smaller room volume and lower ventilation rates. Key parameters that control DBP emission rates from products in CEM 3.2 Models are weight fraction of DBP in the formulation, duration of product use, mass of product used, and frequency of use. Any increase in these parameters results in higher chemical exposure from product use.

CEM default values for key parameters for exposure modeling including product mass used, duration of use, and frequency of use were not available for the specific products identified with DBP content. As such, values for these parameters were based on professional judgment, which incorporated information from product labels and technical specifications as well as information obtained from an informal survey of customer reviews on e-commerce sites. This information was synthesized to better understand how consumers use these products and professional judgment was applied to develop specific values expected to capture a realistic range of values for each parameter. Product densities were taken from product specific technical specifications and SDSs, when possible. In instances where no data were available for a product type a density obtained for a similar product was used as a proxy. A detailed

description of derivations of key parameter values used in CEM 3.2 Models for liquid and paste products is provided below, and a summary of values be found in Table 2-8. Note that articles not modeled for inhalation exposure are not included in the table.

Mass of Product Used

Several products were identified that may be used in a wide variety of DIY home and auto improvement and repair projects, see Section 2.1.2. For these products, the mass of product applied in each scenario was based on the reasonable assumption that the volume in which products are sold is adequate for the tasks they are intended for. Mass of product used inputs was based on a survey of consumer available products fitting the COU description on manufacturers websites, see DBP Product Review tab (links and products available) in *Draft Risk Evaluation for Dibutyl Phthalate (DBP) - Supplemental Information File: Consumer Exposure Analysis* (U.S. EPA, 2025a). This section summarizes the identified information for each product. Auto adhesives were sold in 1.7 or 7.6 fluid oz containers, and coatings used for sealing and refinishing outdoor surfaces were available in 1- and 5-gallon cans. For these products, the high exposure scenario assumed that the entire container with the larger volume is used, reflecting scenarios where a large project or extensive application is undertaken. The low exposure scenario assumed that the entire container with the smaller volume is used, representing more common or average usage for routine maintenance or smaller projects. The medium exposure scenario used the average of the two values.

Metal coating products were available only in a single size (32 fluid oz). For these products, the high exposure scenario for this product assumed that the entire mass of the product container is used, medium exposure scenario assumed half the container's mass was used, and low exposure scenarios assumed a quarter of the container's mass was used, corresponding to minimal use for minor repairs or touch-ups. This approach is consistent with observations of consumer reviews for individual products on vendor websites, which indicated diverse usage patterns among consumers including small, medium, and large projects.

For floor refinishing products, consumer reviews and technical specifications did not indicate that these products are often used for small repair or patching projects. A more specific scenario was developed in which a total of four rooms were assumed to be refinished. Each room was assumed to be 50 m^3 (CEM default value for living room), with a square footage of 222 ft^2. Technical specifications for these products indicated that each gallon of product would cover between 400 to 700 ft^2 per gallon, depending upon floor conditions, and application of three coats was recommended. This range of coverage was used to estimate low and high values for product mass used and a value of 500 ft^2 per gallon was used to estimate a medium value for product mass used per coat of product. Based on this information, the total mass of product used in each room (assuming three coats of product) were 3,755, 5,256, and 6,571 grams for the low, medium, and high exposure scenarios, respectively.

For home cleaning products, values for mass of product used were derived from default values for similar products in CEM. Tub and tile spray used default values from the All Purpose Spray Cleaner Scenario and wax and polish products used default values from the All Purpose Wax and Polishes Scenario.

Duration of Use

For sealing and refinishing sprays for outdoor environments, large projects could be a full day of work, while smaller projects may be accomplished more quickly, so duration of use for high, medium, and low exposure scenarios were assumed to be 480, 240, and 120 minutes. Automotive adhesives, construction adhesives, and metal coating products are expected to be used in comparatively smaller scale projects

and were thus modeled at use durations of 120, 60, and 30 minute. For indoor floor refinishing products, an informal survey of public forums dedicated to DIY home renovation projects indicated that most consumers spend between 30 minutes and 1 hour applying each coat when refinishing floors, see DBP Product Review tab in U.S. EPA (2025a). Based on this information the total time to apply three coats of these products was estimated to be 90, 120, and 270 minutes in low, medium, and high scenarios, respectively.

For home cleaning products, values for duration of use were derived from default values for similar products in CEM. Tub and tile spray used default values from the All Purpose Spray Cleaner Scenario and wax and polish products used default values from the All Purpose Wax and Polishes scenario.

Frequency of Use

The frequency of use input is used in the calculation of acute and chronic exposure durations. Acute exposures are for an exposure duration of one day and chronic exposures are for an exposure duration of 1 year. For sealing and refinishing sprays for outdoor environments, floor refinishing products, automotive adhesives, and construction adhesives; given the significant work required to prepare and clean up after use as well as the relatively niche use, frequency of use of these products is not anticipated to be routine for consumers. For indoor floor refinishing products, each room was assumed to be finished in a single day, for a total of 4 days per year. All other products listed above are assumed to be used for a single project each year, which may take 2 days to complete. For metal coating products, daily use was not considered likely, but the product could reasonably be used weekly for hobby projects or a variety of small projects. Therefore, this product was modeled at a use frequency of 52 times per year. Tub and tile cleaner and wax and polish products were also modeled at a frequency of 52 times per year under the assumption that they may be used in weekly cleaning activities. For all liquid and paste products, acute frequency was modeled as one use per day.

Environmental Parameters

The room of use selected for modeling affects the time occupants spend in the environment while products are actively emitting DBP, the total volume of air in the room, and ventilation rates. Default values are provided in CEM for use environment and ventilation rates in each room, but these may be modified by the user. Time spent in each use environment is defined by activity patterns as described in Section 2.2 and cannot be modified for individual environments within CEM. As such, it is sometimes required to select an environment of use based on the activity pattern required and modify the environmental parameters to reflect conditions in the home area in which a product is expected to be used.

In this assessment, the majority of the products modeled used CEM defaults for all parameters in the specified room of use. However, for indoor floor refinishing products, the garage environment was selected as CEM activity patterns do not include any time in this room. This was chosen to reflect the fact that occupants are not expected to spend time in rooms with recently refinished floors outside of time spent actively applying the products. For this model, room volume and ventilation rates were changed from CEM default values for garage to CEM default values for living room as shown in Table 2-8.

Table 2-8. Summary of Key Parameters for Products Modeled in CEM 3.2

Product	Exposure Scenario Level	Weight Fraction [a]	Density (g/cm^3) [b]	Duration of Use (min) [c]	Product Mass Used (g) [d]	Chronic Freq. of Use (year^{-1})	Acute Freq. of Use (day^{-1})	Use Environ. Volume (m^3) [e]	Air Exchange Rate, Zone 1 and Zone 2 (hr^{-1}) [f]	Interzone Ventilation Rate (m^3/h) [f]
Automotive adhesives	H	0.3	1.78	120	400	2	1	Garage; 90	0.45	109
	M	0.081833		60	245					
	L	0.01		30	90					
Metal coatings	H	0.1	1.51	120	1,427	52	1	Garage; 90	0.45	109
	M	0.04		60	713					
	L	0.01		30	357					
Indoor floor refinishing products	H	0.02	1.04	270	6,571	4	1	Garage; 50	0.45	109
	M	0.015		180	5,256					
	L	0.01		90	3,755					
Sealing and refinishing sprays (outdoor use)	H	0.1	1.37	480	26,003	2	1	Outside; 492	0.45	1.0E−30
	M	0.016688		240	15,602					
	L	0.0005		120	5,201					
Spray cleaner	H	0.0001	1.00	30	60	52	1	Bathroom; 15	0.45	107
	M	0.0001		15	30					
	L	0.0001		5	10					
Waxes and polishes	H	0.001	1.02	60	80	52	1	Living Room; 50	0.45	109
	M	0.001		30	50					
	L	0.001		15	30					

[a] See Section 2.1.2. High intensity use value is the reported range maximum, the low intensity use value is the reported range minimum, and the medium intensity use value is the mean from the reported maximum and low.
[b] Used product SDS reported density value, see Section 2.1.2.
[c] Professional judgment based on product use descriptions, available in DBP Product Review tab in U.S. EPA (2025a).
[d] Based on product use descriptions, available in DBP Product Review tab in U.S. EPA (2025a).
[e] Use environment was determined based on product manufacturer use description.
[f] CEM default. For all scenarios, the near-field modeling option was selected to account for a small personal breathing zone around the user during product use in which concentrations are higher, rather than employing a single well-mixed room. A near-field volume of 1 m^3 was selected.

2.3 Dermal Modeling Approach

This section summarizes the available dermal absorption data related to DBP, the interpretation of the dermal absorption data, and dermal absorption modeling efforts, while uncertainties associated with dermal absorption estimation in Section 4. While inhalation and ingestion pathways were modeled using CEM (Section 2.2), dermal modeling for liquid and solid products was done using the approach described below. Dermal data were sufficient to characterize consumer dermal exposures to liquids or formulations containing DBP (Section 2.3.2), but not sufficient to estimate dermal exposures to solids or articles containing DBP. Therefore, the modeling described in Section 2.3.1 was used to estimate dermal exposures to solids or articles containing DBP. For solid products, EPA used the steady-state permeability coefficient equations defined within the CEM model in a computational approach that bypassed the need for certain inputs required by CEM, like weight fractions and migration rates. Dermal exposures to vapors are not expected to be significant due to the extremely low volatility of DBP (Henry's Law constant is 1.81×10^{-6} atm·m^3/mol at 25 °C, see *Draft Physical Chemistry and Fate and Transport Assessment for Dibutyl Phthalate (DBP)* TSD (U.S. EPA, 2024a)), and therefore, are not included in the dermal exposure assessment of DBP.

For liquid products, the concentration of DBP often exceeds its saturation concentration because DBP molecules form weak chemical bonds with polymer chains in the product/article, which favors migration out of the polymer. During direct dermal contact DBP can migrate to the aqueous phase available in the skin surface or be weakly bound to the polymer. The fraction of DBP associated with polymer chains is less likely to contribute to dermal exposure as compared to the aqueous fraction of DBP because the chemical is strongly hydrophobic. As such, use of the CEM model for dermal absorption, which relies on total concentration rather than aqueous saturation concentration would greatly overestimate exposure to DBP in liquid chemicals.

For solid articles, as there was no empirical data available, EPA used a theoretical framework based on physical and chemical properties of DBP for all solid items except tire crumb rubber. For tire crumb rubber, the method described below was not used as the surface area in contact with the material could not be estimated with confidence based on available data. A detailed description of dermal uptake modeling for DBP from tire crumb rubber is described in detail in Section 2.5.

2.3.1 Dermal Absorption Data

Dermal absorption data related to DBP were identified in the literature. EPA identified six studies directly related to the dermal absorption of DBP. Of the six available studies, the Agency identified one study that was most reflective of DBP exposure from consumer liquid products and formulations (Doan et al., 2010):

- Recent studies were preferred that used modern dermal testing techniques and guidelines for *in vivo* and *in vitro* dermal absorption studies (*i.e.*, OECD Guideline 427 (OECD, 2004a) and Guideline 428 (OECD, 2004b)).
- Studies of human skin were preferred over animal models, and when studies with human skin were not suitable (see other criteria), studies of guinea pig skin were preferred over rat studies. Guinea pig skin absorption is closer to human skin than rats, per OECD 2004a).
- Studies of split skin thickness were preferred over studies of full thickness. Generally, studies should provide information on dermatoming methods and ideally provide a value for thickness in accordance with OECD guideline 428 (OECD, 2004b), which recommends a range of 400 to 800 µm or less than 1 mm.

- *In vivo* or freshly excised (non-frozen) skin studies were preferred, if there was not a significant delay between skin sample retrieval and assay initiation.
- Studies using an aqueous vehicle type were preferred over neat chemical studies as there is greater relevance to consumer product formulations and subsequent exposure, and due to greater uncertainties from neat chemical resulting in lower absorptions than formulations that may enhance dermal absorption.
- Studies with exposure times that are relevant or closer to dermal durations used in the consumer exposure assessment were preferred, see Section 2.3.4.
- Studies with reported sample temperatures that represent human body temperature, in a humidity-controlled environment were preferred.

Doan et al. (2010) conducted *in vivo* and *ex vivo* experiments in female hairless guinea pigs to compare absorption measurements using the same dose of DBP. Compared to other dermal studies, skin samples used in the Doan et al. (2010) study were the most relevant and appropriate as they were exposed to a formulation of 7 percent oil-in-water emulsion, which was preferable over neat chemical. In the *ex vivo* experiments, skin was excised from the animals (anatomical site of the tissue collections were not specified) and radiolabeled DBP (1 mg/m^2) was applied to a split thickness skin preparation (200 µm) for 24 or 72 hours. Absorption was measured every 6 hours in a flow-through chamber. The test system was un-occluded, and skin was washed prior to application. Although certain aspects of the experiment were not reported, overall, the study complies with OECD Guideline 428 (OECD, 2004b). That study was given a medium quality rating. A total of 56.3 percent of the administered dose was absorbed; the percent total recovery was 96.3 percent of the administered dose.

In the *in vivo* experiment, female hairless guinea pigs were given a single dermal application via covered patch (3 × 3 cm^2 area; 9 cm^2) of an oil-in-water emulsion containing 1 mg/cm^2 DBP. The chemical was applied to the mid-scapular region of the guinea pig back, although it is unclear if this represents 10 percent of the animal body surface. The *in vivo* dermal absorption of DBP was estimated to be approximately 62 percent of the applied dose after 24 hours The percent total recovery was 92.9 percent after 24 hours. Total penetration was reported to be 65.4 percent and included total systemic absorption plus skin absorption, and recovery of materials in skin around the dosing site, which is in agreement with the 24-hour *ex vivo* experiment findings. The outcomes assessment method mostly agreed with guideline OECD 427 (OECD, 2004a).

2.3.2 Flux-Limited Dermal Absorption for Liquids

Using the Doan (2010) estimate of 56.3 percent absorption of 1 mg/cm^2 of DBP over 1 day (24 hours), the steady-state flux of neat DBP is estimated as 2.35×10^{-2} mg/cm^2/h. EPA assumed the steady-state flux is equal to the average flux.

The DBP estimated steady-state fluxes, based on the results of Doan (2010), are representative of exposures to liquid materials only. Dermal exposures to liquids containing DBP are described in this section. Regarding dermal exposures to solids containing DBP, there were no available data and dermal exposures to solids are modeled as described in Section 2.3.3.

EPA selects Doan et al. (2010) as a representative study for dermal absorption to liquids. Doan et al. (2010) is a relatively recent (2010) *in vivo* study in guinea pigs, and it uses a formulation consisting of 7 percent oil-in-water, which is preferred over studies that use neat chemicals. Two other older *in vivo* studies were considered: Elsisi et al. (1989) and Janjua et al. (2008). Elsisi et al. (1989) provided data on the dermal absorption of DBP by measuring the percentage of dose excreted in the urine and feces of rats daily over a 7-day exposure. EPA considers more recent data (2010 vs. 1989) and study duration (24

hours vs. 7 days) from Doan et al. (2010) to be more appropriate and representative to TSCA dermal scenarios. The third *in vivo* study, Janjua et al. (2008), applied cream with a 2 percent DBP formulation to the skin of human participants daily for 5 days. This study measured the metabolite of DBP—monobutyl phthalate (MBP)—in urine; however, this study had significant limitations including a very large inter-individual variability in absorption values and daily variations in values for the same individual. Two additional *ex vivo* studies, Scott et al. (1987) and Sugino et al. (2017), noted DBP to be more readily absorbed in rat skin vs. human skin. Ultimately, EPA prefers the use of *in vivo* studies (Doan et al., 2010) versus *ex vivo* studies, when available.

2.3.3 Flux-Limited Dermal Absorption for Solids

The dermal absorption of DBP was estimated based on the flux of material rather than percent absorption. For cases of dermal absorption of DBP from a solid matrix, EPA assumes that DBP first migrates from the solid matrix to a thin layer of moisture on the skin surface. Therefore, absorption of DBP from solid matrices is considered limited by aqueous solubility and is estimated using an aqueous absorption model as described below.

The first step in modeling dermal absorption through aqueous media is to estimate the steady-state permeability coefficient, K_p (cm/h). EPA utilized the CEM K_p equation (U.S. EPA, 2023) to estimate the steady-state aqueous permeability coefficient of DBP as 0.017 cm/h. Next, EPA relied on Equation 3.2 from the *Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual, (Part E: Supplemental Guidance for Dermal Risk Assessment)* (U.S. EPA, 2004), which characterizes dermal uptake (through and into skin) for aqueous organic compounds. Specifically, Equation 3.2 from U.S. EPA (2004), also shown in Equation 2-1 below, was used to estimate the dermally absorbed dose (DA_{event}, mg/cm^2) for an absorption event occurring over a defined duration (t_{abs}).

Equation 2-1. Dermal Absorption Dose During Absorption Event

$$DA_{event} = 2 \times FA \times K_p \times S_W \times \sqrt{\frac{6 \times t_{lag} \times t_{abs}}{\pi}}$$

Where:

DA_{event}	=	Dermally absorbed dose during absorption event t_{abs} (mg/cm^2)
FA	=	Effect of stratum corneum on quantity absorbed = 0.9 (see Exhibit A-5 of U.S. EPA (2004)) and confirmed by Doan (2010) for 0.87
K_p	=	Permeability coefficient = 0.017 cm/h (calculated using CEM (U.S. EPA, 2023))
S_w	=	Water solubility = 11.2 mg/L [see (U.S. EPA, 2024a)]
t_{lag}	=	$0.105*10^{0.0056MW} = 0.105*10^{0.0056*278.35} = 3.80$ hours (calculated from A.4 of U.S. EPA (2004))
t_{abs}	=	Duration of absorption event (hours)

By dividing the dermally absorbed dose (DA_{event}) by the duration of absorption (t_{abs}), the resulting expression yields the average absorptive flux. The dermal consumer exposure assessment scenarios consider a range of exposure durations that capture low, medium, and high intensity use scenarios and are described for each COU and product/article scenario in Section 2.3.4. Figure 2-1 illustrates the relationship between the average absorptive flux and the absorption time for DBP.

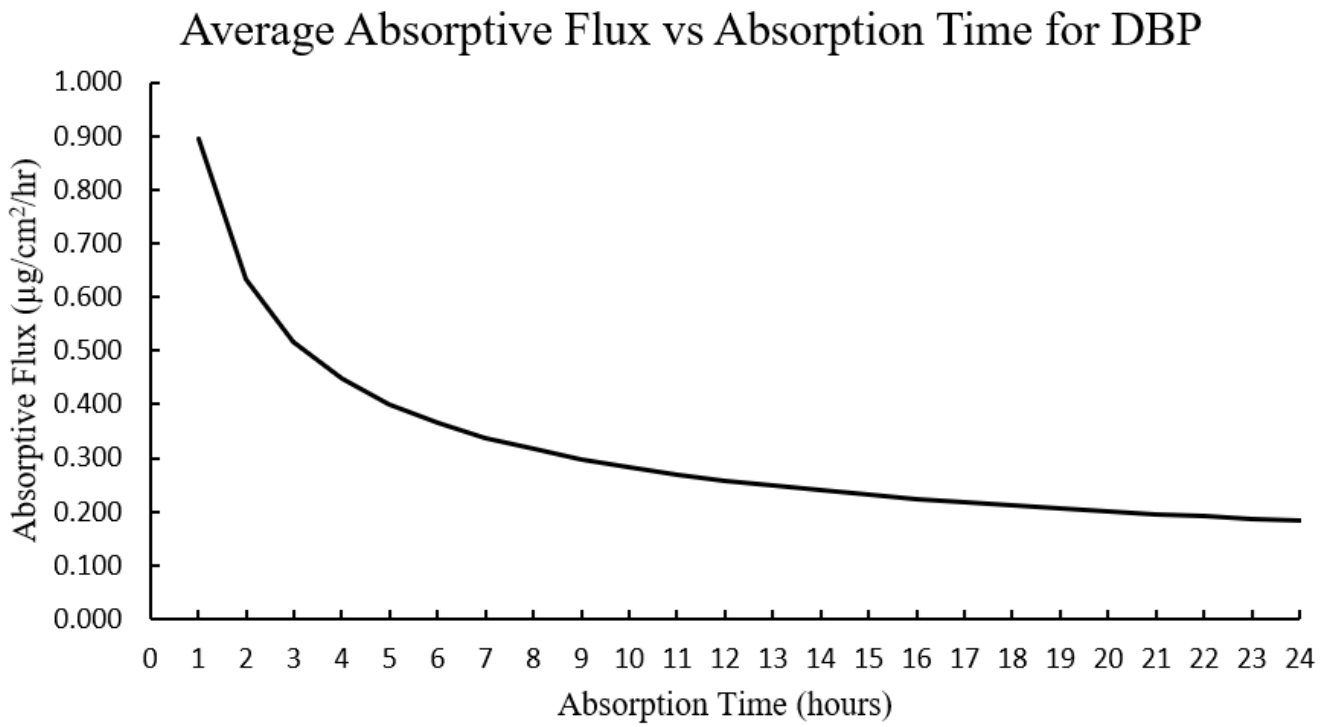

Figure 2-1. DBP Average Absorptive Flux vs. Absorption Time

Using Equation 3.2 from the *Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual, (Part E: Supplemental Guidance for Dermal Risk Assessment)* (U.S. EPA, 2004) which characterizes dermal uptake (through and into skin) for aqueous organic compounds, EPA estimated the steady-state flux of DBP to range from 0.89 to 0.18 µg/cm^2/h at 1 to 24 hours. EPA assumed the steady-state flux is equal to the average flux.

2.3.4 Modeling Inputs and Parameterization

Key parameters for the dermal model include duration of dermal contact, frequency of dermal contact, total contact area, and dermal flux; an increase in any of these parameters results in an increase in exposure. Key parameter values used in models are shown in Table 2-9. For contact area, professional judgment, based on product use descriptions from manufacturers and article typical use, was applied to determine reasonable contact areas for each product or article. For items that were considered to have a high level of uncertainty or potential variability, different surface areas were assumed in high, medium, and low exposure scenarios. In addition to considering typical product and article use, EPA used conservative contact area options with the possibility of further refining the scenario should risk be identified in Section 4 of the *Draft Risk Evaluation for Dibutyl Phthalate (DBP)* (U.S. EPA, 2025d). The subsections under Table 2-9 provide details on assumptions used to derive other key parameters. Calculations, sources, input parameters and results are also available in *Draft Risk Evaluation for Dibutyl Phthalate (DBP) - Supplemental Information File: Consumer Exposure Analysis* (U.S. EPA, 2025a).

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Product	Scenario	Duration of Contact (min)	Frequency of Contact (year $^{-1}$)	Frequency of Contact (day^{-1})	Dermal Flux (mg/cm^2/hour)	Contact Area
Adhesive for small repairs	High	60	52	1	2.35E−02	10% of Hands (some fingers)
	Med	30			2.35E−02	
	Low	15			2.35E−02	
Adult toys	High	60	365	1	9.23E−04	Inside of one hand (palms, fingers)
	Med	30			1.31E−03	
	Low	15			1.85E−03	
Automotive adhesives	High	120	2	1	2.35E−02	Inside of two hands (palms, fingers)
	Med	60			2.35E−02	Inside of one hand (palms, fingers)
	Low	30			2.35E−02	10% of Hands (some fingers)
Car mats	High	60	52	1	9.23E−04	10% of Hands (some fingers)
	Med	30			1.31E−03	
	Low	15			1.85E−03	
Children's toys (legacy)	High	137	365	1	6.11E−04	Inside of two hands (palms, fingers)
	Med	88			7.62E−04	
	Low	24			1.46E−03	
Children's toys (new)	High	137	365	1	6.11E−04	Inside of two hands (palms, fingers)
	Med	88			7.62E−04	
	Low	24			1.46E−03	
Construction adhesives	High	120	2	1	2.35E−02	Inside of two hands (palms, fingers)
	Med	60			2.35E−02	Inside of one hand (palms, fingers)
	Low	30			2.35E−02	10% of Hands (some fingers)
Footwear	High	480	365	1	3.26E−04	Inside of two hands (palms, fingers)
	Med	240			4.62E−04	
	Low	120			6.53E−04	
Metal coatings	High	120	52	1	2.35E−02	Inside of two hands (palms, fingers)
	Med	60			2.35E−02	Inside of one hand (palms, fingers)
	Low	30			2.35E−02	10% of Hands (some fingers)
Indoor floor refinishing products	High	270	4	1	2.35E−02	10% of Hands (some fingers)
	Med	180			2.35E−02	
	Low	90			2.35E−02	
Sealing and refinishing	High	480	2	1	2.35E−02	10% of Hands (some fingers)
	Med	240			2.35E−02	

Product	Scenario	Duration of Contact (min)	Frequency of Contact (year $^{-1}$)	Frequency of Contact (day^{-1})	Dermal Flux (mg/cm^2/hour)	Contact Area
sprays (outdoor use)	Low	120			2.35E−02	
Shower curtains	High	60	365	1	9.23E−04	Inside of one hand (palms, fingers)
	Med	30			1.31E−03	
	Low	15			1.85E−03	
Small articles with semi routine contact	High	120	365	1	6.53E−04	Inside of two hands (palms, fingers)
	Med	60			9.23E−04	Inside of one hand (palms, fingers)
	Low	30			1.31E−03	10% of Hands (some fingers)
Spray cleaner	High	30	52	1	2.35E−02	Inside of two hands (palms, fingers)
	Med	15			2.35E−02	Inside of one hand (palms, fingers)
	Low	5			2.35E−02	10% of Hands (some fingers)
Synthetic leather clothing	High	480	52	1	3.26E−04	50% of Entire Body Surface Area
	Med	240			4.62E−04	25% of Face, Hands, and Arms
	Low	120			6.53E−04	Inside of two hands (palms, fingers)
Synthetic leather furniture	High	480	365	1	3.26E−04	50% of Entire Body Surface Area
	Med	240			4.62E−04	25% of Face, Hands, and Arms
	Low	120			6.53E−04	Inside of two hands (palms, fingers)
Vinyl flooring	High	120	365	1	6.53E−04	Inside of one hand (palms, fingers)
	Med	60			9.23E−04	
	Low	30			1.31E−03	
Wallpaper (in place)	High	60	365	1	3.26E−04	Inside of one hand (palms, fingers)
	Med	30			4.62E−04	
	Low	15			6.53E−04	
Wallpaper (installation)	High	480	1	1	3.26E−04	Inside of two hands (palms, fingers)
	Med	240			4.62E−04	
	Low	120			6.53E−04	
Waxes and polishes	High	60	52	1	2.35E−02	Inside of two hands (palms, fingers)
	Med	30			2.35E−02	Inside of one hand (palms, fingers)
	Low	15			2.35E−02	10% of Hands (some fingers)

Duration of Use/Article Contact Time

For liquid and paste products, it was assumed that contact with the product occurs at the beginning of

the period of use and the product is not washed off until use is complete. As such, the duration of dermal contact for these products is equal to the duration of use applied in CEM modeling for products as described in Section 2.2.3.2. For products not modeled in CEM (concrete adhesive) consumer reviews indicated that the product was used for outdoor projects of moderate size as well as small repairs. As such, duration of use was assumed to be 120, 60, and 30 minutes for large, medium, and small projects.

For articles, which do not use duration of use as an input in CEM, professional judgment was used to select the duration of use/article contact for the low, medium, and high exposure scenario levels. For flooring products (carpet tiles and vinyl flooring), values for dermal contact time are based on EPA's Standard Operating Procedures for Residential Pesticide Exposure Assessment for the high exposure level (2 hour; time spent on floor surfaces) (U.S. EPA, 2012), ConsExpo for the medium exposure level (1 hour; time a child spends crawling on treated floor), and professional judgment for the low exposure level (0.5 hour). For articles used in large home DIY projects (wallpaper installation) it was assumed that a large project could be a full day of work, while smaller projects may be accomplished more quickly, so contact time for high, medium, and low exposure scenarios were assumed to be 480, 240, and 120 minutes. Similarly, clothing, footwear, and indoor furniture have the potential for long durations of dermal contact but may also be used for shorter periods and were thus modeled at 480, 240, and 120 minutes.

For synthetic leather furniture the input parameters in the high intensity use scenario represent either mostly naked or an underdressed (50% of entire body) person laying or seating on the furniture for 8 hours (480 minutes), which may be an overestimated extreme scenario for all lifestages. The high, medium, and low intensity use scenario for infants are likely a misuse because infants should not be set on furniture for extended periods of time; therefore, dermal exposure to infants from synthetic leather furniture is not expected. EPA has low confidence in using toddler lifestages 8- and 4-hour contact duration as it may be an extreme consideration and recommends using the low intensity use contact duration for toddlers. The medium intensity use scenario considers 25 percent of face, hands, and arms surface in contact with the furniture for 4 hours. The medium intensity use scenario represents a dressed person either seating or laying on the furniture, which EPA assumes to be a more representative scenario for preschoolers and older lifestages and the low intensity use scenario contact duration can be used for toddlers' upper-bound estimate.

For the synthetic leather clothing, EPA assumed that these items would be in contact with the skin for 50 percent of entire body surface area for the high intensity use scenario and 25 percent of face, hands, and arms for the medium-intensity use scenario. There is uncertainty in assuming large skin contact for synthetic leather in the high-intensity use scenario. The use of 50 percent of entire body surface equates to contact with tops and bottom items of clothing. The use of synthetic leather tops and bottoms is possible; however, EPA is uncertain in the widespread use of these clothing items. The medium-intensity use scenario for synthetic leather clothing considers 25 percent of face, hands, and arms surface in contact with the clothing item and for 4 hours total. The medium-intensity use synthetic leather scenario represents clothing items similar to synthetic leather coats and accessories. EPA has a robust confidence that the medium-intensity use scenario inputs accurately represent expected uses.

Contact durations of 60, 30, and 15 minutes were assigned to articles anticipated to have low durations of contact (car mats, shower curtain, and routine [in-place] contact with wallpaper and specialty wall coverings). To estimate contact time with children's toys, data were obtained from the Children's *Exposure Factors Handbook* Table 16-26 (U.S. EPA (2011b). Reported values for playtime for children under age 15 ranged from 24 min/day to 137 min/day, with a mean value of 88 min/day; these values were used in the low, high, and medium exposure scenarios. The playtime duration used for children

under 15 was also used for children 16 to 20 years due to lack of playtime duration information for this age range, and as a conservative assumption that can be further refined should risk be identified in the risk characterization stage of this assessment; see Section 4 of the *Draft Risk Evaluation for Dibutyl Phthalate (DBP)* (U.S. EPA, 2025c).

In addition to the scenarios for dermal exposure to DBP from specific articles, a scenario was modeled in which consumers may have semi-routine contact with one or more small items containing DBP. A complete list of articles and associated COUs modeled under this scenario is outlined in Section 2.1. While dermal contact with these individual items is expected to be short and/or irregular in occurrence, use of these articles is not well documented, and there is likely to be significant variability in use patterns between individual consumers. However, given the uncertainty around items with DBP content, EPA considers it reasonable to assume that an individual could have significant daily contact with some combination of items and/or with other similar items that have not been measured during monitoring campaigns. As such, articles modeled under this scenario were assumed to have dermal contact times of 120, 60, and 30 minutes per day.

Frequency of Use

For liquid and paste products modeled in CEM, frequency of contact was assumed to be equal to the frequency of use (per year and per day) that was applied in CEM modeling. For products used in potentially large outdoor DIY projects (concrete adhesives), due to significant work required to prepare and clean-up afterwards it was assumed that these projects were carried out over a 2-day period once per year.

For articles, assumptions about frequency of use were made using professional judgment, based on one contact per event duration as a conservative approach. Further refinement is considered at the risk calculation stage, if necessary (see *Draft Risk Evaluation for Dibutyl Phthalate (DBP)* (U.S. EPA, 2025c)). For articles that are expected to be used on a routine basis, such as children's toys, furniture, and shower curtains, use was assumed to be once per day every day. Similarly, for routine contact with household building materials (carpet tiles, vinyl flooring, and wallpaper), contact was assumed to occur on a daily basis. For articles used in large home DIY projects (wallpaper installation), due to significant work required to prepare and clean-up afterwards it was assumed that installation was carried out over a single day once per year. DBP is expected to be present in PU leather garments. These garments are not expected to be worn daily but could reasonably be worn on a routine basis. As such, dermal contact with clothing was modeled as one wear every week. However, children's clothing items reported in the HPCDS database did not provide adequate descriptive data to draw conclusions about the garment type or specific component measured. As such, both footwear components and children's clothing were modeled with daily contact. Car mats were modeled as a single contact event each week, to represent an individual who does a weekly car cleaning.

2.4 Key Parameters for Intermediate Exposures

The intermediate doses were calculated from the average daily dose (ADD in µg/kg-day) CEM output for that product using the same inputs summarized in Table 2-5 for inhalation and Table 2-9 for dermal. EPA used professional judgment based on manufacturer and online product use descriptions to estimate events per day and per month for the calculation of the intermediate dose (see Appendix A.3).

Table 2-10. Short-Term Event per Month and Day Inputs

Product	Events Per Day[a]	Events Per Month[a]
Automotive adhesives	1	2
Construction adhesives	1	2
Sealing and refinishing sprays (indoor use)	1	2
Sealing and refinishing sprays (outdoor use)	1	2
[a] Events per day and month values determined using professional judgment based on manufacturer product description use.		

2.5 Tire Crumb Rubber Modeling

Tire crumb rubber was modeled using a similar approach to a previously published exposure characterization for the material (U.S. EPA, 2024b). This approach models exposure to tire crumb via inhalation, ingestion, and dermal contact. It was peer reviewed at the time of publication and allows for an estimate of dose with the limited data available.

The exposure characterization provides concentrations of SVOCs in air samples obtained from both outdoor (n = 25) and indoor playing fields (n = 15), and a separate document published in conjunction provided measurements of DBP content in tire particles retrieved from the same locations (U.S. EPA, 2019c). Concentrations of DBP in air were not reported in the exposure characterization report. However, DBP concentrations in the tire particles themselves were reported in the associated tire particle characterization document and were very similar to the reported content of DBP. Physical and chemical properties expected to significantly impact chemical transport including molecular weight, octanol air partitioning coefficient, and solubility in water were used to develop estimates for exposure to DBP during sporting events on tire crumb fields as described below. All calculations are provided in *Draft Consumer Exposure Analysis for Dibutyl Phthalate (DBP)* (U.S. EPA, 2025a).

2.5.1 Tire Crumb Inhalation Exposure

Air samples were collected for SVOC analysis without a size-selective particle inlet to allow both vapor- and particle-phase SVOCs to be collected simultaneously. Separate particle- and gas-phase air concentrations were not measured. However, as previously discussed DBP is more likely to be present in the particulate rather than gaseous phase. As such, it is unlikely that inhaled DBP will be fully absorbed after inhalation and the fraction absorbed was estimated to be 0.7. This was the recommended value in the exposure characterization (U.S. EPA, 2024b) and likely represents a health-protective estimate given the slow rate of diffusion through solid media for DBP and low solubility in aqueous fluids, which would limit partitioning to lung fluids. The inhaled dose per event is defined as:

Equation 2-2. Inhalation Dose Per Exposure Event

$$Inhalation\ Event\ Dose = (C_{air}\ x\ R_{inh}\ x\ ET\ x\ ABS)/BW$$

Where:

C_{air} = Concentration of DBP in air (mg/m^3)
R_{inh} = Inhalation rate (m^3/hour)
ET = Exposure time (hours)
ABS = Fraction absorbed (0.7)
BW = Body weight (kg)

Age-stratified inhalation rates during high intensity activity were taken from *Exposure Factors Handbook* Table 6-2 (U.S. EPA, 2011c). Body weight values were the same as those used in CEM.

Exposure time was assumed to be 1 hour for children aged less than 11 years, 3 hours for teens 11 to 16 years, and 2 hours for older teens and adults.

2.5.2 Tire Crumb Dermal Exposure

Dermal exposure to tire crumb was assessed under the assumption of dermal adherence during play and subsequent absorption; the 10th, 50th, and 90th percentile measurements of DBP in tire crumb samples were used in low, medium, and high exposure scenarios. The fraction of DBP absorbed from each event was assumed to be 10 percent as recommended in the exposure characterization (U.S. EPA, 2024b). It is likely that this value somewhat overestimates exposure given that uptake of DBP is expected to be flux limited. However, a flux-based value could not be calculated as there were no data available to estimate total contact area of the particulate matter adhered to skin and the assumption of 10 percent absorption is expected to provide a reasonable, health protective estimate. Dermal dose per exposure event was defined as follows:

Equation 2-3. Inhalation Dose Per Exposure Event

$$Dermal\ Event\ Dose = (C_{solid}\ x\ ADH\ x\ SA\ x\ ABS)/BW$$

Where:

C_{solid} = Concentration of DBP in crumb rubber (mg/g)
Adh = Solids adherence on skin (g/cm^2 -day)
SA = Skin surface area available for contact (cm^2)
ABS = Fraction absorbed (0.1)
BW = Body weight (kg)

Age-specific adherence factors were calculated by estimating the percentage of skin surface area exposed while wearing a typical sports uniform during the summer, multiplying those percentages by the total surface area per body part found in EPA's *Exposure Factors Handbook* (U.S. EPA, 2011b), summing the products and then dividing by the total exposed surface area of the body parts to get a weighted adherence factor (Equation 5-4); this equation can be found in Chapter 7 of the Handbook (U.S. EPA, 2011b). Body part percentages were assumed to be 100 percent of the face, 72.5 percent of the arms, 40 percent of the legs (to account for socks and short pants), and 100 percent of the hands. These values were recommended in the exposure characterization based on empirical observations.

Values for dermal adherence to skin were obtained from (Kissel et al., 1996b). Only values for adherence of solids to skin after playing sporting events on tire crumb fields was used in this assessment; the upper and lower boundaries of the 95 percent confidence interval were used in high and low exposure scenarios, respectively. The geometric mean reported value was used in the medium exposure scenario.

2.5.3 Tire Crumb Ingestion Exposure

The same values of DBP content in solid particles described in Section 2.5.1 were used to estimate exposure by inadvertent ingestion during play. The absorption fraction of 50 percent recommended in the exposure characterization was used (U.S. EPA, 2024b). Ingestion dose per exposure event was then calculated as follows:

Equation 2-4. Ingestion Dose Per Exposure Event

$$Ingestion\ Event\ Dose = (C_{solid}\ x\ R_{ing}\ x\ ET\ x\ ABS)/BW$$

Where:

C_{solid} = Concentration of DBP in crumb rubber (mg/g)
R_{ing} = Ingestion rate (g/day)
ET = Exposure time (day)
ABS = Fraction absorbed (0.5)
BW = Body weight (kg)

Age-stratified ingestion rates were taken from *Exposure Factors Handbook* Table 5-1 (U.S. EPA, 2011b).

2.5.4 Calculation of Acute and Chronic Doses

For all exposure routes, acute and chronic doses were calculated as follows:

Equation 2-5. Chronic Average Daily Dose (CADD)

$$CADD = (Event\ Dose\ x\ Events\ x\ \ EF)/T_A$$

Where:

EF = Exposure frequency (days/year)
$Events$ = Number of exposure events per day ($days^{-1}$)
T_A = Averaging time (years)

Equation 2-6. Acute Dose Rate (ADR)

$$ADR = (Event\ Dose\ x\ Events\ x\ EF)/T_A$$

Where:

EF = Exposure frequency ($days^{-1}$)
$Events$ = Number of exposure events per day ($days^{-1}$)
T_A = Averaging time (days)

For all exposure scenarios, the number of exposure events per day was assumed to be one. For chronic dose calculations, the averaging time was assumed to be one year for all scenarios and the exposure frequency assigned was 78 days per year for children under 11 years, 138 days per year for older children and teens under 16 years, and 138 days per year for older teens and adults. These values were recommended in the exposure characterization document based on empirical observations (U.S. EPA, 2024b).

3 CONSUMER EXPOSURE MODELING RESULTS

This section summarizes the dose estimates from inhalation, ingestion, and dermal exposure to DBP in consumer products and articles. Exposure via the inhalation route occurs from inhalation of DBP gas-phase emissions or when DBP partitions to suspended particulate from installation of solid articles. Exposure via the dermal route occurs from direct contact with products and articles. Exposure via ingestion depends on the product or article use patterns. It can occur via direct mouthing (*i.e.*, directly putting an article in the mouth) or ingestion of suspended and/or settled dust when DBP migrates from a product or article to dust, or partitions from gas-phase to dust.

3.1 Acute Dose Rate Results, Conclusions and Data Patterns

DBP Draft Consumer Risk Calculator (U.S. EPA, 2025a) summarizes the high, medium, and low acute dose rate results from modeling in CEM and outside of CEM (dermal only) for all exposure routes and all lifestages. Products and articles marked with a dash (–) did not have dose results because the product or article was not targeted for that lifestage or exposure route. Dose results applicable to bystanders are highlighted. Bystanders are people that are not in direct use or application of a product but can be exposed to DBP by proximity to the use of the product via inhalation of gas-phase emissions or suspended dust. Some product scenarios were assessed for bystanders for children under 10 years and as users older than 11 years because the products were not targeted for very young children (<10 years). In instances where a lifestage could reasonably be either a product user or bystander, the user scenarios inputs were selected as proximity to the product during use would result in larger exposure doses. The main purpose of *DBP Draft Consumer Risk Calculator* (U.S. EPA, 2025a) is to summarize acute dose rate results, show which products or articles did not have a quantitative result, and which results are used for bystanders. Data patterns are illustrated in figures and descriptions of the patterns by exposure route and population or lifestage are summarized in this section.

Figure 3-1 through Figure 3-7 show acute dose rate data for all products and articles modeled in all lifestages assessed. The figures show ADR estimated from exposure via inhalation, ingestion (aggregate of mouthing, suspended dust ingestion, and settled dust ingestion), and dermal contact. For teens and adults, dermal contact was a strong driver of exposure to DBP, with the dose received being generally higher than or similar to the dose received from exposure via inhalation or ingestion. Among the younger lifestages, this pattern was less clear as these ages were not designated as product users and therefore not modeled for dermal contact with any of the liquid products assessed. However, dermal contact was still a strong driver of exposure among young age groups, with doses received from contact with solid articles generally being roughly equal to or higher than inhalation and ingestion when all were assessed.

The spread of values estimated for each product or article reflects the aggregate effects of variability and uncertainty in key modeling parameters for each item; acute dose rate for some products and articles covers a larger range than others primarily due to a wider distribution of DBP weight fraction values and behavioral factors such as duration of use or contact time, and mass of product used as described in Section 2.2. Key differences in exposures among lifestages include designation as product user or bystander; behavioral differences such as mouthing durations, hand to mouth contact times, and time spent on the floor; and dermal contact expected from touching specific articles, which may not be appropriate for some lifestages. Figures and observations specific to each lifestage are below.

Infants, Toddlers, Preschoolers, and Middle Childhood (Birth to 10 Years)

Figure 3-1 shows all exposure routes for infants less than a year old and toddlers 1 to 2 years old, and Figure 3-2 shows all exposure routes for preschoolers ages 3 to 5 years and middle childhood children

ages 6 to 10 years. Exposure patterns were very similar for products or articles and routes of exposure across these four lifestages. Ingestion route acute dose results in these figures show the sum of all ingestion scenarios, mouthing, suspended dust, and surface dust when applicable for that scenario (see also Table 2-1).

As previously mentioned, the acute dose values of DBP from exposure to the specific liquid and paste consumer products assessed here are driven by inhalation exposure only. For solid articles, behavioral variability was a significant determinant of exposure routes driving exposure. Exposures to articles are driven primarily by dermal and inhalation, except for vinyl flooring for which the ingestion dose ranges from medium to high intensity use were higher than dermal. Dermal ADR values are sometimes higher, for example, furniture textiles, and children's clothing, and in other scenarios inhalation is higher like vinyl flooring, wallpaper in-place, and legacy children's toys.

Dermal is the highest exposure dose followed by inhalation and then ingestion for products used in small amounts, such as adhesives and sealants. For articles, dermal doses can be higher than doses from other routes (*e.g.*, for clothing, carpet tiles, furniture components, shower curtains, and new children's toys) or lower than doses from inhalation (*e.g.*, vinyl flooring and legacy children's toys). In the case of vinyl flooring and legacy children's toys, the higher inhalation dose is due to larger DBP weight fractions than in other articles. Dermal exposure differences among scenarios are driven mainly by the exposure duration, frequency of the contact, and exposed dermal surface area. Dermal dose values for children's clothing and furniture textiles were higher mainly because these scenarios used contact durations longer than the other dermal scenarios. Dermal exposure durations used for furniture textiles and clothing ranged from 2 to 8 hours per event while for other articles the dermal exposure durations ranged from 2 hours to 15 minutes. In addition, furniture textiles and clothing scenarios used larger surface area of skin exposed than for other products and articles, like wallpaper, flooring, small articles, footwear that may have similar contact durations, but less contact skin surface area such as hands, palms, and fingers.

The highest acute dose for these age groups is from inhalation of suspended dust and gas-phase emissions from vinyl flooring, followed by furniture components, adhesives, children's toys, in-place wallpaper, carpet tiles, shower curtains, and car mats. Inhalation doses of adhesives and sealants for these lifestages represent bystander exposures, which is a person in the proximity of someone else using such products. These products inhalation doses are higher than certain articles, like carpet tiles, children's toys, and in-place wallpaper, and lower for vinyl flooring and furniture textiles doses. The differences are driven by DBP weight fractions and total surface area of articles and indoor presence, for example, vinyl flooring and furniture surfaces are much larger than those covered by toys, shower curtains, and smaller or less numerous articles, in addition to also having larger weight fractions.

Ingestion of DBP has the overall lowest doses across scenarios, except for vinyl flooring. For articles assessed for mouthing, such as toys and furniture textiles, exposure from mouthing is expected to have a larger impact on the overall ingestion dose because it is a direct exposure (see Figure 3-3 and Figure 3-4). Mouthing tendencies decrease or cease entirely for children 6 to 10 years; thus, there is no contribution to ingestion doses from mouthing for ages above 6 years. Articles not assessed for mouthing were assessed for ingestion of settled and suspended dust, in which the settled dust exposures tend to be larger than ingestion from suspended dust.

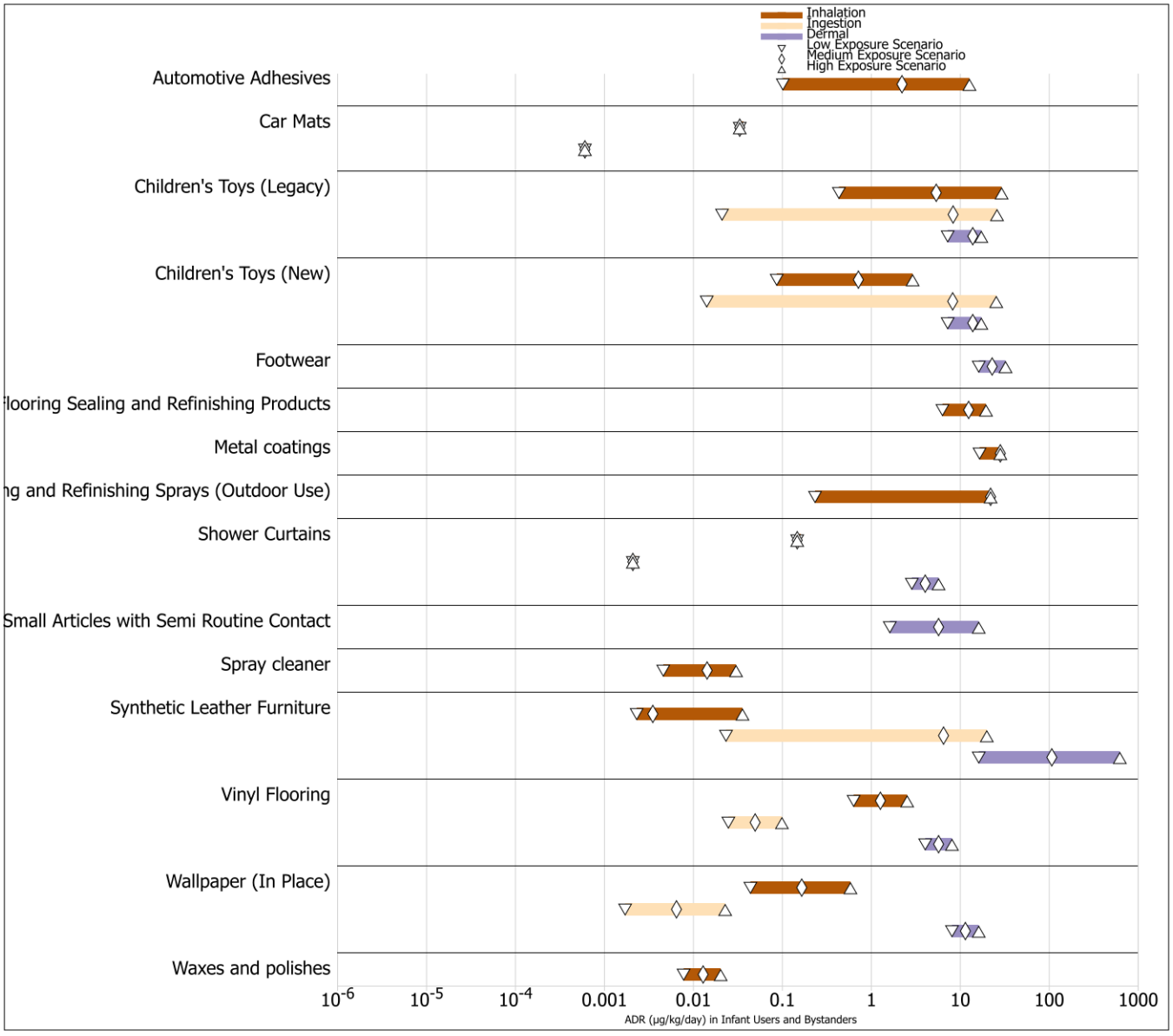

Figure 3-1. Acute Dose Rate for DBP from Ingestion, Inhalation, and Dermal Exposure Routes in Infants (<1 Year) and Toddlers (1–2 Years)

Note: Horizontal axis label is for infants and toddlers. Cutoff labels in order from top to bottom are flooring sealing and refinishing products, sealing and refinishing sprays (outdoor use), and small articles with potential for semi-routine contact. Figure will be fixed in finalization.

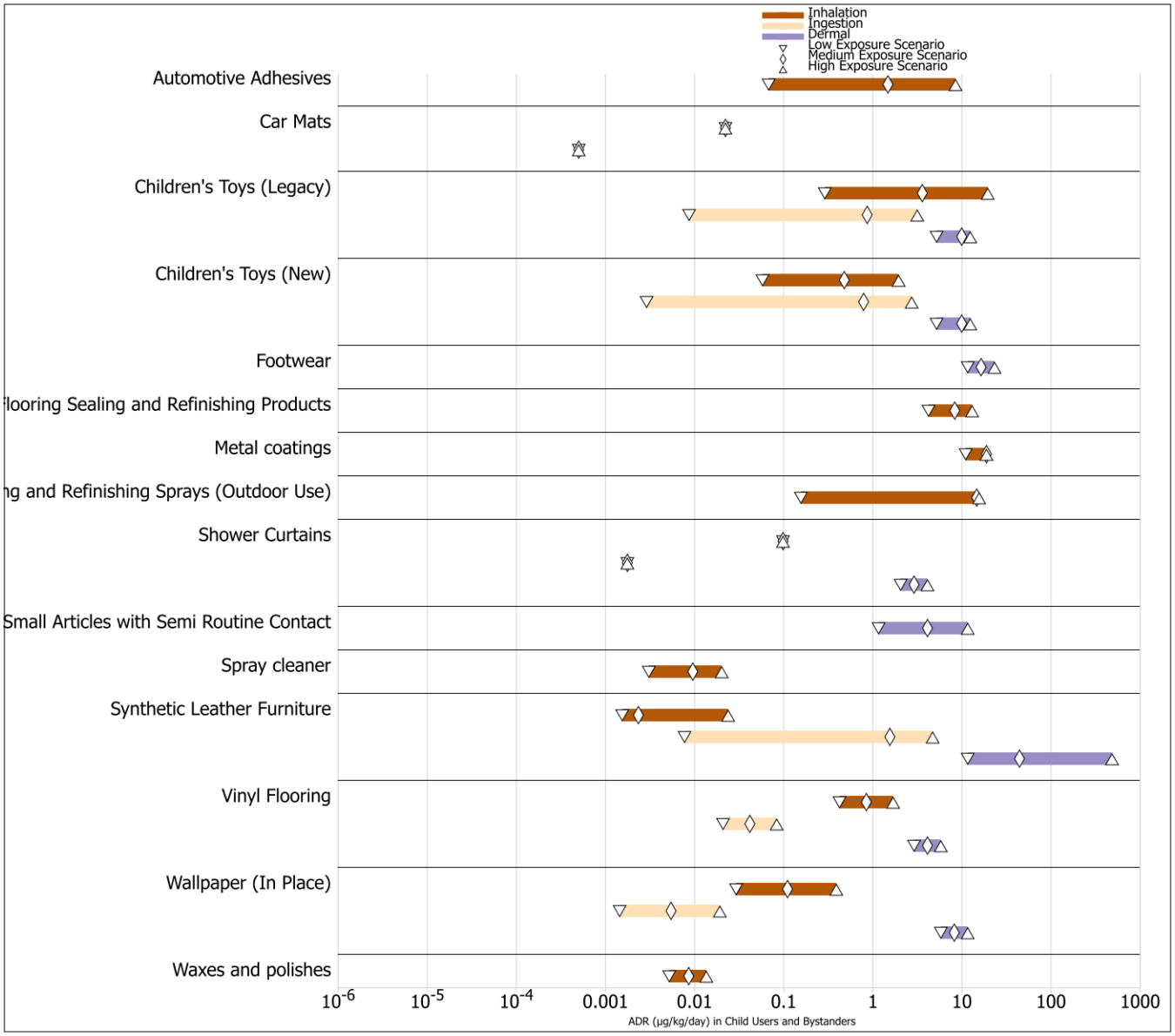

Figure 3-2. Acute Dose Rate of DBP from Ingestion, Inhalation, and Dermal Exposure Routes for Preschoolers (3–5 Years) and Middle Childhood (6–10 Years)

Note: Horizontal axis label is for preschoolers and middle childhood. Cutoff labels in order from top to bottom are flooring sealing and refinishing products, sealing and refinishing sprays (outdoor use), and small articles with potential for semi-routine contact. Figure will be fixed in finalization.

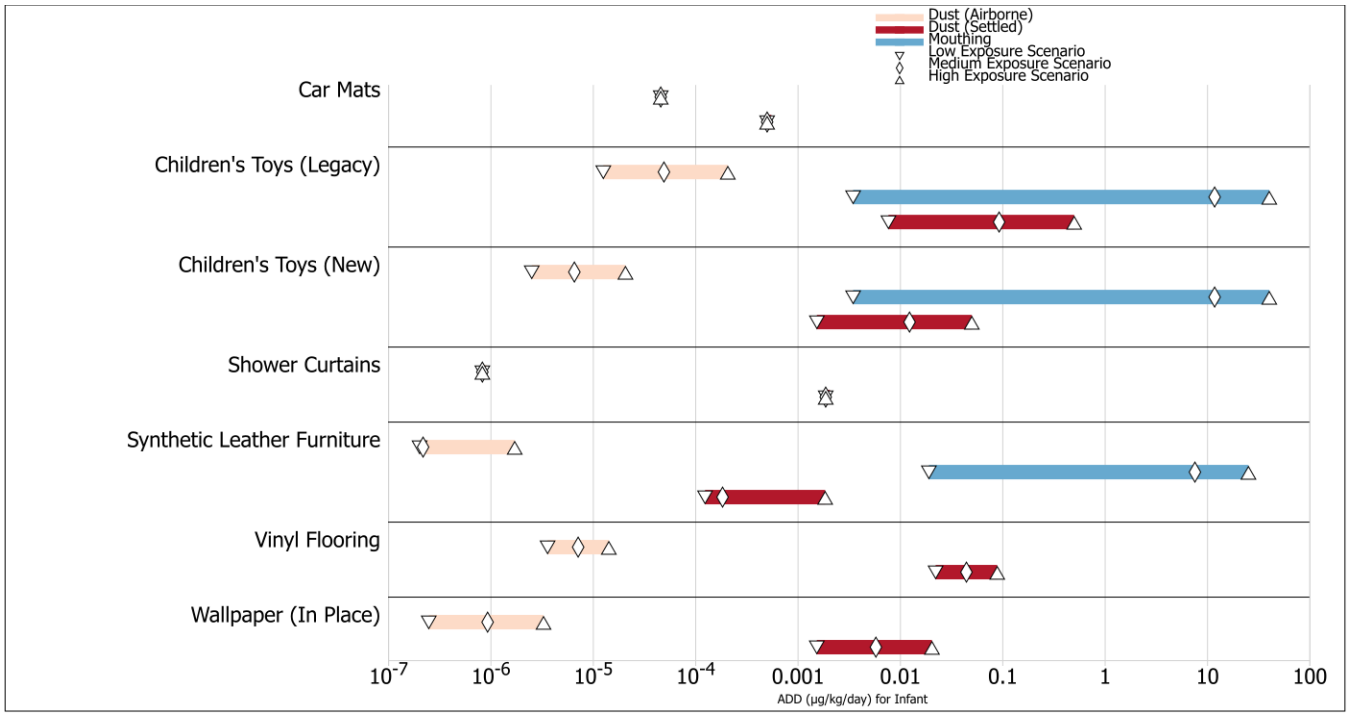

Figure 3-3. Acute Dose Rate of DBP from Suspended and Settled Dust Ingestion and Mouthing for Infants (<1 Year)

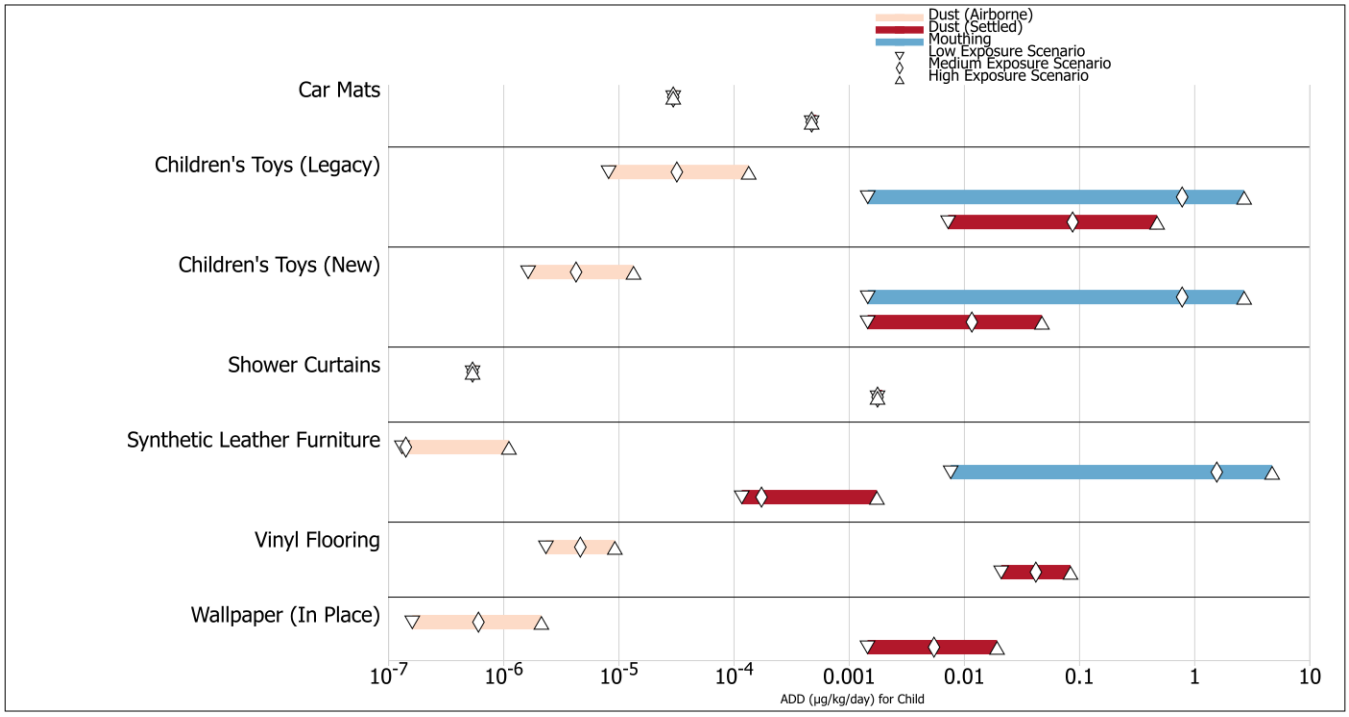

Figure 3-4. Acute Dose Rate of DBP from Suspended and Settled Dust Ingestion and Mouthing for Preschoolers (3–5 Years)

Young Teens, Teenagers, Young Adults, and Adults (11–20 Years and 21+ Years)

Figure 3-5 show all exposure routes for young teens (11–15 years) and teenagers and young adults (16–20 years) combined. Figure 3-6 show all exposure routes for adults above 21 years of age. Exposure

patterns were very similar for all products and articles and routes of exposure in these three lifestages. For all of the liquid and paste products assessed, inhalation exposure as a bystander was not assessed for any of these lifestages as it was deemed reasonable that teenagers, young adults, and adults could all be users, and the exposure scenario for a user is assumed to be protective of that for a bystander. Users have higher exposure doses than bystanders due to direct contact with and use of the product. Dermal exposure resulted in the highest doses overall for both consumable products and solid articles. Inhalation was also a significant driver of exposure for liquid and paste products. Ingestion was only a significant source of exposure for these lifestages for the adult toy article, which was modeled for mouthing exposure. Ingestion via mouthing was not considered for any other articles in these lifestages, as these lifestages are not expected to engage in mouthing exposure routinely.

The scenarios with higher inhalation doses are driven by larger weight fractions in comparison to other articles. Ingestion of settled dust is the highest ingestion pathway for products and articles, see Figure 3-7, but dust ingestion was not a significant driver of exposure as compared to inhalation.

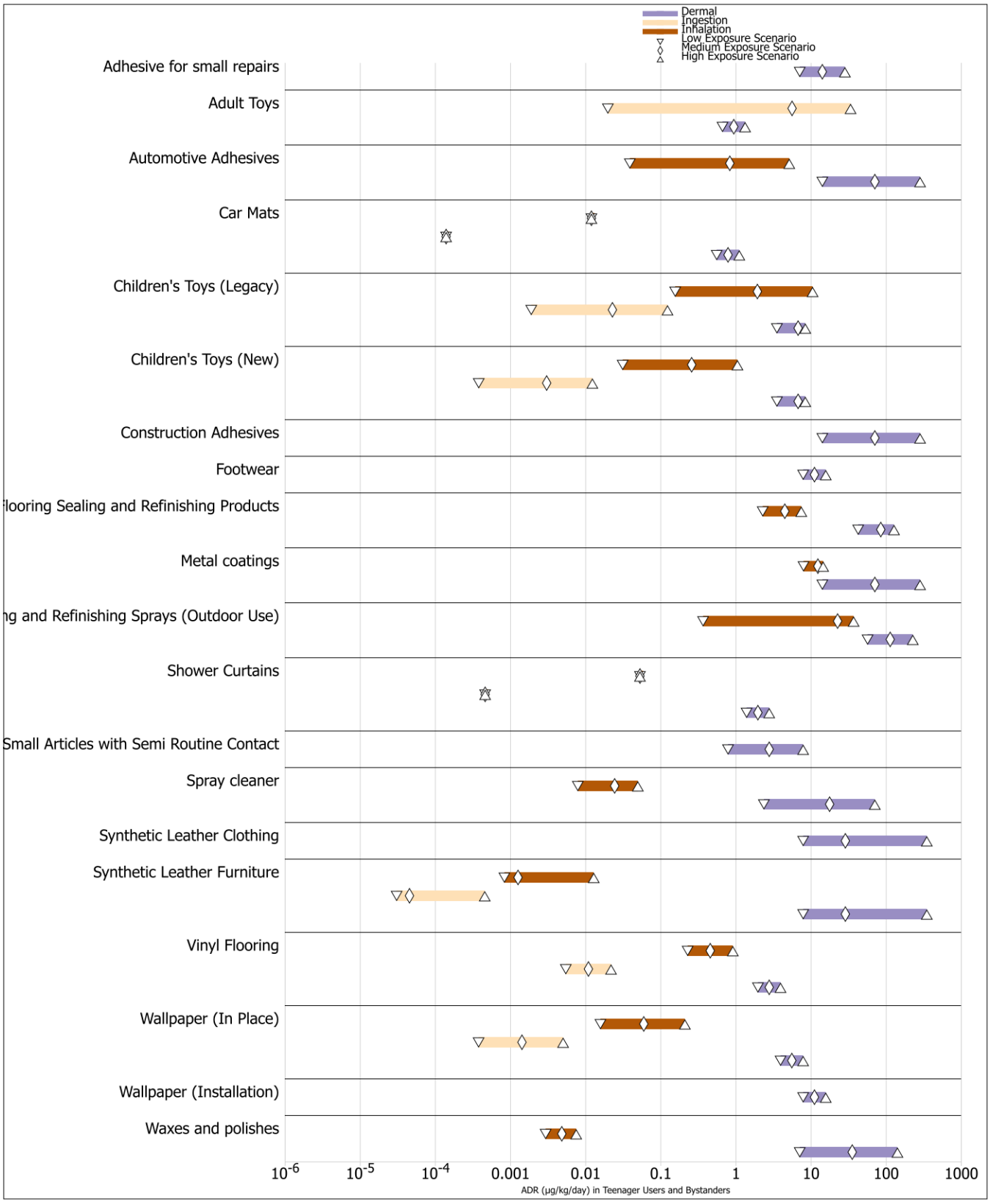

Figure 3-5. Acute Dose Rate of DBP from Ingestion, Inhalation, and Dermal Exposure Routes for Young Teens (11–15 Years) and for Teenagers and Young Adults (16–20 Years)

Note: Horizontal axis label is for young teens and teenagers and young adults. Cutoff labels in order from top to bottom are flooring sealing and refinishing products, sealing and refinishing sprays (outdoor use), and small articles with potential for semi-routine contact. Figure will be fixed in finalization.

Figure 3-6. Acute Dose Rate of DBP from Ingestion, Inhalation, and Dermal Exposure Routes in Adults (21+ Years)

Note: Cutoff labels in order from top to bottom are flooring sealing and refinishing products, sealing and refinishing sprays (outdoor use), and small articles with potential for semi-routine contact. Figure will be fixed in finalization.

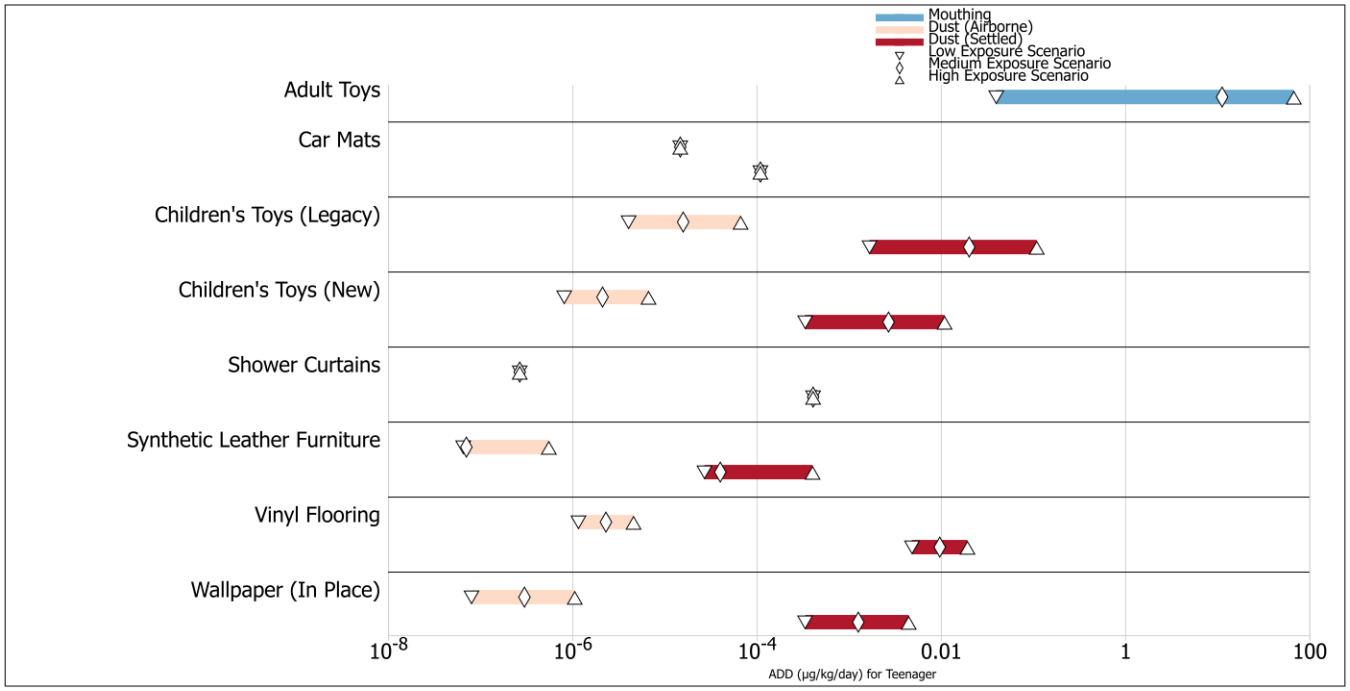

Figure 3-7. Acute Dose Rate of DBP from Suspended and Settled Dust Ingestion Exposure Routes for Young Teens (11–15 Years), Teenagers and Young Adults (16–20 Years), and Adults (21+ Years)

3.2 Intermediate Average Daily Dose Conclusions and Data Patterns

The *DBP Draft Consumer Risk Calculator* (U.S. EPA, 2025a) summarizes the high- (H), medium- (M), and low (L)-intensity use intermediate dose results from modeling in CEM and outside of CEM (dermal calculations and tire crumb exposure all routes) for all exposure routes and all lifestages. Intermediate exposure durations assess product use in a 30-day period (≈1 month). Three product examples were identified that could reasonably be expected to be used more than once within a 30-day time frame; two products belonging to the Paints and coatings COU, and one belonging to the Adhesives and sealants COU. These products were modeled for intermediate exposure scenarios as shown below. Note that some products do not have dose results for some exposure routes in infants and children because the product examples were not targeted for that lifestage. However, infants to middle childhood lifestages are considered bystanders when these products are in use, and thus are exposed via inhalation. Direct dermal contact has larger doses than inhalation for the users during application of the product (*e.g.*, automotive adhesives and flooring sealing and refinishing products). See Figure 3-8 to Figure 3-11 for intermediate dose visual representation.

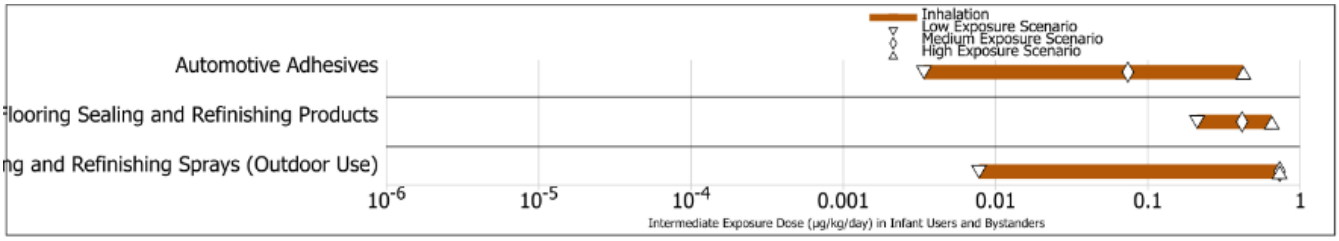

Figure 3-8. Intermediate Dose Rate for DBP from Inhalation Exposure Route in Infants (< Year) and Toddlers (1–2 Years)

Note: Horizontal axis label is for infants and toddlers. Cutoff labels in order from top to bottom are flooring sealing and refinishing products and sealing and refinishing sprays (outdoor use). Figure will be fixed in

finalization.

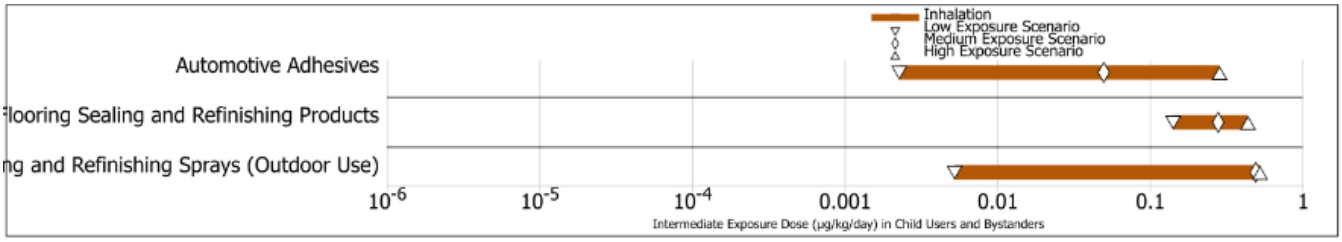

Figure 3-9. Intermediate Dose Rate for DBP from Inhalation Exposure Route in Preschoolers (3–5 Years) and Middle Childhood (6–10 Years)

Note: Horizontal axis label is for preschoolers and middle childhood. Cutoff labels in order from top to bottom are flooring sealing and refinishing products and sealing and refinishing sprays (outdoor use). Figure will be fixed in finalization.

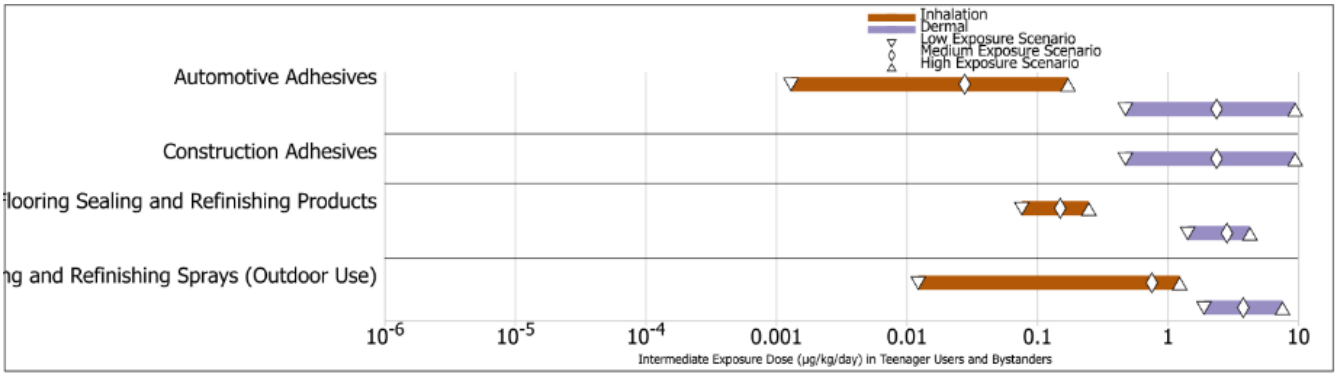

Figure 3-10. Intermediate Dose Rate of DBP from Inhalation and Dermal Exposure Routes for Young Teens (11–15 Years) and for Teenagers and Young Adults (16–20 Years)

Note: Horizontal axis label is for young teens and teenagers and young adults. Cutoff labels in order from top to bottom are flooring sealing and refinishing products and sealing and refinishing sprays (outdoor use). Figure will be fixed in finalization.

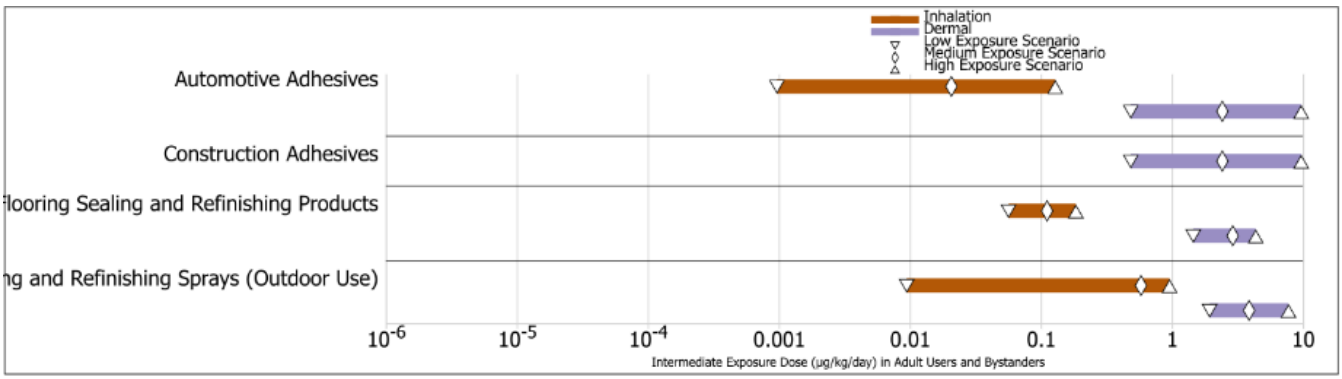

Figure 3-11. Intermediate Dose Rate of DBP from Inhalation and Dermal Exposure Routes for Adults (21+ Years)

Note: Cutoff labels in order from top to bottom are flooring sealing and refinishing products and sealing and refinishing sprays (outdoor use). Figure will be fixed in finalization.

3.3 Non-Cancer Chronic Dose Results, Conclusions and Data Patterns

The *DBP Draft Consumer Risk Calculator* (U.S. EPA, 2025a) also summarizes the high-, medium-, and low-intensity use chronic daily dose results from modeling in CEM and outside of CEM (dermal only)

for all exposure routes and all lifestages. Some products and articles did not have dose results because the product or article was not targeted for that lifestage or exposure route. Bystanders are people that are not in direct use or application of the product but can be exposed to DBP by proximity to the use of the product via inhalation of gas-phase emissions or suspended dust. Some product scenarios (*e.g.*, adhesives and sealants) were assessed for bystanders for children under 10 years and as users 11 years or older because the products were not targeted for use by very young children (<10 years). People older than 11 years can also be bystanders; however, the user scenarios utilize inputs that would result in larger exposure doses.

The main purpose of *DBP Draft Consumer Risk Calculator* (U.S. EPA, 2025a) is to summarize chronic daily dose results, show which products or articles did not have a quantitative result, and which results are used for bystanders. Data patterns are illustrated in figures in this section, which also includes summary descriptions of the patterns by exposure route and lifestage. The following set of figures (Figure 3-12 to Figure 3-15) show chronic average daily dose data for all products and articles modeled in all lifestages. For each lifestage, figures are provided that show CADD estimated from exposure via inhalation, ingestion (aggregate of mouthing, suspended dust ingestion, and settled dust ingestion), and dermal contact. The CADD figures resulted in similar overall data patterns as the acute doses. In general, exposure was driven largely by dermal exposure for young teens to adults. Ingestion exposures were generally higher for articles modeled for mouthing in lifestage groups assessed for mouthing behaviors.

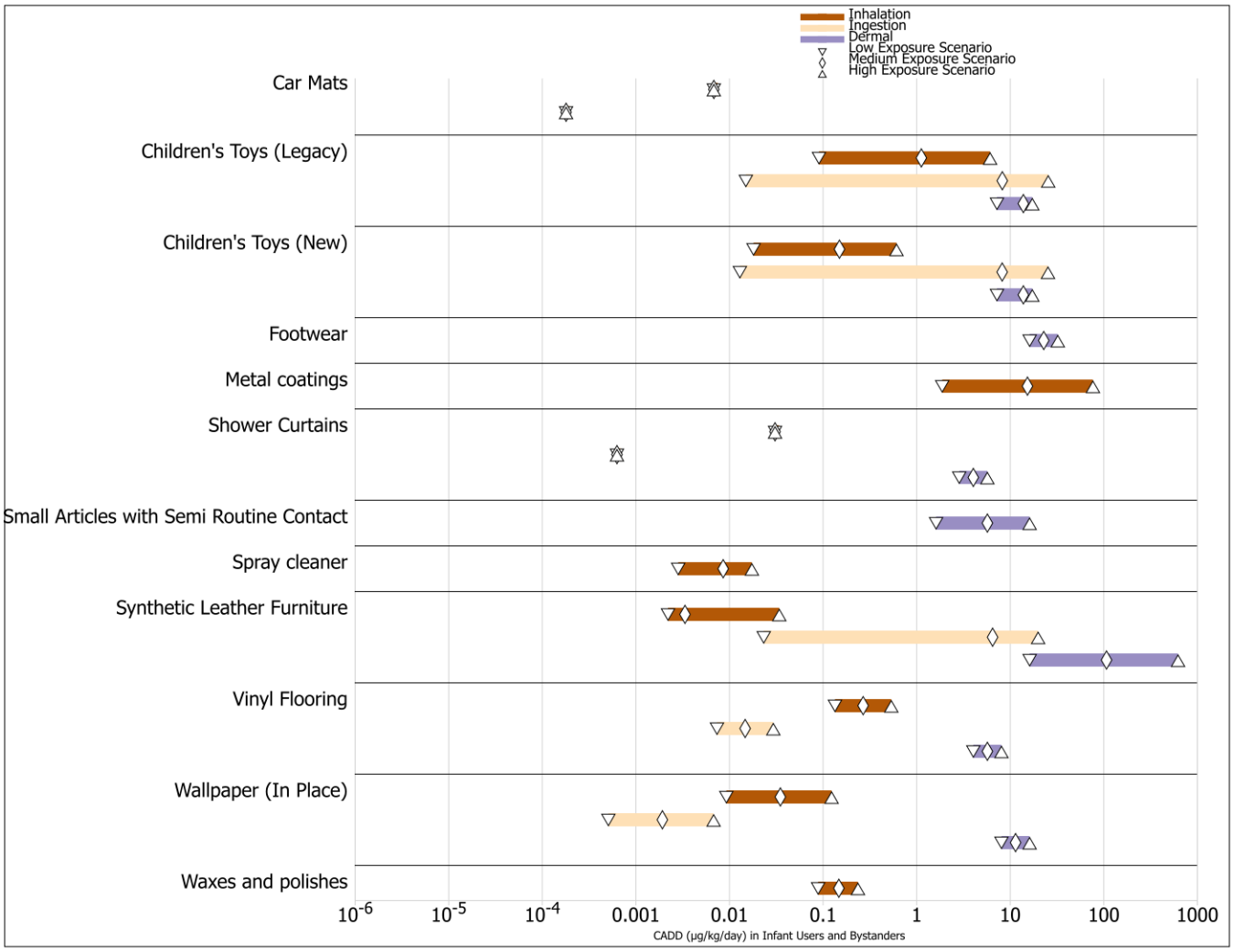

Figure 3-12. Chronic Dose Rate for DBP from Ingestion, Inhalation, and Dermal Exposure Routes in Infants (<1 Year Old) and Toddlers (1–2 Years)

Note: Horizontal axis label is for infants and toddlers. Cutoff label is for small articles with potential for semi-routine contact. Figure will be fixed in finalization.

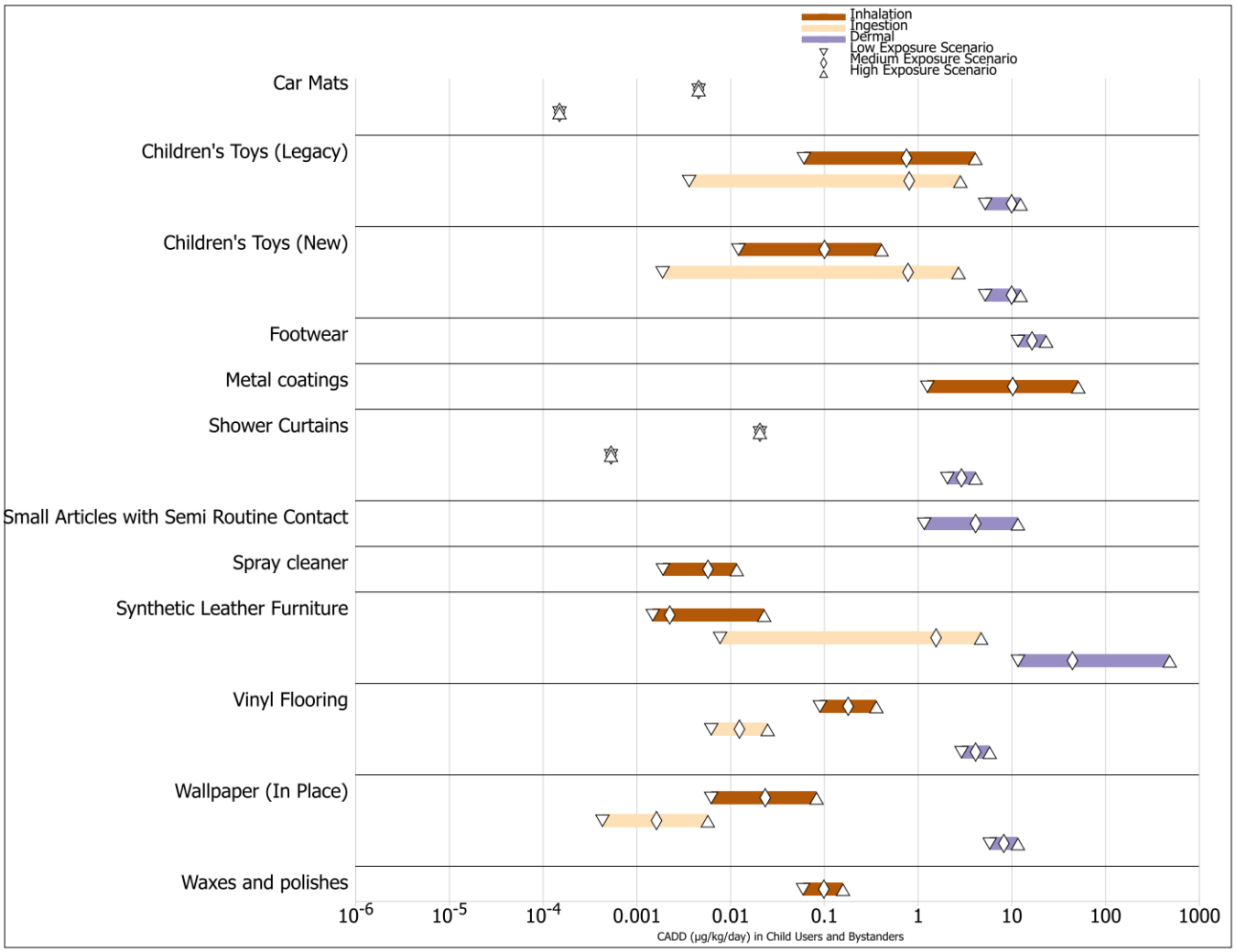

Figure 3-13. Chronic Dose Rate of DBP from Ingestion, Inhalation, and Dermal Exposure Routes for Preschoolers (3–5 Years) and Middle Childhood (6–10 Years)

Note: Horizontal axis label is for preschoolers and middle childhood. Cutoff label is for small articles with potential for semi-routine contact. Figure will be fixed in finalization.

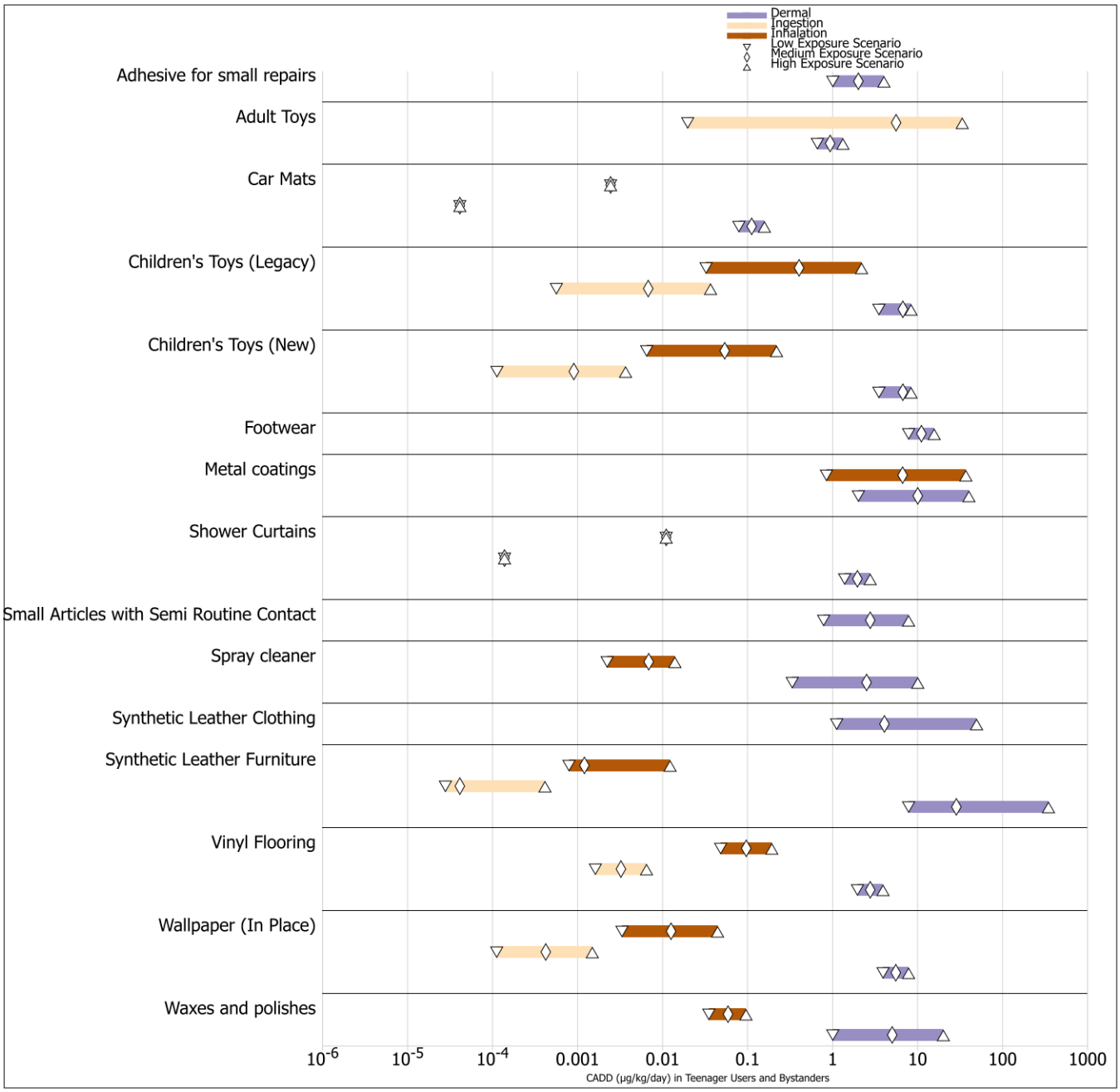

Figure 3-14. Chronic Dose Rate of DBP from Ingestion, Inhalation, and Dermal Exposure Routes for Young Teens (11–15 Years) and for Teenagers and Young Adults (16–20 Years)

Note: Horizontal axis label is for young teens and teenagers and young adults. Cutoff label is for small articles with potential for semi-routine contact. Figure will be fixed in finalization.

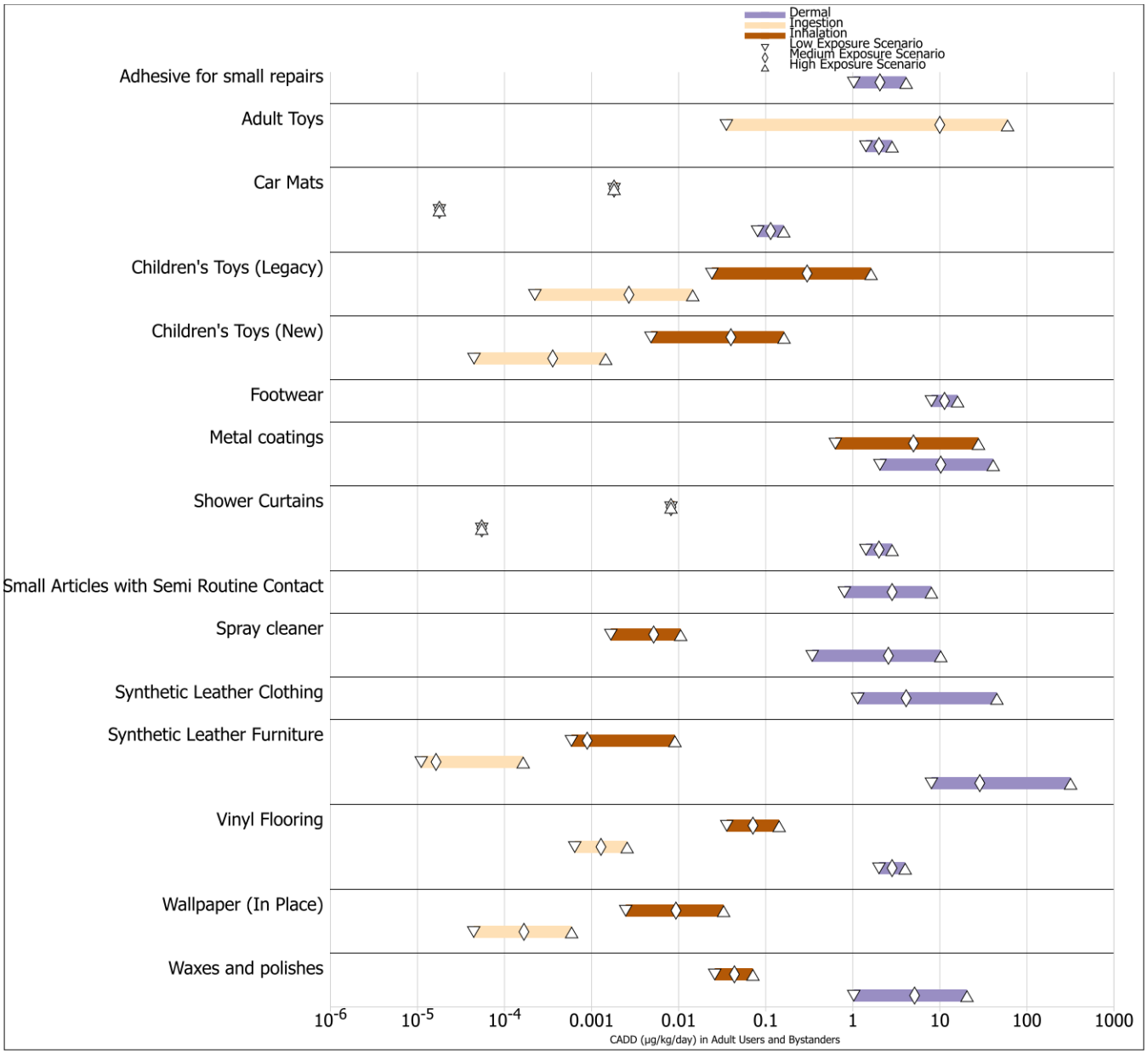

Figure 3-15. Chronic Dose Rate of DBP from Ingestion, Inhalation, and Dermal Exposure Routes in Adults (21+ Years)

Note: Cutoff label is for small articles with potential for semi-routine contact. Figure will be fixed in finalization.

4 INDOOR DUST MODELING AND MONITORING COMPARISON

In this indoor dust exposure assessment, EPA compared modeling and monitoring data. Modeling data used in this comparison originated from the consumer exposure assessment (Table 2-1) to reconstruct major indoor sources of DBP in dust and obtain COU and product specific exposure estimates for ingestion and inhalation of dust. Exposure to DBP via ingestion of dust was assessed for all articles expected to contribute significantly to dust concentrations due to high surface area (exceeding ≈1 m^2) for either a single article or a collection of like articles, as appropriate. These included the following:

- synthetic leather furniture;
- vinyl flooring;
- in-place wallpaper;
- car mats;
- shower curtains;
- children's toys, both legacy and new; and
- tire crumb.

These exposure scenarios were modeled in CEM for inhalation, ingestion of suspended dust, and ingestion of dust from surfaces. See Section 2.2.3.1 for CEM parameterization, input values, and article specific scenario assumptions and sources. The *DBP Consumer Risk Calculator* (U.S. EPA, 2025a) summarizes ingestion of settled dust doses used in this comparison. Other non-residential environments can have these articles, such as daycares, offices, malls, schools, car interiors, and other public indoor spaces. The indoor consumer articles exposure scenarios were modeled with stay-at-home parameters that consider use patterns similar to or higher than those in other indoor environments. Therefore, EPA concludes that the residential assessment represents a health protective upper-bound scenario, which is inclusive of exposure to similar articles in other indoor environments.

The monitoring data considered are from residential dust samples from U.S. based studies. Measured DBP concentrations were compared to evaluate consistency among datasets. EPA used ten (10) U.S. monitoring studies to generate an estimate of overall DBP exposure from ingestion of indoor dust and performed a monitoring and modeling comparison (Section 0). The monitoring studies and assumptions made to estimate exposure are described in Section 4.1.

4.1 Indoor Dust Monitoring

The studies not used in the comparison with modeling data measured DBP dust concentrations in non-residential buildings such as offices, schools, businesses, and day cares, and/or were not conducted in the United States. Data from other countries were not included in the comparison because of the expected difference in use patterns, behaviors, and residential characteristics as compared to the U.S. population. Eighty-eight studies were identified during systematic review as containing measured DBP concentrations. Of the 88 studies, 11 were identified as containing U.S. data on measured DBP concentrations in dust in homes, offices, and other indoor environments. Out of the 11 studies, 10 were selected because they collected settled indoor dust, which is used in the comparison to indoor dust ingestion modeling data (Section 0). Evaluating the sampled population and sampling methods across studies was important to determine whether the residential monitoring data were conducted on broadly representative populations (*i.e.*, not focused on a particular subpopulation).

In Wilson et al. (2001), 10 settled dust samples were collected from U.S. child daycare centers. Five private, four Head Start (daycare centers), and one back-up center participated. All centers have at least one classroom with preschool children aged 3 to 5 years. Three centers were in rural communities and six were in urban centers. Classroom floor dust was collected in the area where the children played the

most.

In Wilson et al. (2003), four settled dust samples were collected from U.S. child daycare centers and nine from children's homes. In addition, nine hand wipe samples were taken from children at the daycares. Classroom and house floor dust were collected in the areas indicated by the teacher or parent as being where the children played most often. For hand wipe samples, each child's samples were collected by the child's caregiver. Two wipes for each child were collected at the daycare center, one just before lunch and before washing the child's hands, on each of the two sampling days. Two additional wipes were collected at home, just before dinner and before washing the child's hands, on each of the two sampling days.

In Rudel et al. (2001), six settled dust samples were collected from the United States. One sample was from an office and five samples were from three different homes in the living areas, attic, and basement. The study does not report the year of the samples taken. Sample collection was taken by slowly and lightly drawing the crevice tool just above the surface of rugs, upholstery, wood floors, windowsills, ceiling fans, and furniture in each room.

In Guo and Kannan (2011), 33 settled dust samples were collected from Albany, New York, between December 2007 and January 2008, as well as during May 2010. Samples contained particles from carpet flooring and were taken by vacuum cleaner bags of several homes.

In Dodson et al. (2015), 49 settled dust samples were collected from homes in California during 2006. Dust samples were collected by slowly dragging the crevice tool just above the surface of rugs, upholstery, wood floors, windowsills, ceiling fans, and furniture in the primary living areas of the home for approximately 30 minutes.

In Bi et al. (2015), 43 settled dust samples were collected from multiple indoor environments in Delaware during 2013. These included 7 apartments, 3 gyms, 4 commercial stores, 5 college student dormitories, 7 offices, 3 house garages, 10 houses, and 5 daycare centers.

In Bi et al. (2018), 92 settled dust samples were collected from homes in Texas during 2014 and 2015. For settled dust, a modified vacuum cleaner was used, which was connected to a special aluminum nozzle holder to avoid contact between dust and plastic parts and limit potential contamination. Dust sampling was conducted mainly in children's rooms. Dust was collected from the floor surface and from objects within 30 cm above the floor.

Hammel et al. (2019) measured DBP concentrations in residential dust and was not focused on a subpopulation. This study collected paired house dust, hand wipe, and urine samples from 203 children aged 3 to 6 years from 190 households in Durham, North Carolina, between 2014 and 2016, and additionally analyzed product use and presence of materials in the house. The households were participants in the Newborn Epigenetics Study (NEST), a prospective pregnancy cohort study that was conducted between 2005 and 2011. Participants were recontacted and invited to participate in a follow-up study on phthalate and SVOC exposure, which was titled the Toddlers' Exposure to SVOCs in the Indoor Environment (TESIE) Study. That study involved home visits conducted between 2014 and 2016.

Table 4-1 reports summary statistics for DBP content in dust from indoor environments. EPA compiled data from multiple indoor environments such as homes, retail, offices, daycares, and gyms. The studies reported various indoor environments, see Table 4-1. Statistics (*e.g.*, mean, median, etc.) were directly

taken from each study, and when individual data were provided EPA calculated the summary statistics. Sampling methods that used wipes and vacuums to collect samples from surfaces were categorized as settled dust and were used in the assessment of dust ingestion route in the monitoring indoor dust exposure assessment. Combined indoor environments mean and medians tend to be higher than individual environments.

Table 4-1. Detection and Quantification of DBP in House Dust from Various Studies

Study	Indoor Environment	N	Central Tendency (µg/g)		Min (µg/g)	Max (µg/g)	SD (µg/g)	95th Percentile (µg/g)	Detection Frequency (%)
			Mean	Median					
Wilson et al. (2001)	Daycare Center	15	18.4	NR	1.58	46.3	NR	NR	NR
Wilson et al. (2003)	Home	9	1.21 [a]	NR	0.384	3.03	NR	NR	NR
	Daycare Center	4	1.87	NR	0.058	5.85	NR	NR	NR
Rudel et al. (2001)	Combined [b]	6	27.4	NR	11.1	59.4	17.2	NR	100
Guo and Kannan (2011)	Home	33	NR	13.1 [a]	4.5	94.5	NR	NR	100
Dodson et al. (2015)	Home	49	NR	11 [a]	NR	56	NR	35 [a]	98
Bi et al. (2015)	Combined [b]	43	255	27	5	2,300	574	NR	100
	Apartment	7	36	12 [a]	9.2	99	36	NR	100
	Home	10	43	24 [a]	5.4	43	59	NR	100
	Home Garage	3	6.3	6.3	4.4	7.3	1.3	NR	100
	Student Dormitory	5	829	360	110	2,151	886	NR	100
	Gym	3	45	31	17	87	37	NR	100
	Office	7	786	110	17	2,300	963	NR	100
	Commercial Stores	4	22	20	5	42	16	NR	100
	Daycare Center	5	77	20	8.8	321	137	NR	100
Bi et al. (2018)	Home	92	115 [a]	<MDL	<MDL	950	228	NR	NR
Hammel et al. (2019)	Home	188	NR	9.634	ND	NR	NR	72.532 [a]	100

MDL = method detection limit; NR = not reported; ND = not detected
[a] Used in dust ingestion calculations for central tendency (mean) and high-end tendency (95th percentile); see Equation 4-2.
[b] Combined refers to multiple indoor environments including household living areas, attic, basement, and an office building.

The number of studies sampled, states, and samples among the studies provides a robust level of confidence in these data adequately representing the U.S. population. Additionally, the study with the largest number of samples, Hammel et al. (2019), provided generic descriptions of the articles that may be sources of DBP in the indoor environment sampled. A comparison between modeled and monitoring data can provide some insight into the distribution and variability within monitoring and modeling estimates. However, it is noteworthy that the monitoring data is an aggregate of all indoor TSCA and non-TSCA sources of DBP in dust and a comparison with only TSCA sources modeling results can be challenging to characterize.

4.2 Indoor Dust Monitoring Approach and Results

To estimate DBP dust ingestion, the central tendency ingestion weighted average dose is first calculated from the reported means and medians of measured concentrations for residential samples (homes and apartments) in Table 4-1 (see footnote a). Studies that did not report means were not used in the calculation—only residential settled dust concentration values were used to compare to modeling results (Section 0). The same equation was used to calculate the high-end value using the reported maximums and 95th percentile. The central tendency ingestion weighted average concentration is calculated using Equation 4-1.

Equation 4-1. Ingestion Weighted Average Concentration Calculation

$$DBP\ Ingestion\ Weighted\ Average\ (\mu g/g\ DBP) = \frac{Mean\ Ingestion\ Set\ 1\left(\frac{\mu g}{g}\ DBP\right) \times Number\ in\ Set\ 1 \ldots + Mean\ Ingestion\ Set\ N\left(\frac{\mu g}{g}\ DBP\right) \times Number\ in\ Set\ N}{Number\ in\ Set\ 1 \ldots + Number\ in\ Set\ N}$$

EPA used recent U.S. sources for dust ingestion rate and body weights from Özkaynak et al. (2022). In their study, Özkaynak et al. (2022) parameterized the Stochastic Human Exposure Dose Simulation (SHEDS) Model to estimate dust and soil ingestion for children ages 0 to 21 years with U.S. data, including the Consolidated Human Activity Database (CHAD) diaries. This most recent version incorporates new data for young children including pacifier and blanket use, which is important because dust and soil ingestion is higher in young children relative to older children and adults due to pacifier and blanket use, increased hand-to-surface contact, and increased rates of hand-to-mouth activity. Geometric mean and 95th percentile dust ingestion rates for ages 0 to 21 years were taken from Özkaynak et al. (2022) to estimate DBP ingestion doses in dust (Table 4-2). The geometric mean (GM) was used as the measure of central tendency because the distribution of doses is skewed as dust ingestion doses in young children (3 months to 2 years) are higher vs. older children and adults.

Body weights representative of the U.S. population were taken from Table 8-1 in the *Exposure Factors Handbook* (U.S. EPA, 2011b). DBP ingestion was calculated according to Equation 4-2 for two scenarios: central tendency (geometric mean (GM) dust ingestion, median DBP concentration in dust) and high-end (dust ingestion, 95th percentile DBP concentration in dust).

Equation 4-2. Calculation of DBP Settled Dust Ingestion Dose

$$DBP\ Ingestion\ Dose\ \left(\frac{\mu g\ DBP}{kg\ bw \times day}\right) = \frac{Dust\ ingestion\left(\frac{mg\ dust}{day}\right) \times Dust\ concentration\left(\frac{\mu g\ DBP}{g\ dust}\right)}{kg\ bw} \times \frac{1\ g}{1000\ mg}$$

Özkaynak et al. (2022) did not estimate dust ingestion rates for ages exceeding 21 years. However, the *Exposure Factors Handbook* does not differentiate dust or soil ingestion beyond 12 years (U.S. EPA, 2017). Therefore, ingestion rates for 16 to 21 years, the highest age range estimated in Özkaynak et al. (2022), were used for ages beyond 21 years. Using body weight estimates from the Handbook, estimates were calculated for DBP ingestion dose for 21 to exceeding 80 years (Table 4-3).

Estimates of DBP ingestion in indoor dust per day based on monitoring data are presented in Table 4-2 and Table 4-3.

Table 4-2. Estimates of DBP Settled Dust Ingestion Per Day from Monitoring, Ages 0–21 Years

Age Range		0 to <1 Months	1 to <3 Months	3 to <6 Months	6 Months to <1 Year	1 to <2 Years	2 to <3 Years	3 to <6 Years	6 to <11 Years	11 to <16 Year	16 to <21 Years
Dust ingestion (mg/day) [a]	Geometric mean	19	21	23	26	23	14	15	13	8.8	3.5
	95th Percentile	103	116	112	133	119	83	94	87	78	46
Body weight (kg) [b]		4.8	5.9	7.4	9.2	11.4	13.8	18.6	31.8	56.8	71.6
DBP Ingestion (µg/kg-day)	Central tendency (38.8µg DBP/g dust)	1.5E−01	1.4E−01	1.2E−01	1.1E−01	7.8E−02	3.9E−02	3.1E−02	1.6E−02	6.0E−03	1.9E−03
	High-end (64.8 µg DBP/g dust)	2.6E−01	2.3E−01	2.0E−01	1.8E−01	1.3E−01	6.6E−02	5.2E−02	2.6E−02	1.0E−02	3.2E−03

[a] From Özkaynak et al. (2022)
[b] From U.S. EPA (2011b)

Table 4-3. Estimates of DBP Settled Dust Ingestion Per Day from Monitoring, Ages 21–80+ Years

Age Range		21 to <30 Years	30 to <40 Years	40 to <50 Years	50 to <60 Years	60 to <70 Years	70 to <80 Years	80+ Years
Dust ingestion (mg/day) [a]	Geometric mean	3.5	3.5	3.5	3.5	3.5	3.5	3.5
	95th percentile	46	46	46	46	46	46	46
Body weight (kg) [b]		78.4	80.8	83.6	83.4	82.6	76.4	68.5
DBP ingestion (µg/kg-day)	Central tendency (38.8 µg DBP/g dust)	1.7E−03	1.7E−03	1.6E−03	1.6E−03	1.6E−03	1.8E−03	2.0E−03
	High-end (64.8 µg DBP/g dust)	2.9E−03	2.8E−03	2.7E−03	2.7E−03	2.7E−03	3.0E−03	3.3E−03

[a] From Özkaynak et al. (2022) (rates for 16–21 years)
[b] From U.S. EPA (2011b)

4.3 Indoor Dust Comparison Between Monitoring and Modeling Ingestion Exposure Estimates

The exposure dose estimates for indoor dust from the CEM model are larger than those indicated by the monitoring approach, with the exception of the infant and toddler lifestages. Table 4-4 compares the sum of the chronic dose central tendency for indoor dust ingestion from CEM outputs for all COUs to the central tendency predicted daily dose from the monitoring approach. EPA only considered modeling TSCA COU related articles that are present in residences and homes for comparison with monitoring data. Car mats and tire crumb rubber are present in indoor environments like vehicles but are not used in homes and hence inclusion would not be appropriate in this comparison analysis.

Table 4-4. Comparison Between Modeled and Monitored Daily Dust Intake Estimates for DBP

Lifestage	Daily DBP Intake Estimate from Dust, µg/kg-day, Modeled Exposure [a]	Daily DBP Intake Estimate from Dust, µg/kg-day, Monitoring Exposure [b]	Margin of Error (Modeled ÷ Monitoring)
Infant (<1 year)	0.047	0.13 [c]	0.36
Toddler (1–2 years)	0.058	0.078	0.75
Preschooler (3–5 years)	0.066	0.035	1.9
Middle Childhood (6–10 years)	0.023	0.016	1.5
Young Teen (11–15 years)	0.013	0.0060	2.2
Teenager (16–20 years)	0.010	0.0019	5.4
Adult (21+ years)	0.0046	0.0017 [d]	2.7

[a] Sum of chronic doses for indoor dust ingestion for the "medium" intake scenario for all COUs modeled in CEM
[b] Central tendency estimate of daily dose for indoor dust ingestion from monitoring data
[c] Weighted average by month of monitored lifestages from birth to 12 months
[d] Weighted average by year of monitored lifestages from 21–80 years

The sum of DBP doses from dust in CEM modeled scenarios were higher than those predicted by the monitoring approach for preschoolers to adults, see Table 4-4. These discrepancies partially stem from differences in the exposure assumptions of the CEM model vs. the assumptions made when estimating daily dust doses in Özkaynak et al. (2022). Dust doses in Özkaynak et al. (2022) decline rapidly as a person ages due to behavioral factors including walking upright instead of crawling, cessation of exploratory mouthing behavior, and a decline in hand-to-mouth events. This age-mediated decline in dust dose, which is more rapid for the Özkaynak et al. (2022) study than in CEM, partially explains why the margin of error between the modeled and monitoring results grows larger with age. Another source of the margin between the two approaches is the assumption that the sum of the indoor dust sources in the CEM modeled scenario is representative of items found in typical indoor residences. It is likely that individual residences have varying assortments and amounts of the products and articles that are sources of DBP, resulting in lower and higher exposures. The modeling scenario with the largest relative contribution, 99 percent, to the total modeling aggregate is vinyl flooring. This modeling scenario may be using a larger surface area presence than the actual in U.S. homes and other indoor environments. In addition, because the monitoring data is an aggregate of all indoor TSCA and non-TSCA sources of DBP in dust, a comparison with TSCA-only sources modeling results is challenging.

In the indoor dust modeling assessment, EPA reconstructed the scenario using consumer articles as the source of DBP in dust. CEM modeling parameters and inputs for dust ingestion can partially explain the

differences between modeling and monitoring estimates. For example, surface area, indoor environment volume, and ingestion rates by lifestage were selected to represent common use patterns. CEM calculates DBP concentration in small particles (respirable particles) and large particles (dust) that are settled on the floor or surfaces. The model assumes these particles bound to DBP are available via incidental dust ingestion and estimates exposure based on a daily dust ingestion rate and a fraction of the day that is spent in the zone with the DBP-containing dust. The use of a weighted dust concentration can also introduce discrepancies between monitoring and modeling results. Additionally, the scenario that is mainly driving the large difference is vinyl flooring that may overestimate surface area presence in indoor environments.

5 WEIGHT OF SCIENTIFIC EVIDENCE

5.1 Consumer Exposure Analysis Weight of the Scientific Evidence

This section describes the sources of variability and uncertainty, the strengths and weaknesses, and the overall confidence in the modeled consumer and indoor dust exposure analysis. Variability refers to the inherent heterogeneity or diversity of data in an assessment. It is a description of the range or spread of a set of values. Uncertainty refers to a lack of data or an incomplete understanding of the context of the risk evaluation decision. Variability cannot be reduced, but it can be better characterized while uncertainty can be reduced by collecting more or better data. Uncertainty is addressed qualitatively by including a discussion of factors such as data gaps and subjective decisions or instances where professional judgment was used. Uncertainties associated with approaches and data used in the evaluation of consumer exposures are described below.

The exposure assessment of chemicals from consumer products and articles has inherent challenges due to many sources of uncertainty in the analysis, including variations in product formulation, patterns of consumer use, frequency, duration, and application methods. Variability in environmental conditions may also alter physical and/or chemical behavior of the product or article. Key sources of uncertainty for evaluating exposure to DBP in consumer goods and strategies to address those uncertainties are described in this section.

Generally, designation of robust confidence suggests thorough understanding of the scientific evidence and uncertainties. The supporting weight of the scientific evidence outweighs the uncertainties to the point where it is unlikely that the uncertainties could have a significant effect on the exposure estimate. The designation of moderate confidence suggests some understanding of the scientific evidence and uncertainties. More specifically, the supporting scientific evidence weighed against the uncertainties is reasonably adequate to characterize exposure estimates. The designation of slight confidence is assigned when the weight of the scientific evidence may not be adequate to characterize the scenario, and when the assessor is making the best scientific assessment possible in the absence of complete information and there are additional uncertainties that may need to be considered. Table 5-1 summarizes the overall uncertainty per COU, and a discussion of rationale used to assign the overall uncertainty. The subsections ahead of the table describe sources of uncertainty for several parameters used in consumer exposure modeling that apply across COUs and provide an in depth understanding of sources of uncertainty and limitations and strengths within the analysis. The confidence to use the results for risk characterization ranges from moderate to robust (Table 5-1). The basis for the moderate to robust confidence in the overall exposure estimates is a balance between using parameters that represent various populations, use patterns, and lean on protective assumptions that are not outliers, excessive, or unreasonable.

Product Formulation and Composition

Variability in the formulation of consumer products, including changes in ingredients, concentrations, and chemical forms, can introduce uncertainty in exposure assessments. In addition, data were sometimes limited for weight fractions of DBP in consumer goods. EPA obtained DBP weight fractions in various products and articles from material SDSs, databases, and existing literature (Section 2.1). A significant number of DBP concentration in consumer goods data values were published across several studies published by the Danish EPA. EPA used the Danish EPA information under the assumption that the weight fractions reported by the Danish EPA are representative of DBP content that could be present in items sold in the United States. Where possible, EPA obtained multiple values for weight fractions for similar products or articles. The lowest value was used in the low exposure scenario, the highest value in

the high exposure scenario, and the average of all values in the medium exposure scenario. EPA decreased uncertainty in exposure and subsequent risk estimates in the high, medium, and low intensity use scenarios by capturing the weight fraction variability and obtaining a better characterization of the varying composition of products and articles within one COU. Overall weight fraction confidence is *moderate* for products/articles with multiple sources but insufficient description on how the concentrations were obtained, *robust* for products/articles with more than one source, and *slight* for articles with only one source with unconfirmed content or little understanding on how the information was produced.

Product Use Patterns

Consumer use patterns such as frequency of use, duration of use, method of application, and skin contact area are expected to differ. Where possible, high, medium, and low default values from CEM 3.2's prepopulated scenarios were selected for mass of product used, duration of use, and frequency of use. In instances where no prepopulated scenario was appropriate for a specific product, low, medium, and high values for each of these parameters were estimated based on the manufacturers' product descriptions. EPA decreased uncertainty by selecting use pattern inputs that represent product and article use descriptions and furthermore capture the range of possible use patterns in the high- to low-intensity use scenarios. Exposure and risk estimates are considered representative of product use patterns and well characterized. Most use patterns overall confidence is rated *robust.*

Article Use Patterns

For articles inhalation and ingestion exposures the high, medium, and low intensity use scenarios default values from CEM 3.2's prepopulated scenarios were selected for indoor use environment/room volume, interzone ventilation, and surface layer thickness. For articles dermal exposures use patterns such as duration and frequency of use and skin contact area are expected to have a range of low to high use intensities. For articles that do not use duration of use as an input in CEM, professional judgment was used to select the duration of use/article contact duration for the low, medium, and high exposure scenario levels for most articles except for carpet tiles and vinyl flooring. Carpet tiles and vinyl flooring contact duration values were taken from EPA's Standard Operating Procedures for Residential Pesticide Exposure Assessment for the high exposure level (2 hours = time spent on floor surfaces) (U.S. EPA, 2012). ConsExpo (U.S. EPA, 2012) for the medium exposure level (1 hour = time a child spends crawling on treated floor), and professional judgment for the low exposure level (0.5 hour). Because there are additional uncertainties in the assumptions and professional judgment for contact duration inputs for articles, EPA has *moderate* confidence in those inputs.

Article Surface Area

The surface area of an article directly affects the potential for DBP emissions to the environment. For each article modeled for inhalation exposure, low, medium, and high estimates for surface area were calculated (Section 2.1). This approach relied on manufacturer-provided dimensions where possible, or values from the *Exposure Factors Handbook* (U.S. EPA, 2011b) for floor and wall coverings. For small items that might be expected to be present in a home in significant quantities, such as children's toys, aggregate values were calculated for the cumulative surface area for each type of article in the indoor environment. Overall confidence in surface area is *robust* for articles like furniture, wall coverings, flooring, toys, and shower curtains because there is a good understanding of the presence and dimensions of these articles in indoor environments.

Human Behavior

CEM 3.2 has three different activity patterns: stay-at-home, part-time out-of-the home (daycare, school, or work), and full-time out-of-the-home. The activity patterns were developed based on the

Consolidated Human Activity Database (CHAD). For all products and articles modeled, the stay-at-home activity pattern was chosen as it is the most protective assumption.

Mouthing durations are a source of uncertainty in human behavior. The data used in this assessment are based on a study in which parents observed children (n = 236) ages 1 month to 5 years for 15 minutes per sessions and 20 sessions in total (Smith and Norris, 2003). There was considerable variability in the data due to behavioral differences among children of the same lifestage. For instance, while children aged 6 to 9 months had the highest average mouthing duration for toys at 39 minutes per day, the minimum duration was 0 minutes and the maximum was 227 minutes per day. The observers noted that the items mouthed were made of plastic roughly 50 percent of the mouthing time, but this was not limited to soft plastic items likely to contain significant plasticizer content. In another study, 169 children aged 3 months to 3 years were monitored by trained observers for 12 sessions at 12 minutes each (Greene, 2002). They reported mean mouthing durations ranging from 0.8 to 1.3 minutes per day for soft plastic toys and 3.8 to 4.4 minutes per day for other soft plastic objects (except pacifiers). Thus, it is likely that the mouthing durations used in this assessment provide a health protective estimate for mouthing of soft plastic items likely to contain DBP. EPA assigned a *moderate* confidence associated with the duration of activity for mouthing because the magnitude of the overestimation is not well characterized. All other human behavior parameters are well understood, or the ranges used capture use patterns representative of various lifestages, which results in a *robust* confidence in use patterns.

Inhalation and Ingestion Modeling Tool

Confidence in the model used considers whether the model has been peer reviewed, as well as whether it is being applied in a manner appropriate to its design and objective. The model used, CEM 3.2, has been peer reviewed (ERG, 2016), is publicly available, and has been applied in the manner intended by estimating exposures associated with uses of household products and/or articles. This also considers the default values data source(s) such as building and room volumes, interzonal ventilation rates, and air exchange rates. Overall confidence in the proper use of CEM for consumer exposure modeling is *robust*.

Dermal Modeling of DBP Exposure for Liquids

Experimental dermal data was identified via the systematic review process to characterize consumer dermal exposures to liquids or mixtures and formulations containing DBP. Section 2.3.1 provides a description of the selected study and rationale to use (Doan et al., 2010) and Section 2.3.2 summarizes the approach and dermal absorption values used. The confidence in the dermal exposure to liquid products model used in this assessment is *moderate*.

EPA selected Doan et al. (2010) as a representative study for dermal absorption to liquids. Doan et al. (2010) is a relatively recent (2010) *in vivo* study in guinea pigs, and it uses a formulation consisting of 7 percent oil-in-water, which is preferred over studies that use neat chemicals. In addition, Doan et al. (2010) conducted *in vivo* and *ex vivo* experiments in female hairless guinea pigs to compare absorption measurements using the same dose of DBP, which increases confidence in the data used. Though there is uncertainty regarding the magnitude of the difference between dermal absorption through guinea pigs' skin vs. human skin for DBP, based on DBP physical and chemical properties (size, solubility), EPA is confident that the *in vivo* dermal absorption data using guinea pigs for (Doan et al., 2010) provides an upper-bound of dermal absorption of DBP.

Another source of uncertainty regarding the dermal absorption of DBP from products or formulations stems from the varying concentrations and co-formulants that exist in products or formulations containing DBP. Dermal contact with products or formulations that have lower concentrations of DBP may exhibit lower rates of flux since there is less material available for absorption. Conversely, co-

formulants or materials within the products or formulations may lead to enhanced dermal absorption, even at lower concentrations, but EPA is unclear of the magnitude of the enhanced dermal absorption. Therefore, it is uncertain whether the products or formulations containing DBP would result in decreased or increased dermal absorption.

In summary, for purposes of this risk evaluation, EPA assumes that the absorptive flux of DBP measured from *in vivo* guinea pig experiments serves as an upper-bound of potential absorptive flux of chemical into and through the skin for dermal contact with all liquid products or formulations.

Dermal Modeling of DBP Exposure for Solids

Experimental dermal data were not identified via the systematic review process to estimate dermal exposures to solid products or articles containing DBP, and thus a modeling approach was used to estimate exposures (see Section 2.3.3). EPA notes that there is uncertainty with respect to the modeling of dermal absorption of DBP from solid matrices or articles. Because there were no available data related to the dermal absorption of DBP from solid matrices or articles, the Agency has assumed that dermal absorption of DBP from solid objects would be limited by aqueous solubility of DBP. To determine the maximum steady-state aqueous flux of DBP, EPA utilized CEM (U.S. EPA, 2023) to first estimate the steady-state aqueous permeability coefficient of DBP. The estimation of the steady-state aqueous permeability coefficient within CEM (U.S. EPA, 2023) is based on a quantitative structure-activity relationship (QSAR) model presented by ten Berge (2009), which considers chemicals with log(K_{ow}) ranging from −3.70 to 5.49 and molecular weights ranging from 18 to 584.6. The molecular weight and log(K_{ow}) of DBP falls within the range suggested by ten Berge (2009). Therefore, there is low to medium uncertainty regarding the accuracy of the QSAR model used to predict the steady-state aqueous permeability coefficient for DBP. There are some uncertainties on the assumption of migration from solid to aqueous media to skin, which assumes the aqueous dermal exposure model assumes that DBP absorbs as a saturated aqueous solution (*i.e.*, concentration of absorption is equal to water solubility), which would be the maximum concentration of absorption of DBP expected from a solid material. EPA has *moderate* confidence in the dermal exposure to solid products or articles modeling approach.

Ingestion Via Mouthing

The chemical migration rate of DBP was estimated based on data compiled in a review published by the Danish EPA in 2016 (Danish EPA, 2016) (see Section 2.2.3.1). For chemical migration rates to saliva, existing data were highly variable both within and between studies; for example, the mild mouthing intensity ranges from 0.04 to 5.8 µg/cm^2-h with an average of 0.17 µg/cm^2-h and a standard deviation of 1.4 µg/cm^2-h. As such, based on available data for chemical migration rates of DBP to saliva, the range of values used in this draft assessment (0.17, 24.3, and 48.5 µg/cm^2-h, for the mild, medium, and harsh intensity, respectively) are considered likely to capture the true value of the parameter depending on article expected uses. For example, EPA assumes children mouthing practices can be mild, medium, or harsh for children's toys. While adults' mouthing practices for adult toys are not expected to be harsh. Harsh mouthing of adult toys can likely result in the breakage or destruction of the article and adults tend to control the harshness of their mouthing better than infants and toddlers. EPA calculated a high intensity use of adult toys using harsh mouthing approaches as part of the screening approach and recognized that this highly conservative result is very unlikely behavior. The Agency did not identify use pattern information regarding adult toys and most inputs are based on professional judgment assumptions.

A major limitation of all existing data is that DBP weight fractions for products tested in mouthing studies skew heavily towards relatively high weight fractions (30–60%) and measurements for weight

fractions less than 15 percent are very rarely represented in the data set. Thus, it is unclear whether the migration rate values are applicable to consumer goods with low (<15%) weight fractions of DBP, whereas rates might be lower than represented by typical or worst-case values determined by existing data sets.

EPA has a moderate confidence in mouthing estimates due to uncertainties about professional judgment inputs regarding mouthing durations for adult toys and synthetic leather furniture for children. In general, the chemical migration rate input parameter has a moderate confidence due to the large variability in the empirical data used in this assessment and unknown correlation between chemical migration rate and DBP concentration in articles.

Table 5-1. Weight of Scientific Evidence Summary Per Consumer COU

Consumer COU Category and Subcategory	Weight of Scientific Evidence	Overall Confidence
Construction, paint, electrical, and metal products; Adhesives and sealants	Three different scenarios were assessed under this COU for three product types with differing use patterns: Adhesives for small repairs, automotive adhesives, and construction adhesives. Adhesives for small repairs and construction adhesives were assessed for dermal exposures only - due to the small product amount and surface area used in each application, inhalation and ingestion would have low exposure potential for these two scenarios. Automotive adhesives were assessed for dermal and inhalation exposures. The overall confidence in this COU's inhalation exposure estimate is robust because the CEM default parameters represent actual use patterns and location of use. See Section 2.1.2 for number of products, product examples, and weight fraction data. For dermal exposure EPA used a dermal flux-limited approach, which was estimated based on DBP *in vivo* dermal absorption in guinea pigs. The flux-limited approach likely results in overestimations due to the assumption about excess DBP in contact with skin. An overall moderate confidence in dermal assessment of adhesives was assigned. Uncertainties about the difference between human and guinea pig skin absorption increase uncertainty and due to increased permeability of guinea pig skin as compared to human skin dermal absorption estimates likely overestimate exposures. Other parameters such as frequency and duration of use, and surface area in contact, are well understood and representative, resulting in a moderate overall confidence.	Inhalation – Robust Dermal – Moderate
Construction, paint, electrical, and metal products; Paints and coatings	Three different scenarios were assessed under this COU for three product types with differing use patterns: metal coatings, indoor sealing and refinishing sprays, and outdoor sealing and refinishing sprays. All three scenarios were assessed for dermal and inhalation exposures. The overall confidence in this COU inhalation exposure estimate is robust because the CEM default parameters represent actual use patterns and location of use. See Section 2.1.2 for number of products, product examples, and weight fraction data. For dermal exposure EPA used a dermal flux-limited approach, which was estimated based on DBP *in vivo* dermal absorption in guinea pigs. The flux-limited approach likely results in overestimations due to the assumption about excess DBP in contact with skin. An overall moderate confidence in dermal assessment of adhesives was assigned. Uncertainties about the difference between human and guinea pigs skin absorption increase uncertainty and due to increased permeability of guinea pig skin as compared to human skin dermal absorption estimates likely overestimate exposures. Other parameters such as frequency and duration of use, and surface area in contact, are well understood and representative, resulting in an overall confidence of moderate.	Inhalation – Robust Dermal – Moderate
Furnishing, cleaning, treatment care products; Fabric, textile, and leather products	Two different scenarios were assessed under this COU for articles with differing use patterns: synthetic leather clothing and synthetic leather furniture. Indoor synthetic furniture articles were assessed for all exposure routes as part of the indoor exposure assessment (*i.e.*, inhalation, ingestion (suspended and settled dust, and mouthing), and dermal), while synthetic clothing was only assessed for dermal contact since the articles were too small to result in significant inhalation and ingestion exposures. The overall confidence in the synthetic leather furniture and clothing COU inhalation exposure estimate is robust because the CEM default parameters are representative of typical use patterns and location of use. The stay-at-home activity use input parameter is considered a conservative input that although representative of actual uses for some populations is also believed to result in an	Inhalation – Robust Ingestion – Moderate Dermal – Moderate

Consumer COU Category and Subcategory	Weight of Scientific Evidence	Overall Confidence
	upper-bound exposure. See Section 2.1.2 for number of products, product examples, and weight fraction data. The indoor furniture ingestion via mouthing exposure estimate overall confidence is moderate due to uncertainties in the parameters used for chemical migration to saliva, such as large variability in empirical migration rate data for harsh, medium, and mild mouthing approaches. Additionally, there are uncertainties from the unknown correlation between chemical concentration in articles and chemical migration rates, and no reasonably available data were available to compare and confirm selected rate parameters to better understand uncertainties. The dermal absorption estimate assumes that dermal absorption of DBP from solid objects would be limited by the aqueous solubility of DBP. EPA has moderate confidence in the aspects of the exposure estimate for solid articles because of the high uncertainty in the assumption of partitioning from solid to liquid, and because subsequent dermal absorption is not well characterized. Additionally, there are uncertainties associated to the flux-limited approach which likely results in overestimations due to the assumption about excess DBP in contact with skin. Other parameters such as frequency and duration of use, and surface area in contact have unknown uncertainties due to lack of information about use patterns, resulting in an overall confidence of moderate.	
Furnishing, cleaning, treatment/care products; Floor coverings; Construction and building materials covering large surface areas including stone, plaster, cement, glass, and ceramic articles; Fabrics, textiles, and apparel	Two different scenarios were assessed under this COU for articles with differing use patterns: vinyl flooring and wallpaper. Both scenarios were part of the indoor assessment and evaluated for all exposure routes except mouthing. The scenarios capture the variability from varying manufacturing formulations in the high, medium, and low intensity use estimates and the weight fraction ranges reported. The overall confidence in the vinyl flooring and wallpaper COU inhalation exposure estimate is moderate because the CEM input parameters are representative, but there are uncertainties in the surface area used and location of use. The stay-at-home activity use input parameter is considered a conservative input that although representative of actual uses for some populations is also believed to result in an upper-bound exposure. See Section 2.1.2 for number of products, product examples, and weight fraction data. The dermal absorption estimate assumes that dermal absorption of DBP from solid objects would be limited by the aqueous solubility of DBP. EPA has moderate confidence in the aspects of the exposure estimate for solid articles because of the high uncertainty in the assumption of partitioning from solid to liquid, and because subsequent dermal absorption is not well characterized. Additionally, there are uncertainties associated to the flux-limited approach, which likely results in overestimations due to the assumption about excess DBP in contact with skin. Other parameters such as frequency and duration of use, and surface area in contact, have unknown uncertainties due to lack of information about use patterns, resulting in an overall confidence of moderate.	Inhalation – Moderate Ingestion – Moderate Dermal – Moderate
Furnishing, cleaning, treatment/care products; Cleaning and furnishing care products	Two different scenarios were assessed under this COU for two product types with differing use patterns: Spray clear and waxes and polishes. Both scenarios were assessed for dermal and inhalation exposures. The overall confidence in this COU inhalation exposure estimate is robust because the CEM default parameters represent actual use patterns and location of use.	Ingestion – Moderate Dermal –

Consumer COU Category and Subcategory	Weight of Scientific Evidence	Overall Confidence
	For dermal exposure EPA used a dermal flux approach, which was estimated based on DBP *in vivo* dermal absorption in guinea pigs. An overall moderate confidence in dermal assessment of adhesives was assigned. Uncertainties about the difference between human and guinea pigs skin absorption increase uncertainty. Other parameters such as frequency and duration of use, and surface area in contact, are well understood and representative, resulting in an overall confidence of moderate in a health protective estimate.	Moderate
Other uses; Novelty articles	One scenario, adult toys, was assessed for this COU. The scenario was assessed for dermal contact and ingestion via mouthing exposures. Inhalation exposures were determined to be minimal due to small surface area to release DBP. The adult toys ingestion exposure estimate overall confidence is moderate due to uncertainties in the parameters used for chemical migration to saliva such as large variability in empirical migration rate data for harsh, medium, and mild mouthing approaches. Additionally, there are uncertainties from the unknown correlation between chemical concentration in articles and chemical migration rates, and no data were reasonably available to compare and confirm selected rate parameters to better understand uncertainties. In addition, there are unknown uncertainties in the use duration input parameters, which were assumed based on professional judgment. EPA calculated a high intensity use of adult toys using harsh mouthing approaches as part of the screening approach, however recognizing that this highly conservative use pattern is very unlikely behavior, it is not to be used to estimate risk. EPA did not identify use pattern information regarding adult toys. The dermal absorption estimate assumes that dermal absorption of DBP from solid objects would be limited by the aqueous solubility of DBP. EPA has moderate confidence in the aspects of the exposure estimate for solid articles because of the high uncertainty in the assumption of partitioning from solid to liquid, and because subsequent dermal absorption is not well characterized. Additionally, there are uncertainties associated to the flux-limited approach, which likely results in overestimations due to the assumption about excess DBP in contact with skin. Other parameters such as frequency and duration of use, and surface area in contact have unknown uncertainties due to lack of information about use patterns, resulting in an overall confidence of moderate.	Inhalation and Dust Ingestion – Robust Dermal – Moderate
Other uses; Automotive articles	Two different scenarios were assessed under this COU for articles with differing use patterns: car mats and synthetic leather seats. Both scenarios were part of the indoor assessment and evaluated for all exposure routes except mouthing. The overall confidence in the inhalation exposure estimate for the car mats and synthetic leather seats COU is robust because the CEM input parameters are representative. The stay-at-home activity use input parameter is considered a conservative input that although representative of actual uses for some populations is also believed to result in an upper-bound exposure. See Section 2.1.2 for number of products, product examples, and weight fraction data. The dermal absorption estimate assumes that dermal absorption of DBP from solid objects would be limited by the aqueous solubility of DBP. EPA has moderate confidence in the aspects of the exposure estimate for solid	Dermal – Moderate

Consumer COU Category and Subcategory	Weight of Scientific Evidence	Overall Confidence
	articles because of the high uncertainty in the assumption of partitioning from solid to liquid, and because subsequent dermal absorption is not well characterized. Additionally, there are uncertainties associated to the flux-limited approach, which likely results in overestimations due to the assumption about excess DBP in contact with skin. Other parameters such as frequency and duration of use, and surface area in contact have unknown uncertainties due to lack of information about use patterns, resulting in an overall confidence of moderate.	
Other uses; Chemiluminescent light sticks	One scenario was assessed for this COU, chemiluminescent light sticks. The scenario was assessed for dermal exposures. Inhalation and ingestion exposures were determined to be minimal due to small surface area to release DBP. The dermal absorption estimate assumes that dermal absorption of DBP from solid objects would be limited by the aqueous solubility of DBP. EPA has moderate confidence in the aspects of the exposure estimate for solid articles because of the high uncertainty in the assumption of partitioning from solid to liquid, and because subsequent dermal absorption is not well characterized. Additionally, there are uncertainties associated to the flux-limited approach, which likely results in overestimations due to the assumption about excess DBP in contact with skin. Other parameters such as frequency and duration of use, and surface area in contact, have unknown uncertainties due to lack of information about use patterns, resulting in an overall confidence of moderate.	Inhalation and Dust Ingestion – Robust Dermal – Moderate
Packaging, paper, plastic, hobby products; Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft); other articles with routine direct contact during normal use, including rubber articles; plastic articles (hard)	Three different scenarios were assessed under this COU for three article types with differing use patterns: footwear, shower curtains, and small articles with semi routine contact (*e.g.*, miscellaneous items including a pen, pencil case, hobby cutting board, costume jewelry, tape, garden hose, disposable gloves, and plastic bags/pouches). Footwear and small articles with semi routine contact scenarios were assessed for dermal exposures only. Shower curtains were assessed for dermal and also part of the indoor assessment and evaluated for all exposure routes except mouthing. The overall confidence in this COU inhalation exposure estimate is robust because the CEM input parameters are representative. The stay-at-home activity use input parameter is considered a conservative input that although representative of actual uses for some populations is also believed to result in an upper-bound exposure. See Section for number of products, product examples, and weight fraction data. The dermal absorption estimate assumes that dermal absorption of DBP from solid objects would be limited by the aqueous solubility of DBP. EPA has moderate confidence in the aspects of the exposure estimate for solid articles because of the high uncertainty in the assumption of partitioning from solid to liquid, and because subsequent dermal absorption is not well characterized. Additionally, there are uncertainties associated to the flux-limited approach, which likely results in overestimations due to the assumption about excess DBP in contact with skin. Other parameters such as frequency and duration of use, and surface area in contact, have unknown uncertainties due to lack of information about use patterns, resulting in an overall confidence of moderate.	CEM Inhalation – Robust Ingestion, Tire crumb Inhalation, and Dermal – Moderate
Packaging, paper, plastic,	Four different scenarios were assessed under this COU for various articles with differing use patterns: legacy	Inhalation–

Consumer COU Category and Subcategory	Weight of Scientific Evidence	Overall Confidence
hobby products; Toys, playground, and sporting equipment	children's toys, and new children's toys, tire crumb and artificial turf, and a variety of PVC articles with potential for routine contact. Toys scenarios were included in the indoor assessment for all exposure routes (inhalation, dust ingestion, mouthing, and dermal) with varying use patterns and inputs. Tire crumb was also part of the indoor assessment for all exposure routes except mouthing, while articles of routine contact were only assessed for dermal exposures since they are too small to result in impactful inhalation or ingestion exposures. The high, medium, and low intensity scenarios capture variability and provide a range of representative use patterns. The overall confidence in this COU inhalation exposure estimate is robust because a good understanding of the CEM model parameter inputs and representativeness of actual use patterns and location of use. The stay-at-home activity use input parameter is considered a conservative input that although representative of actual uses for some populations is also believed to result in an upper-bound exposure. See Section 2.1.2 for number of products, product examples, and weight fraction data. Tire crumb inhalation confidence is moderate due to higher uncertainty in using surrogate chemical air concentrations, while all other parameters are well understood and representative of use patterns by the various age groups. The overall confidence in this COU's mouthing and dermal exposure assessment is moderate. The mouthing parameters used like duration and surface area for infants to children are very well understood, while older groups have less specific information because mouthing behavior is not expected. The chemical migration value is DBP specific, and the only sources of uncertainty are related to a large variability in empirical migration rate data for harsh, medium, and mild mouthing approaches. Additionally, there are uncertainties from the unknown correlation between chemical concentration in articles and chemical migration rates, and no data were reasonably available to compare and confirm selected rate parameters to better understand uncertainties. Dermal absorption estimates are based on the assumption that dermal absorption of DBP from solid objects will be limited by aqueous solubility of DBP. EPA has moderate confidence for solid objects because the high uncertainty in the assumption of partitioning from solid to liquid and subsequent dermal absorption is not well characterized. Additionally, there are uncertainties associated to the flux-limited approach, which likely results in overestimations due to the assumption about excess DBP in contact with skin. Other parameters like frequency and duration of use, and surface area in contact have unknown uncertainties due to lack of information about use patterns, making the overall confidence of moderate.	Robust Dermal – Moderate

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5.2 Indoor Dust Monitoring Weight of the Scientific Evidence

The weight of scientific evidence (WOSE) for the indoor dust exposure assessment of DBP (Table 5-2) is dependent on studies that include indoor residential dust monitoring data (Table 4-4). Studies included indoor dust samples taken from residences and multiple indoor environments were extracted. In the case of DBP, three studies were identified as containing data on indoor environment dust in the United States and were selected for use in the indoor dust monitoring assessment as described in Section 4.1. The study rating per the exposure systematic review criteria is listed in Table 5-2.

Table 5-2. Weight of the Scientific Evidence Conclusions for Indoor Dust Ingestion Exposure

Studies Used in Monitoring Indoor Analysis	Systematic Review Rating	Confidence in Data Used	Confidence in Model Inputs		Weight of Scientific Evidence Conclusion
			Body Weight [a]	Dust Ingestion Rate [b]	
Wilson et al. (2003)	Medium	Moderate	Robust	Moderate	Moderate
Guo and Kannan (2011)	High	Slight			Moderate
Dodson et al. (2015)	Medium	Moderate			Moderate
Bi et al. (2015)	High	Robust			Robust
Bi et al. (2018)	High	Moderate			Moderate
Hammel et al. (2019)	High	Robust			Robust
Shin et al. (2019)	Medium	Moderate			Moderate

[a] U.S. EPA (2011b)
[b] Özkaynak et al. (2022)

Table 5-2 presents the assessor's level of confidence in the data quality of the input datasets for estimating dust ingestion from monitoring data, including the DBP dust monitoring data themselves, the estimates of U.S. body weights, and the estimates of dust ingestion rates, according to the following rubric:

- Robust confidence means the supporting weight of the scientific evidence outweighs the uncertainties to the point that the assessor has decided that it is unlikely that the uncertainties could have a significant effect on the exposure estimate.
- Moderate confidence means the supporting scientific evidence weighed against the uncertainties is reasonably adequate to characterize exposure estimates, but uncertainties could have an effect on the exposure estimate.
- Slight confidence means the assessor is making the best scientific assessment possible in the absence of complete information. There may be significant uncertainty in the underlying data that needs to be considered.

These confidence conclusions were derived from a combination of systematic review (*i.e.*, the quality determinations for individual studies) and the assessor's professional judgment.

In Wilson et al. (2003) (systematic review rating was medium), monitoring data was collected in Durham, North Carolina for DBP in children's homes. This study sampled nine homes as well as nine hand wipe samples. House floor dust samples were collected with a High Volume Small Surface Sampler (HVS3; Cascade Stack Sampling Systems Inc., Bend, Oregon) in the areas indicated by the teacher or parent as being where the children played most often. While these samples could be representative of the general U.S. population, the small sample size and lack of geographic diversity,

selection of certain types of homes for the children in the study add to the uncertainty. Because of these uncertainties, EPA has assigned moderate confidence to our use of this model input.

In Guo and Kannan (2011) (systematic review rating was high), monitoring data was collected in Albany, New York for DBP between 2007 and 2008 for 33 houses. Dust samples were collected by sweeping the floor and wiping the top of furniture as well as from vacuum cleaner bags of several homes. Information was not given about the type of housing and if it is representative of the general U.S. population. Because of this uncertainty, EPA has assigned moderate confidence to our use of this model input.

In Dodson et al. (2015) (systematic review rating was medium), monitoring data was collected in Richmond and Bolinas, California for DBP from the California Household Exposure Study (CAHES) study conducted in 2006. This study sampled 49 nonsmoking homes in a low-income urban community and a rural community around the San Francisco area. Samples were collected by slowly dragging a crevice tool just above the surface of rugs, upholstery, wood floors, windowsills, ceiling fans, and furniture in the primary living areas of the home for approximately 30 minutes. While these samples collect indoor dust samples from an existing study, the low income and rural population studied might not be representative of the general U.S. public. Because of this uncertainty, EPA has assigned moderate confidence to our use of this model input.

In Bi et al. (2015) (systematic review rating was high), monitoring data was collected from Dover, Delaware for DBP in 2013. This study sampled 10 houses, with the floor material being made of carpet, hardwood or a combination of both. The study also indicated that the houses did not have a custodian for daily cleaning. Dust samples were collected using a bagged vacuum cleaner through an easily cleaned suction tube. Before each sampling, the internal surface of the suction tube was cleaned using an animal-hair brush and a piece of clean cloth, and a new bag was placed for dust collection. EPA believes these samples may not be a general representation of the U.S. population due to small number of samples and lack of geographic variability. Because of this, EPA has assigned robust confidence to our use of this model input.

In Bi et al. (2018) (systematic review rating was high), monitoring data was collected from Texas for DBP in 2014 and 2015. The study is part of a large project to investigate asthma triggers for children in low-income homes. A total of 54 homes (92 samples) from rural/semi-rural areas of central Texas enrolled in this study. Dust sampling was conducted mainly in children's rooms. Dust was collected from the floor surface and from objects within 30 cm above the floor. While these samples collect indoor dust samples from homes, the study selected low-income homes for children and is not representative of the general U.S. public. Because of this uncertainty, EPA has assigned moderate confidence to our use of this model input.

Monitoring data collected in the United States was identified for DBP from the Toddlers' Exposure to SVOCs in the Indoor Environment (TESIE) study conducted between 2014 and 2016 (Hammel et al., 2019) (systematic review rating was high). This study sampled 190 residences in Durham, North Carolina, and included vacuum dust sampling as well as hand wipes and urine samples. Households were selected from participants in the Newborn Epigenetics Study, which is a prospective pregnancy cohort that began in 2005 and recruited pregnant women who received services at Duke obstetrics facilities. Although these facilities are associated with a teaching hospital and university, services are not restricted to students, and the demographic characteristics of the TIESIE study population match those of the Durham community (see Table 1 in Hammel et al. (2019)). Because this study carefully selected participants to avoid oversampling subpopulations and investigated a relatively large number of

residences for a study of this type, and because EPA identified no reason to believe that households in the study location (Durham, North Carolina) would represent an outlier population that would not adequately represent the consumer practices of the broader U.S. public, EPA has assigned robust confidence to our use of this model input.

In Shin et al. (2019) (systematic review rating was medium), monitoring data was collected in Northern California from 2015 to 2016. This study sampled 38 family homes. From each household, one dust sample from an approximate 2 m^2 area in the main living room using a high-volume small surface sampler (HVS3) were collected. Since the study does not provide much information about the households, it is hard to determine if they are representative of the general U.S. public. Because of this uncertainty, EPA has assigned moderate confidence to our use of this model input.

Body weight data was obtained from the *Exposure Factors Handbook* (U.S. EPA, 2011b). This source is considered the default for exposure related inputs for EPA risk assessments and is typically used unless there is a particular reason to seek alternative data. Because the Exposure Factors Handbook is generally considered the gold standard input for body weight, and because the underlying body weight data were derived from the U.S. nationally representative NHANES dataset, EPA has assigned robust confidence to our use of this model input.

Total daily dust intake was obtained from Özkaynak et al. (2022). This study used a mechanistic modeling approach to aggregate data from a wide variety of input variables (Table 5-3). These input variables were derived from several scientific sources as well as from the professional judgment of the study authors. The dust ingestion rates are similar to those found in the *Exposure Factors Handbook* (U.S. EPA, 2011c) for children under 1 year old but diverge above this age (Table 5-4). The Özkaynak et al. (2022) dust ingestion rates are one-half to approximately one-fifth as large, depending on age. This is because the *Handbook* rates are a synthesis of several studies in the scientific literature, including tracer studies that use elemental residues in the body to estimate the ingestion of soil and dust. According to the discussion presented in Özkaynak et al. (2022), these tracer studies may be biased high, and in fact as shown in Figure 4 of Özkaynak et al. (2022), non-tracer studies align much more closely with the dust ingestion rates used in this analysis. Because some input variables were unavailable in the literature and had to be based on professional judgment, and the dust ingestion rates differ from those in the Handbook, EPA has assigned moderate confidence to this model input.

Taken as a whole, with robust confidence in the DBP concentration monitoring data in indoor residential dust from Hammel et al. (2019), robust confidence in body weight data from the *Exposure Factors Handbook* U.S. EPA (2011b), and moderate confidence in dust intake data from Özkaynak et al. (2022), EPA has assigned a WOSE rating of robust confidence to estimates of daily DBP intake rates from ingestion of indoor dust in residences.

5.2.1 Assumptions in Estimating Intakes from Indoor Dust Monitoring

5.2.1.1 Assumptions for Monitored DBP Concentrations in Indoor Dust

The DBP concentrations in indoor dust were derived from the seven studies in Table 4-1. Five of the studies rated moderate and two studies rated robust in confidence in data used. The studies rated moderate were assumed to not be representative of a typical U.S. household while the robust studies were assumed to be representative. For some studies, samples were either taken from the living room or children's room, where the children's room was identified as the room in which the child(ren) residing in the home spent the most time. A key assumption made in this analysis is that dust concentrations in playrooms and living rooms are representative of those in the remainder of the home.

5.2.1.2 Assumptions for Body Weights

Body weights were taken from the Exposure Factors Handbook (U.S. EPA, 2011b), in which they were derived from the NHANES 1999 to 2006 dataset. The NHANES studies were designed to obtain a nationally representative dataset for the United States and include weight adjustment for oversampling of certain groups (children, adolescents 12–19 years, persons 60+ years of age, low-income persons, African Americans, and Mexican Americans). Body weights were aggregated into the age ranges shown in Table 4-2, Table 4-3, and Table 4-4 and were averaged by sex.

5.2.1.3 Assumptions for Dust Ingestion Rates

To estimate daily intake of DBP in residential indoor dust, a daily rate of dust ingestion is required. EPA used rates from Özkaynak et al. (2022), which modeled to estimate dust and soil intakes for children from birth to 21 years. A probabilistic approach was used in the Özkaynak et al. (2022) study to assign exposure parameters including behavioral and biological variables. The exposure parameters are summarized in Table 5-3 and the statistical distributions chosen are reproduced in detail in the supplemental material for Özkaynak et al. (2022).

Table 5-3. Summary of Variables from Özkaynak et al. 2022 Dust/Soil Intake Model

Variable	Description	Units	Source
Bath_days_max	Maximum # days between baths/showers	days	Ozkaynak et al. (2011), based on Kissel 2003 (personal communication)
Dust_home_hard	Dust loading on hard floors	µg/cm^2	Adgate et al. (1995)
Dust_home_soft	Dust loading on carpet	µg/cm^2	Adgate et al. (1995)
F_remove_bath	Fraction of loading removed by bath or shower	(-)	Professional judgment
F_remove_hand_mouth	Fraction of hand loading removed by one mouthing event	(-)	Kissel et al. (1998) and (Hubal et al., 2008)
F_remove_hand_wash	Fraction of hand loading removed by hand washing	(-)	Professional judgment
F_remove_hour	Fraction of dermal loading removed by passage of time	(-)	Ozkaynak et al. (2011)
F_transfer_dust_hands	Fraction of floor dust loading transferred to hands by contact	(-)	Ozkaynak et al. (2011)
F_transfer_object_mouth	Fraction transferred from hands to mouth	(-)	Zartarian et al. (2005), based on Leckie et al. (2000)
Hand_contact_ratio	Ratio of floor area contacted hourly to the hand surface area	1/h	Freeman et al. (2001) and Zartarian et al. (1997)
Hand_load_max	Maximum combined soil and dust loading on hands	µg/cm^2	Ozkaynak et al. (2011)
Hand_washes_per_day	Number of times per day the hands are washed	1/day	Zartarian et al. (2005)
Object_floor_dust_ratio	Relative loadings of object and floor dust after contact	(-)	Professional judgment, based on Gurunathan et al. (1998)
P_home_hard	Probability of being in part of home with hard floor	(-)	Ozkaynak et al. (2011)
P_home_soft	Probability of being in part of home with carpet	(-)	Ozkaynak et al. (2011)
Adherence_soil [a]	Accumulated mass of soil that is transferred onto skin	mg/cm^2	Zartarian et al. (2005), based on Holmes et al. (1999), Kissel et al. (1996a), and

Variable	Description	Units	Source
			Kissel et al. (1996b)
Hand_mouth_fraction [a]	Fraction of hand area of one hand contacting the inside of the mouth	(-)	Tsou et al. (2017)
Hand_mouth_freq [a] (indoor/outdoor)	Frequency of hand-mouth contacts per hour while awake – separate rate for indoor/outdoor behavior	(-)	Black et al. (2005) and Xue et al. (2007)
Object_mouth_area [a]	Area of an object inserted into the mouth	cm^2	Leckie et al. (2000)
Object_mouth_freq [a]	Frequency at which objects are moved into the mouth	(-)	Xue et al. (2010)
P_blanket [b]	Probability of blanket use	(-)	Professional judgment
F_blanket [b]	Protective barrier factor of blanket when used	(-)	Professional judgment
Pacifier_size [b]	Area of pacifier surface	cm^2	Özkaynak et al. (2022)
Pacifier_frac_hard [b]	Fraction of pacifier drops onto hard surface	(-)	Professional judgment
Pacifier_frac_soft [b]	Fraction of pacifier drops onto soft surface	(-)	Professional judgment
Pacifier_transfer [b]	Fraction of dust transferred from floor to pacifier	(-)	Extrapolated from Rodes et al. (2001), Beamer et al. (2009), and (Hubal et al., 2008)
Pacifier_washing [b]	Composite of the probability of cleaning the pacifier after it falls and efficiency of cleaning	(-)	Conservative assumption (zero cleaning is assumed)
Pacifier_drop [b]	Frequency of pacifier dropping	(-)	Tsou et al. (2015)
P_pacifier [b]	Probability of pacifier use	(-)	Tsou et al. (2015)

[a] Variable distributions differ by lifestage
[b] Variable only applies to children younger than 2 years

5.2.2 Uncertainties in Estimating Intakes from Monitoring Data

5.2.2.1 Uncertainties for Monitored DBP Concentrations in Indoor Dust

For all seven studies, there is uncertainty for sampling biases which can include choice of study location, include only households that contain children and by differences among the households that chose to participate in the study. For example, Hammel et al. (2019) sampled residential house dust in 190 households in Durham, North Carolina, from a population selected from an existing pregnancy cohort study. In addition, differences in consumer behaviors, housing type and quality, tidiness, and other variables that affect DBP concentrations in household dust are possible between participating households and the general population.

5.2.2.2 Uncertainties for Body Weights

Body weights were obtained from the *Exposure Factors Handbook* (U.S. EPA, 2011c), which contains data from the 1999 to 2006 NHANES. Body weights were aggregated across lifestages and averaged by sex. In general, body weights have increased in the United States since 2006 (CDC, 2013), which may lead to an underestimate of body weight in this analysis. This would lead to an overestimate of DBP dose per unit body weight, because actual body weights in the U.S. population may be larger than those assumed in this analysis.

5.2.2.3 Uncertainties for Dust Ingestion Rates

Dust ingestion rates were obtained from Özkaynak et al. (2022), which uses mechanistic methods (the SHEDS Model) to estimate dust ingestion using a range of parameters (Table 5-3). Each of these parameters is subject to uncertainty, especially those that are derived primarily from the professional judgment of the authors. Because of the wide range of parameters and the lack of comparator data against which to judge, EPA is unable to determine the direction of potential bias in each of the parameters individually. For dust ingestion rates overall, the rates derived from Özkaynak et al. (2022) can be compared to those found in the Exposure Factors Handbook (U.S. EPA, 2017) (Table 5-4).

Table 5-4. Comparison Between Özkaynak et al. 2022 and *Exposure Factors Handbook* Dust Ingestion Rates

Age Range		0 to <1 Month	1 to <3 Months	3 to <6 Months	6 Months to <1 Year	1 to <2 Years	2 to <3 Years	3 to <6 Years	6 to <11 Years	11 to <16 Years	16 to <21 Years
Central tendency dust ingestion (mg/day)	Özkaynak et al. (2022)	19	21	23	26	23	14	15	13	8.8	3.5
	U.S. EPA (2017)	20	20	20	20	50	30	30	30	20 [a]	20

[a] The intake for an 11-year-old based on the *Exposure Factors Handbook* is 30 mg/day. Not that the age ranges do not align between the two sources in this instance.

The Özkaynak et al. (2022) dust intake estimates for children above 1 year old are substantially lower than those in the *Exposure Factors Handbook* (U.S. EPA, 2011c), while the estimate for children between 1 month and 1 year old are slightly higher. The authors of the Özkaynak et al. (2022) study offer some justification for the discrepancy by noting that the Handbook recommendations are a synthesis of several types of study, including tracer studies that "[suffer] from various sources of uncertainty that could lead to considerable study-to-study variations." Biokinetic and activity pattern studies, such as Von Lindern et al. 2016 and Wilson et al. 2013 respectively, achieve results that are closer to the Özkaynak et al. (2022) results (see Fig. 4, Özkaynak et al. (2022).

5.2.2.4 Uncertainties in Interpretation of Monitored DBP Intake Estimates

There are several potential challenges in interpreting available indoor dust monitoring data. The challenges include the following:

- Samples may have been collected at exposure times or for exposure durations not expected to be consistent with a presumed hazard based on a specified exposure time or duration.
- Samples may have been collected at a time or location when there were multiple sources of DBP that included non-TSCA COUs.
- None of the identified monitoring data contained source apportionment information that could be used to determine the fraction of DBP in dust samples that resulted from a particular TSCA or non-TSCA COU. Therefore, these monitoring data represent background concentrations of DBP and are an estimate of aggregate exposure from all residential sources.
- Activity patterns may differ according to demographic categories (*e.g.*, stay at home/work from home individual vs. an office worker), which can affect exposures especially to articles that continually emit a chemical of interest.
- Some indoor environments may have more ventilation than others, which may change across seasons.

6 CONCLUSION AND STEPS TOWARD RISK CHARACTERIZATION

Indoor Dust

For the indoor exposure assessment, EPA considered modeling and monitoring data. Monitoring data is expected to represent aggregate exposure to DBP in dust resulting from all sources present in a home. Although it is not a good indicator of individual contributions of specific COUs, it provides a real-world indicator of total exposure through dust. For the modeling assessment of indoor dust exposures and estimating contribution to dust from individual COUs, EPA re-created indoor environments using consumer products and articles commonly present in indoor spaces. For example, the indoor assessment considered inhalation exposure from toys, flooring, synthetic leather furniture, wallpaper, and others including a consideration of dust collected on the surface of a relatively large area, like flooring, furniture, and wallpaper, but also multiple toys and wires collecting dust with DBP and subsequent inhalation and ingestion.

While there are differences between modeled and monitoring indoor dust assessment estimates, EPA considers the differences minor and a way to confirm the approaches used in the modeling and monitoring indoor dust assessment. The monitoring estimates were used as a comparator to show that the modeled DBP exposure estimates were health protective relative to residential monitored exposures (Table 4-4). This comparison was a key input to our robust confidence in the overall health protectiveness of our exposure assessment for ingestion of DBP in indoor dust. The individual COU scenarios had a moderate to robust confidence in the exposure dose results and protectiveness of parameters used. Thus, the COU scenarios of the articles used in the indoor assessment were utilized in risk estimates calculations.

Consumer

All COU exposure dose results summarized in Section 3 and the *DBP Draft Consumer Risk Calculator* (U.S. EPA, 2025a) have a moderate to robust confidence and hence can be used for risk estimate calculations and to determine risk to the various lifestages. The consumer assessment has low, medium, and high exposure scenarios that represent use patterns of high-, medium-, and low-intensity uses. The high exposure scenarios capture use patterns for high exposure potential from high frequency and duration use patterns, extensive mouthing behaviors, and conditions that promote greater migration of DBP from products/articles to sweat and skin. Low and medium exposure scenarios represent less intensity in use patterns, mouthing behaviors, and conditions that promote DBP migration to sweat and skin, capturing populations with different lifestyles.

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Appendix A ACUTE, CHRONIC, AND INTERMEDIATE DOSE RATE EQUATIONS

The equations provided in this section were taken from the CEM user guide and associated appendices.

A.1 Acute Dose Rate

Acute dose rate for inhalation of product used in an environment (CEM P_INH1 Model), such as indoor, outdoor, living room, garage, kitchen, bathroom, office, etc. was calculated as follows:

Equation_Apx A-1. Acute Dose Rate for Inhalation of Product Used in an Environment

$$ADR = \frac{C_{air} \times Inh \times FQ \times D_{ac} \times ED}{BW \times AT \times CF_1}$$

Where:

ADR	=	Acute Dose Rate (mg/kg-day)
C_{air}	=	Concentration of DBP in air (mg/m^3)
Inh	=	Inhalation rate (m^3/h)
FQ	=	Frequency of product use (events/day)
D_{ac}	=	Duration of use (min/event), acute
ED	=	Exposure duration (days of product usage)
BW	=	Body weight (kg)
AT	=	Averaging time (days)
CF_1	=	Conversion factor (60 min/h)

For the ADR calculations, an averaging time of 1 day is used. The airborne concentration in the above equation is calculated using the high-end consumer product weight fraction, duration of use, and mass of product used. Therefore, in this case, the ADR represents the maximum time-integrated dose over a 24-hour period during the exposure event. CEM calculates ADRs for each possible 24-hour period over the 60-day modeling period (*i.e.*, averaging of hours 1–24, 2–25, etc.) and then reports the highest of these computed values as the ADR.

Acute dose rate for inhalation from article placed in environment (CEM A_INH1 Model) was calculated as follows, where the term environment refers to any indoor and outdoor location, such as garage, kitchen, bathroom, living room, car interior, daycare, school room, office, backyard and so on:

Equation_Apx A-2. Acute Dose Rate for Inhalation from Article Placed in Environment

$$ADR_{Air} = \frac{C_{gas\_max} \times FracTime \times InhalAfter \times CF_1}{BW \times CF_2}$$

Equation_Apx A-3. Acute Dose Rate for Particle Inhalation from Article Placed in Environment

$$ADR_{Particulate} = \frac{DBPRP_{air\_max} \times RP_{air\_avg} \times FracTime \times InhalAfter \times CF_1}{BW \times CF_2}$$

Equation_Apx A-4. Total Acute Dose Rate for Inhalation of Particulate and Air

$$ADR_{total} = ADR_{Air} + ADR_{Particulate}$$

Where:

ADR_{Air}	=	Acute Dose Rate, air (mg/kg-day)
$ADR_{Particulate}$	=	Acute Dose Rate, particulate (mg/kg-day)
ADR_{total}	=	Acute Dose Rate, total (mg/kg-day)
C_{gas_max}	=	Maximum gas phase concentration (µg/m^3)
$DBPRP_{air\_max}$	=	Maximum DBP in respirable particle (RP) concentration, air (µg/mg)
RP_{air_max}	=	Maximum respirable particle concentration, air (mg/m^3)
$FracTime$	=	Fraction of time in environment (unitless)
$InhalAfter$	=	Inhalation rate after use (m^3/h)
CF_1	=	Conversion factor (24 h/day)
BW	=	Body weight (kg)
CF_2	=	Conversion factor (1,000 µg/mg)

Acute dose rate for ingestion after inhalation (CEM A_ING1 Model) was calculated as follows:

Equation_Apx A-5. Acute Dose Rate from Ingestion After Inhalation

$$ADR_{IAI} = \frac{\left[\left(DBPRP_{air\_max} \times RP_{air\_max} \times IF_{RP}\right) + \left(DBPDust_{air\_max} \times Dust_{air\_max} \times IF_{Dust}\right) + \left(DBPAbr_{air\_max} \times Abr_{air\_max} \times IF_{Abr}\right)\right] \times InhalAfter \times CF_1}{BW \times CF_2}$$

Where:

ADR_{IAI}	=	Acute Dose Rate from Ingestion and Inhalation (mg/kg-day)
$DBPRP_{air\_max}$	=	Maximum DBP in respirable particles (RP) concentration, air (µg/mg)
RP_{air_max}	=	Maximum RP concentration, air (mg/m^3)
IF_{TSP}	=	RP ingestion fraction (unitless)
$DBPDust_{air\_max}$	=	Maximum DBP in dust concentration, air (µg/mg)
$Dust_{air\_max}$	=	Maximum dust concentration, air (mg/m^3)
IF_{Dust}	=	Dust ingestion fraction (unitless)
$DBPAbr_{air\_avg}$	=	Maximum DBP in abraded particle concentration, air (µg/mg)
Abr_{air_avg}	=	Maximum abraded particle concentration, air (mg/m^3)
IF_{Abr}	=	Abraded particle ingestion fraction (unitless)
$InhalAfter$	=	Inhalation rate after use (m^3/h)
CF_1	=	Conversion factor (24 h/day)
BW	=	Body weight (kg)
CF_2	=	Conversion factor (1,000 mg/g)

Acute daily dose rate for ingestion of article mouthed (CEM A_ING2 Model) was calculated as follows:

Equation_Apx A-6. Acute Dose Rate for Ingestion of Article Mouthed

$$ADR = \frac{MR \times CA \times D_m \times ED_{ac} \times CF_1}{BW \times AT_{ac} \times CF_2}$$

Where:

ADR	=	Acute Dose Rate (mg/kg-day)
MR	=	Migration rate of chemical from article to saliva (mg/cm^2/h)
CA	=	Contact area of mouthing (cm^2)
D_m	=	Duration of mouthing (min/h)
ED_{ac}	=	Exposure duration, acute (days)
CF_1	=	Conversion factor (24 h/day)
BW	=	Body weight (kg)
AT_{ac}	=	Averaging time, acute (days)
CF_2	=	Conversion factor (60 min/h)

See Section 2.2.1 for migration rate inputs and determination of these values.

Acute dose rate for incidental ingestion of dust (CEM A_ING3 Model) was calculated as follows:

The article model named E6 in CEM calculates DBP concentration in small particles, termed respirable particles (RP), and large particles, termed dust, that are settled on the floor or surfaces. The model assumes the particles bound to DBP are available via incidental dust ingestion assuming a daily dust ingestion rate and a fraction of the day that is spent in the zone with the DBP-containing dust. The model uses a weighted dust concentration, shown in Equation_Apx A-6.

Equation_Apx A-7. Acute Dust Concentration

$$Dust_{ac\_wgt} = \frac{(RP_{floor\_max} \times DBPRP_{floor\_max}) + (Dust_{floor\_max} \times DBPDust_{floor\_max}) + (AbArt_{floor\_max} \times DBPAbArt_{floor\_max})}{(TSP_{floor\_max} + Dust_{floor\_max} + AbArt_{floor\_max})}$$

Where:

$Dust_{ac\_wgt}$	=	Acute weighted dust concentration (µg/mg)
RP_{floor_max}	=	Maximum RP mass, floor (mg)
$DBPRP_{floor\_max}$	=	Maximum DBP in RP concentration, floor (µg/mg)
$Dust_{floor\_max}$	=	Maximum dust mass, floor (mg)
$DBPDust_{floor\_max}$	=	Maximum DBP in dust concentration, floor (µg/mg)
$AbArt_{floor\_max}$	=	Maximum abraded particles mass, floor (mg)
$DBPAbArt_{floor\_max}$	=	Maximum floor dust DBP concentration (µg/mg)

Equation_Apx A-8. Acute Dose Rate for Incidental Ingestion of Dust

$$ADR = \frac{Dust_{ac\_wgt} \times FracTime \times DustIng}{BW \times CF}$$

Where:

ADR	=	Acute dose rate (mg/kg-day)
$Dust_{ac\_wgt}$	=	Acute weighted dust concentration (µg/mg)
$FracTime$	=	Fraction of time in environment (unitless)
$DustIng$	=	Dust ingestion rate (mg/day)

BW = Body weight (kg)
CF = Conversion factor (1,000 µg/mg)

The above equations assume DBP can volatilize from the DBP-containing article to the air and then partition to dust. Alternately, DBP can partition directly from the article to dust in direct contact with the article. This is also estimated in A_ING3 Model assuming the original DBP concentration in the article is known, and the density of the dust and dust-air and solid-air partitioning coefficients are either known or estimated as presented in E6. The model assumes partitioning behavior dominates, or instantaneous equilibrium is achieved. This is presented as a worst-case or upper-bound scenario.

Equation_Apx A-9. Concentration of DBP in Dust

$$C_d = \frac{C_{0\_art} \times K_{dust} \times CF}{K_{solid}}$$

Where:

C_d = Concentration of DBP in dust (mg/mg)
C_{0_art} = Initial DBP concentration in article (mg/cm^3)
K_{dust} = DBP dust-air partition coefficient (m^3/mg)
CF = Conversion factor (10^6 cm^3/m^3)
K_{solid} = Solid air partition coefficient (unitless)

Once DBP concentration in the dust is estimated, the acute dose rate can be calculated. The calculation relies on the same upper end dust concentration.

Equation_Apx A-10. Acute Dose Rate from Direct Transfer to Dust

$$ADR_{DTD} = \frac{C_d \times FracTime \times DustIng}{BW}$$

Where:

ADR_{DTD} = Acute Dose Rate from direct transfer to dust (mg/kg-day)
C_d = Concentration of DBP in dust (mg/mg)
$FracTime$ = Fraction of time in environment (unitless)
$DustIng$ = Dust ingestion rate (mg/day)
BW = Body weight (kg)

Acute dose rate for ingestion of product swallowed (CEM P_ING1 module) was calculated as follows:

Equation_Apx A-11. Acute Dose Rate for Ingestion of Product Swallowed by Mouthing

$$ADR = \frac{FQ_{ac} \times M \times WF \times F_{ing} \times CF_1 \times ED_{ac}}{BW \times AT_{ac}}$$

Where:

ADR = Acute Dose Rate (mg/kg-day)
FQ_{ac} = Frequency of use, acute (events/day)
M = Mass of product used (g)
WF = Weight fraction of chemical in product (unitless)
F_{ing} = Fraction of product ingested (unitless)
CF_1 = Conversion factor (1,000 mg/g)

ED_{ac} = Exposure duration, acute (days)
AT_{ac} = Averaging time, acute (days)
BW = Body weight (kg)

The model assumes that the product is directly ingested as part of routine use, and the mass is dependent on the weight fraction and use patterns associated with the product.

A.2 Non-Cancer Chronic Dose

Chronic average daily dose rate for inhalation of product used in an environment (CEM P_INH1 Model) was calculated as follows:

Equation_Apx A-12. Chronic Average Daily Dose Rate for Inhalation of Product Used in an Environment

$$CADD = \frac{C_{air} \times Inh \times FQ \times D_{cr} \times ED}{BW \times AT \times CF_1 \times CF_2}$$

Where:

$CADD$ = Chronic average daily dose (mg/kg-day)
C_{air} = Concentration of chemical in air (mg/m^3)
Inh = Inhalation rate (m^3/h)
FQ = Frequency of use (events/year)
D_{cr} = Duration of use (min/event), chronic
ED = Exposure duration (years of product usage)
BW = Body weight (kg)
AT = Averaging time (years)
CF_1 = Conversion factor (365 days/year)
CF_2 = Conversion factor (60 min/h)

CEM uses two defaults inhalation rates that trace to the *Exposure Factors Handbook* (see Table_Apx A-1 footnote) , one when the person is using the product and another after the use has ended. Table_Apx A-1 shows the inhalation rates by receptor age category for during and after product use.

Table_Apx A-1. Inhalation Rates Used in CEM Product Models

Age Group	Inhalation Rate During Use (m^3/h) [a]	Inhalation Rate After Use (m^3/h) [b]
Adult (21+ years)	0.74	0.61
Youth (16–20 years)	0.72	0.68
Youth (11–15 years)	0.78	0.63
Child (6–10 years)	0.66	0.5
Small Child (3–5 years)	0.66	0.42
Infant (1–2 years)	0.72	0.35
Infant (<1 year)	0.46	0.23

[a] Table 6-2, light intensity values (U.S. EPA, 2011a)
[b] Table 6-1 (U.S. EPA, 2011a)

The inhalation dose is calculated iteratively at a 30-second interval during the first 24 hours and every hour after that for 60 days, taking into consideration the chemical emission rate over time, the volume of

the house and each zone, the air exchange rate and interzonal airflow rate, and the exposed individual's locations and inhalation rates during and after product use.

Chronic average daily dose rate for inhalation from article placed in environment (CEM A_INH1 Model) was calculated as follows:

Equation_Apx A-13. Chronic Average Daily Dose Rate for Inhalation from Article Placed in Environment in Air

$$CADD_{Air} = \frac{C_{gas\_avg} \times FracTime \times InhalAfter \times CF_1}{BW \times CF_2}$$

Equation_Apx A-14. Chronic Average Daily Dose Rate for Inhalation from Article Placed in Environment in Particulate

$$CADD_{Particulate} = \frac{DBPRP_{air\_avg} \times RP_{air\_avg} \times (1 - IF_{RP}) FracTime \times InhalAfter \times CF_1}{BW \times CF_2}$$

Equation_Apx A-15. Total Chronic Average Daily Dose Rate for Inhalation of Particulate and Air

$$CADD_{total} = CADD_{Air} + CADD_{Particulate}$$

Where:

$CADD_{Air}$	=	Chronic average daily dose, air (mg/kg-day)
$CADD_{Particulate}$	=	Chronic average daily dose, particulate (mg/kg-day)
$CADD_{total}$	=	Chronic average daily dose, total (mg/kg-day)
C_{gas_avg}	=	Average gas phase concentration (µg/m^3)
$DBPRP_{air\_avg}$	=	Average DBP in respirable particles (RP) concentration, air (µg/mg)
RP_{air_avg}	=	Average RP concentration, air (mg/m^3)
IF_{RP}	=	RP ingestion fraction (unitless)
$FracTime$	=	Fraction of time in environment (unitless)
$InhalAfter$	=	Inhalation rate after use (m^3/h)
CF_1	=	Conversion factor (24 h/day)
BW	=	Body weight (kg)
CF_2	=	Conversion factor (1,000 µg/mg)

Chronic average daily dose rate for ingestion after inhalation (CEM A_ING1 Model) was calculated as follows:

The CEM Article Model, E6, estimates DBP concentrations in small and large airborne particles. Although these particles are expected to be inhaled, not all are able to penetrate the lungs and be trapped in the upper airway and subsequently swallowed. The model estimates the mass of DBP bound to airborne small particles, respirable particles (RP), and large particles (*i.e.*, dust) that are inhaled and trapped in the upper airway. The fraction that is trapped in the airway is termed the ingestion fraction (IF). The mass trapped is assumed to be available for ingestion.

Equation_Apx A-16. Chronic Average Daily Dose Rate from Ingestion After Inhalation

$$CADD_{IAI} = \frac{\left[\left(DBPRP_{air\_avg} \times RP_{air_{avg}} \times IF_{RP}\right) + \left(DBPDust_{air\_avg} \times Dust_{air_{avg}} \times IF_{Dust}\right) + \left(DBPAbr_{air\_avg} \times Abr_{air\_avg} \times IF_{Abr}\right)\right] \times InhalAfter \times CF_1}{BW \times CF_2}$$

Where:

$CADD_{IAI}$	=	Chronic average daily dose from ingestion after inhalation (mg/kg-day)
$DBPRP_{air\_avg}$	=	Average DBP in RP concentration, air (µg/mg)
RP_{air_avg}	=	Average RP concentration, air (mg/m^3)
IF_{RP}	=	RP ingestion fraction (unitless)
$DBPDust_{air\_avg}$	=	Average DBP dust concentration, air (µg/mg)
$Dust_{air\_avg}$	=	Average dust concentration, air (mg/m^3)
IF_{Dust}	=	Dust ingestion fraction (unitless)
$DBPAbr_{air\_avg}$	=	Average DBP in abraded particle concentration, air (µg/mg)
Abr_{air_avg}	=	Average abraded particle concentration, air (mg/m^3)
IF_{Abr}	=	Abraded particle ingestion fraction (unitless)
$InhalAfter$	=	Inhalation rate after use (m^3/h)
CF_1	=	Conversion factor (24 h/day)
BW	=	Body weight (kg)
CF_2	=	Conversion factor (1,000 mg/g)

Chronic average daily dose rate for ingestion of article mouthed (CEM A_ING2 Model) was calculated as follows:

The model assumes that a fraction of the chemical present in the article is ingested via object-to-mouth contact or mouthing where the chemical of interest migrates from the article to the saliva. See Section 2.2.1 for migration rate inputs and determination of these values.

Equation_Apx A-17. Chronic Average Daily Dose Rate for Ingestion of Article Mouthed

$$\boldsymbol{CADD = \frac{MR \times CA \times D_m \times ED_{cr} \times CF_1}{BW \times AT_{cr} \times CF_2}}$$

Where:

$CADD$	=	Chronic average daily dose (mg/kg-day)
MR	=	Migration rate of chemical from article to saliva (mg/cm^2/h)
CA	=	Contact area of mouthing (cm^2)
D_m	=	Duration of mouthing (min/h)
ED_{cr}	=	Exposure duration, chronic (years)
CF_1	=	Conversion factor (24 h/day)
AT_{cr}	=	Averaging time, chronic (years)
BW	=	Body weight (kg)
CF_2	=	Conversion factor (60 min/h)

Chronic average daily rate for incidental ingestion of dust (CEM A_ING3 Model) was calculated as follows:

The article model in CEM E6 calculates DBP concentration in small particles, termed respirable

particles (RP), and large particles, termed dust, that are settled on the floor or surfaces. The model assumes these particles, bound to DBP, are available via incidental dust ingestion assuming a daily dust ingestion rate and a fraction of the day that is spent in the zone with the DBP-containing dust. The model uses a weighted dust concentration, shown in Equation_Apx A-18.

Equation_Apx A-18. Chronic Dust Concentration

$$Dust_{cr\_wgt} = \frac{\left(RP_{floor\_avg} \times DBPRP_{floor\_avg}\right) + \left(Dust_{floor\_avg} \times DBPDust_{floor\_avg}\right) + \left(AbArt_{floor\_avg} \times DBPAbArt_{floor\_avg}\right)}{\left(RP_{floor\_avg} + Dust_{floor\_avg} + AbArt_{floor\_avg}\right)}$$

Where:

$Dust_{cr\_wgt}$	=	Chronic weighted dust concentration (µg/mg)
RP_{floor_avg}	=	Average RP mass, floor (mg)
$DBPRP_{floor\_avg}$	=	Average DBP in RP concentration, floor (µg/mg)
$Dust_{floor\_avg}$	=	Average dust mass, floor (mg)
$DBPDust_{floor\_avg}$	=	Average DBP in dust concentration, floor (µg/mg)
$AbArt_{floor\_avg}$	=	Average abraded particles mass, floor (mg)
$DBPAbArt_{floor\_avg}$	=	Average floor dust DBP concentration (µg/mg)

Equation_Apx A-19. Chronic Average Daily Dose Rate for Incidental Ingestion of Dust

$$\boldsymbol{CADD = \frac{Dust_{cr\_wgt} \times FracTime \times DustIng}{BW \times CF}}$$

Where:

$CADD$	=	Chronic average daily dose (mg/kg-day)
$Dust_{cr\_wgt}$	=	Chronic weighted dust concentration (µg/mg)
$FracTime$	=	Fraction of time in environment (unitless)
$DustIng$	=	Dust ingestion rate (mg/day)
BW	=	Body weight (kg)
CF	=	Conversion factor (1,000 µg/mg)

The above equations assume DBP can volatilize from the DBP-containing article to the air and then partition to dust. Alternately, DBP can partition directly from the article to dust in direct contact with the article. This is also estimated in the A_ING3 Model assuming the original DBP concentration in the article is known, and the density of the dust and dust-air and solid-air partitioning coefficients are either known or estimated as presented in the E6 CEM Model. The model assumes partitioning behavior dominates, or instantaneous equilibrium is achieved. This is presented as a worst-case or upper-bound scenario.

A.3 Intermediate Average Daily Dose

The intermediate doses were calculated from the average daily dose, ADD, (µg/kg-day) CEM output for that product using the same inputs summarized in Table 2-5 for inhalation and Table 2-9 for dermal. EPA used professional judgment based on manufacturer and online product use descriptions to estimate events per day and per month for the calculation of the intermediate dose:

Equation_Apx A-20. Intermediate Average Daily Dose Equation

$$Intermediate\ Dose = \frac{ADD \times Event\ per\ Month}{Events\ per\ Day}$$

Where:

$Intermediate\ Dose$	=	Intermediate average daily dose, µg/kg-month
ADD	=	Average daily dose, µg/kg-day
$Event\ per\ Month$	=	Events per month, month^{-1}, see Table_Apx A-2
$Event\ per\ Day$	=	Events per day, day^{-1}, see Table_Apx A-2

Table_Apx A-2. Short-Term Event per Month and Day Inputs

Product	Events Per Day	Events Per Month
Automotive adhesives	1	2
Construction adhesives	1	2
Sealing and refinishing sprays (indoor use)	1	2
Sealing and refinishing sprays (outdoor use)	1	2

A.4 Dermal Absorption Dose Modeling for Acute and Chronic Exposures

After calculating dermal absorption dose per event for each lifestage, chronic average daily dose, acute average daily dose, and intermediate average daily dose were calculated as described below.

Acute dose rate for direct dermal contact with product or article was calculated as follows:

Equation_Apx A-21. Acute Dose Rate for Dermal

$$ADR_{Dermal} = \frac{Dose\ per\ Event \times Acute\ Frequency}{Averaging\ Time}$$

Where:

ADR_{Dermal}	=	Acute dose rate for dermal contact, mg/kg-day by body weight
$Dose\ per\ Event$	=	Amount of chemical absorbed per use, mg/kg by body weight
$Acute\ Frequency$	=	Number of exposure events per averaging period
$Averaging\ Time$	=	Acute averaging time, day^{-1}

Chronic average daily dose rate for direct dermal contact with product or article was calculated as follows:

Equation_Apx A-22. Chronic Average Daily Dose Rate for Dermal

$$CADD_{Dermal} = \frac{Dose\ per\ Event \times Chronic\ Frequency}{Averaging\ Time}$$

Where:

$CADD_{Dermal}$	=	Chronic dermal rate for dermal contact, mg/kg-day by body weight
$Dose\ per\ Event$	=	Amount of chemical absorbed per use, mg/kg by body weight
$Chronic\ Frequency$	=	Number of exposure events per averaging period
$Averaging\ Time$	=	Chronic averaging time, day^{-1}