

GreenScreen™ Assessment for
Benzoic acid, 2,3,4,5-tetrabromo-, 2-ethylhexyl ester (TBB) (CAS# 183658-27-7)

Method Version: GreenScreen™ Version 1.2¹

GreenScreen (GS) Assessment Type²: CERTIFIED

Introduction^{3,4,5}

This GreenScreen assessment, for all hazard endpoints (except reactivity), is based solely on the information reported in the corresponding chemical hazard profile in “An Alternatives Assessment for Flame Retardants Used in Flexible Polyurethane Foam³.”

Additional information on hazard endpoints (other than reactivity) beyond what was reported in the draft June 2014 report was not sought. It was necessary to supplement the hazard classification for reactivity as it is not included in the DfE approach but is needed in order to apply the GreenScreen Benchmarks.

Differences in hazard classification levels reported in the DfE profiles and in this GreenScreen report may be due to differences between criteria as defined in the DfE “Alternatives Assessment Criteria for Hazard Evaluation”⁴ and the GreenScreen for Safer Chemicals v1.2 methods⁵. Any differences in interpretation are explained and justified in this GreenScreen report.

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Licensed Profiler or Certified Practitioner (specify): N/A	Licensed Profiler or Certified Practitioner (specify): N/A

Confirm application of the *Disclosure and Assessment Rules and Best Practice*⁶: (List any deviations)

Disclosure thresholds applied by DfE are unclear in the DfE report.

Chemical Name (CAS #):

Benzoic acid, 2,3,4,5-tetrabromo-, 2-ethylhexyl ester (TBB) (CAS# 183658-27-7)

¹ Use GreenScreen™ Assessment Procedure (Guidance) V1.2

² Available at: <http://www.greenscreenchemicals.org/about/greenscreen-terms-of-use>

³ Available at: <http://www.epa.gov/dfepubs/projects/flameret/ffr-update-complete.pdf>, accessed 11/2014.

⁴ Available at: http://www.epa.gov/dfepubs/alternatives_assessment_criteria_for_hazard_eval.pdf, accessed 10/2013.

⁵ Details available at: <http://www.cleanproduction.org/Greenscreen.v1-2.php>, accessed 10/2013.

⁶ See GreenScreen Guidance V1.2 Section 8

Also Called:

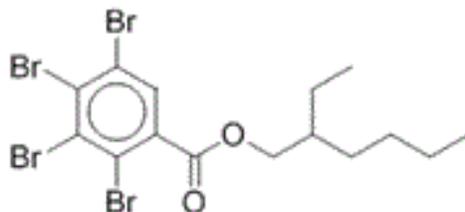
Benzoic acid, 2,3,4,5-tetrabromo-, 2-ethylhexyl ester; TBB; EH-TBB. Related trade names: this chemical is one of the components of the commercial products BZ-54, CN-2065 and Firemaster 550 (FM550).

Suitable analogs or moieties of chemicals used in this assessment (CAS #'s):

Confidential analogs

Chemical Structure(s):

*Note: Include chemical structure(s) of all suitable analogs (and /or moieties) used in the assessment.



Notes related to production specific attributes⁷:

For Inorganic Chemicals and relevant particulate organics (if not relevant, list NA)

Define Properties:

1. Particle size (e.g., silica of respirable size): NA
2. Structure (e.g., amorphous vs. crystalline): NA
3. Mobility (e.g., water solubility, volatility): NA
4. Bioavailability: TBB is estimated to have poor absorption by all routes of exposure based on analogy to a structurally similar confidential analog; however, experimental data for Firemaster 550 (a mixture made up of a sum total of TBB and TBPH of 50%) indicate that absorption of TBB can occur in rats following oral exposure from gestation through lactation.

Identify Applications/Functional Uses: (e.g., Cleaning product, TV casing)

1. Flame Retardant

⁷ Note any composition or hazard attributes of the chemical product relevant to how it is manufactured. For example, certain synthetic pathways or processes result in typical contaminants, by-products or transformation products. Explain any differences between the manufactured chemical product and the GreenScreen assessment of the generic chemical by CAS #.

GreenScreen Benchmark™ Score and Hazard Summary Table:^{8,9,10,11}

Benzoic acid, 2,3,4,5-tetrabromo-, 2-ethylhexyl ester (TBB) was assigned a **GS Benchmark Score of 2** based on moderate Group I human toxicity endpoints and in addition to high persistence and bioaccumulation. In a worst case scenario benzoic acid, 2,3,4,5-tetrabromo-, 2-ethylhexyl ester (TBB) would become a benchmark 1 if respiratory sensitization data gap was filled with data indicating a high hazard score.

Green Screen Hazard Ratings: Benzoic acid, 2,3,4,5-tetrabromo-, 2-ethylhexyl ester																			
Group I Human					Group II and II* Human								Ecotox		Fate		Physical		
C	M	R	D	E	AT	ST		N		SnS*	SnR*	IrS	IrE	AA	CA	P	B	Rx	F
						single	repeated	single	repeated										
<i>M</i>	<i>L</i>	<i>M</i>	<i>M</i>	<i>M</i>	L	NA	<i>M</i>	NA	<i>M</i>	<i>M</i>	DG	<i>M</i>	<i>M</i>	<i>L</i>	<i>L</i>	H	H	<i>L</i>	<i>L</i>

Note: Hazard levels (Very High (vH), High (H), Moderate (M), Low (L), Very Low (vL)) in *italics* reflect estimated values, authoritative B lists, screening lists, weak analogues, and lower confidence. Hazard levels in **BOLD** font are used with good quality data, authoritative A lists, or strong analogues. Group II Human Health endpoints differ from Group II* Human Health endpoints in that they have four hazard scores (i.e., vH, H, M and L) instead of three (i.e., H, M and L), and are based on single exposures instead of repeated exposures. NA reflects that there was not data for this endpoint in the DfE assessment; however, it is not considered a data gap if DfE reports assesses repeated dose data for the same endpoint.

Environmental Transformation Products and Ratings¹²: Identify feasible and relevant environmental transformation products (i.e., dissociation products, transformation products, valence states) and/or moieties of concern¹³

Functional Use	Life Cycle Stage	Transformation Pathway	Environmental Transformation Products	CAS #	Feasible and Relevant?	GS List Translator or Benchmark Score
			di- and tri-brominated analogs			

⁸ See Appendix A for a glossary of hazard endpoint acronyms

⁹ See Appendix B for alternative GreenScreen Hazard Summary Table (Classification presented by exposure route)

¹⁰ For inorganic chemicals only, see GreenScreen Guidance V1.2 Section 14.4. (Exceptions for Persistence)

¹¹ For Systemic Toxicity and Neurotoxicity, repeated exposure data are preferred. Lack of single exposure data is not a Data Gap when repeated exposure data are available. In that case, lack of single exposure data may be represented as NA instead of DG. See GreenScreen Guidance V1.2 Section 9.3.

¹² See GreenScreen Guidance V1.2 Section 13

¹³ A moiety is a discrete chemical entity that is a constituent part or component of a substance. A moiety of concern is often the parent substance itself for organic compounds. For inorganic compounds, the moiety of concern is typically a dissociated component of the substance or a transformation product.

Introduction

This is a discrete organic chemical with a MW below 1,000. EPI v4.11 was used to estimate physical/chemical and environmental fate values where adequate experimental data were lacking.

Hazard Classification Summary Section:

Group I Human Health Effects (Group I Human)

Carcinogenicity (C) Score (H, M or L): *M*

Benzoic acid, 2,3,4,5-tetrabromo-, 2-ethylhexyl ester was assigned a score of MODERATE for carcinogenicity based on a moderate score within the EPA's DfE Alternatives Assessment. The EPA's classification is based on analogy to closely related chemical classes and professional judgment. The moderate carcinogenic designation in the EPA's Alternatives Assessment is equivalent to a moderate designation within the GreenScreen. The score was based on expert judgment and is therefore reported in italics within the GreenScreen assessment.

The summary provided within the EPA's Alternatives Assessment was as follows:

MODERATE: There is uncertainty due to lack of data for this substance. TBB is estimated to have uncertain potential for carcinogenicity based on analogy to a closely related confidential analog and professional judgment; carcinogenic effects cannot be ruled out..

Mutagenicity/Genotoxicity (M) Score (H, M or L): *L*

Benzoic acid, 2,3,4,5-tetrabromo-, 2-ethylhexyl ester was assigned a score of LOW for mutagenicity based on a low score within the EPA's DfE Alternatives Assessment. The EPA's classification is based on *in vitro* data for a commercial mixture containing TBB and TBPH. The low designation for mutagenicity in both GreenScreen and EPA's Alternatives Assessment is based on the same criteria. The score was based on data for a commercial mixture of unknown purity within EPA's Alternatives Assessment and therefore is reported in italics within the GreenScreen assessment.

The summary provided within the EPA's Alternatives Assessment was as follows:

LOW: Estimated based on negative results for mutagenicity in bacteria and chromosomal aberrations in clastogenicity assays for a component of Firemaster 550 (a commercial mixture containing TBB and TBPH).

Reproductive Toxicity (R) Score (H, M, or L): *M*

Benzoic acid, 2,3,4,5-tetrabromo-, 2-ethylhexyl ester was assigned a score of MODERATE for reproductive toxicity based on a data within the EPA's DfE Alternatives Assessment. The EPA's classification is based on results from a reproductive/developmental toxicity screen in rats which observed reduced number of successful pregnancies and viable offspring, histopathological effects in male reproductive organs (testes and epididymides) and histopathological effects in female reproductive organs. For reproductive toxicity EPA's DFE uses numerical data quantifying the hazard associated with the 3 different hazard levels, whereas GreenScreen does not base the hazard score on a numerical rating system but bases classifications on listing under GHS, the EU, and NTP. Therefore the conversion of DfE's reproductive toxicity conclusion to comparable GreenScreen hazard scores is done on a case by case basis. It has been concluded herein that the two reproductive toxicity studies included within the DfE report do not fulfill the level of confidence required to assign a GHS category 1 reproductive hazard classification. The available data is more adequately characterized as a GHS category 2 and a moderate hazard under the GreenScreen. The score was

based upon study data using a commercial mixture containing TBB and TBPH within the EPA's Alternatives Assessment and therefore is reported in italics within the GreenScreen assessment.

The summary provided within the EPA's Alternatives Assessment was summarized as follows: MODERATE: No reproductive effects were reported in a 2-generation oral (gavage) reproductive toxicity study in rats at doses up to 165 mg/kg-day (highest dose tested) of Firemaster BZ 54 (commercial mixture of TBB and TBPH) with a larger constituent of TBB. The NOAEL of 165 mg/kg-day falls within the Moderate hazard criteria range; it is possible that effects driven by either component may occur within the Moderate hazard range if tested at a higher dose. It is not clear which component or components of the commercial mixture caused the reported developmental effects. Data from a reproductive/developmental toxicity screen in rats exposed to a similar compound to a component of Firemaster 550 (commercial mixture containing TBB and TBPH) indicated histopathological effects in female reproductive organs at doses ≥ 25 mg/kg-day (lowest dose tested; a NOAEL was not identified). It is uncertain if the commercial mixture contained TBB.

Developmental Toxicity incl. Developmental Neurotoxicity (D) Score (H, M or L): *M*

Benzoic acid, 2,3,4,5-tetrabromo-, 2-ethylhexyl ester was assigned a score of MODERATE for developmental toxicity based on a data provided within the EPA's DfE Alternatives Assessment. The EPA's classification is based on early female puberty, weight gain, altered exploratory behavior, and increased male left ventricle thickness in rat developmental studies. For developmental toxicity, EPA's DFE uses numerical data quantifying the hazard associated with the 3 different hazard levels, whereas GreenScreen does not base the hazard score on a numerical rating system but bases classifications on listing under GHS, the EU, and NTP. Therefore the conversion of DfE's developmental toxicity conclusions to comparable GreenScreen hazard scores is done on a case by case basis. It has been concluded herein that the developmental toxicity studies included within the DfE report fulfill the level of confidence required to assign a GHS category 2 developmental hazard classification and is adequately characterized as a moderate hazard under the GreenScreen. The reported hazard effects are based on exposures to a commercial mixture of TBB and TBPH and therefore the moderate hazard score is reported in italics within the GreenScreen assessment.

The summary provided within the EPA's Alternatives Assessment was as follows:

MODERATE: Developmental effects were reported in a 2-generation reproductive toxicity study in rats and a prenatal study in rats exposed to CN-2065 (a commercial mixture of TBB and TBPH with the predominant constituent being TBB). Developmental effects were reported at doses of 165 mg/kg-day and 100 mg/kg-day in the 2-generation and prenatal studies, respectively. Both studies had a NOAEL of 50 mg/kg-day which falls within the Moderate hazard criteria range. It is not clear which component or components of the commercial mixture caused the reported developmental effects. Development/neurodevelopmental effects were reported in a study in pregnant Wistar rats administered a FM550 mixture (sum total of TBB and TBPH approximately 50%) during gestation though lactation (GD8 - PND21); developmental effects included early female puberty, weight gain, altered exploratory behavior, and increased male left ventricle thickness (LOAEL = 1 mg/kg-day, NOAEL = 0.1 mg/kg-day). It is uncertain which component or components of the FM 550 mixture is driving the reported developmental effects. While the FM 550 mixture data indicates a High hazard potential, it may be the other components driving the reported toxicity. Experimental data indicated no effects on embryonic survival or development in exposed zebrafish embryos.

Endocrine Activity (E) Score (H, M or L): *M*

The DfE Alternative Assessment does not assign a hazard score for endocrine activity but provides information relevant to this endpoint. Using EPA provided data benzoic acid, 2,3,4,5-tetrabromo-, 2-

ethylhexyl ester was assigned a score of MODERATE for endocrine activity based on evidence of endocrine activity without clear evidence of related human health effects. Reported effects in rats include increased serum thyroxine (T4) levels and histopathological effects reported in the male rat thymus and female rat adrenal glands. The score was based on data for Firemaster 550 (commercial mixture containing TBB and TBPH) within the EPA's Alternatives Assessment and therefore is reported in italics within the GreenScreen assessment.

The summary provided within the EPA's Alternatives Assessment was as follows:
Increased serum thyroxine (T4) levels were reported in the serum of dams following oral administration to FM550 (mixture of 50% sum total of TBB and TBPH); other components of the mixture were not identified. It is unclear which component or components of the mixture are driving the endocrine activity effects. There was no experimental data located specifically for the TBB compound.

Group II and II* Human Health Effects (Group II and II* Human)

Note: Group II and Group II endpoints are distinguished in the v 1.2 Benchmark system (the asterisk indicates repeated exposure). For Systemic Toxicity and Neurotoxicity, Group II and II* are considered sub-endpoints. When classifying hazard for Systemic Toxicity/Organ Effects and Neurotoxicity endpoints, repeated exposure results are required and preferred. Lacking repeated exposure results in a data gap. Lacking single exposure data does not result in a data gap when repeated exposure data are present (shade out the cell in the hazard table and make a note). If data are available for both single and repeated exposures, then the more conservative value is used.*

Acute Mammalian Toxicity (AT) Group II Score (vH, H, M or L): L

Benzoic acid, 2,3,4,5-tetrabromo-, 2-ethylhexyl ester was assigned a score of LOW for acute mammalian toxicity based on a low score within the EPA's DfE Alternatives Assessment. Acute mammalian toxicity classification in both the EPA's DfE and GreenScreen is based on the same criteria. The acute mammalian toxicity score was based on test data for TBB and therefore is reported in bold within the GreenScreen assessment.

The summary provided within the EPA's Alternatives Assessment was as follows:
LOW: Based on a rat oral LD₅₀ >2,000 mg/kg. Acute toxicity values are estimated to be a Low hazard for components of a commercial mixture containing TBB and TBPH (Firemaster 550).

Systemic Toxicity/Organ Effects incl. Immunotoxicity (ST)

(ST-single) Group II Score (single dose: vH, H, M or L):

DfE evaluates Systemic Toxicity based on repeated exposures. Lack of data for Systemic Toxicity based on a single exposure does not constitute a data gap when data for repeated exposures are available. This endpoint was not assessed in this evaluation and is assigned an 'NA'.

(ST-repeat) Group II* Score (repeated dose: H, M, L): M

Benzoic acid, 2,3,4,5-tetrabromo-, 2-ethylhexyl ester was assigned a score of MODERATE for repeated exposure systemic toxicity/organ effects based on data within the EPA's DfE report. The moderate designation for repeated exposure systemic toxicity/organ effects in both GreenScreen and EPA's Alternatives Assessment is based on the same criteria. The DfE's score for this endpoint is based on rat NOAELs for increased incidence of sparse hair in abdominal region, reduced body weight, and reduced food consumption. It has been concluded herein that the GreenScreen moderate

score is based on estimates from a closely related confidential analog and professional judgment that TBB will have liver effects. The data for immunotoxicity included in the DfE report, further supports a moderate GreenScreen score. The score was based on expert judgment and analog and therefore is reported in italics within the GreenScreen assessment.

The summary provided within the EPA's Alternatives Assessment was as follows:

MODERATE: Estimated based on an increased incidence of sparse hair in abdominal region, reduced body weight, and reduced food consumption in dams during gestation in a prenatal study in rats exposed to CN-2065 (commercial mixture of TBB and TBPH with the predominant constituent being TBB) on GD 6-19 at doses ≥ 100 mg/kg-day (NOAEL = 50 mg/kg-day). Reduced body weight and body weight gain during the pre-mating period in parental F0 and F1 female rats treated with 165 mg/kg-day CN- 2065 (NOAEL = 50 mg/kg-day) was also reported in a 2-generation oral reproductive toxicity in rats. In addition, TBB is Estimated to have a moderate potential for liver effects and cerebral hemorrhages based on a closely related confidential analog and professional judgment and is estimated to have kidney, liver, adrenal, thymus, developmental, reproductive, and neurological effects following long-term exposure to commercial mixtures that included TBB.

In addition for immunotoxicity:

Estimated to have potential for immunotoxicity based on a structural alert for polyhalogenated aromatic hydrocarbons.

Neurotoxicity (N)

(N-single) Group II Score (single dose: vH, H, M or L):

DfE evaluates Neurotoxicity based on repeated exposures. Lack of data for Neurotoxicity based on a single exposure does not constitute a data gap when data for repeated exposures are available. This endpoint was not assessed in this evaluation and is assigned an 'NA'.

(N-repeat) Group II* Score (repeated dose: H, M, L): *M*

Benzoic acid, 2,3,4,5-tetrabromo-, 2-ethylhexyl ester was assigned a score of MODERATE for neurotoxicity based on a moderate score within the EPA's DfE Alternatives Assessment. The moderate designation in both GreenScreen and EPA's Alternatives Assessment is based on the same criteria. The score was estimated based on an analogy to a component of Firemaster 550 (commercial mixture containing TBB and TBPH) and study data within EPA's Alternatives Assessment; therefore it is reported in italics within the GreenScreen assessment.

The summary provided within the EPA's Alternatives Assessment was as follows:

MODERATE: Estimated based on analogy to a component of Firemaster 550 (commercial mixture containing TBB and TBPH). There is potential for neurological effects after breathing or swallowing large amounts or after long-term exposure to this analog. There were no neurotoxic effects reported in a 28-day oral toxicity study in rats treated with the analog.

Skin Sensitization (SnS) Group II* Score (H, M or L): *M*

Benzoic acid, 2,3,4,5-tetrabromo-, 2-ethylhexyl ester was assigned a score of MODERATE for skin sensitization based on a moderate score within the EPA's DfE Alternatives Assessment. The moderate designation for skin sensitization in both GreenScreen and EPA's Alternatives Assessment is based on the same criteria. The score was based on a commercial mixture containing TBB and

TBPH within EPA's Alternatives Assessment and therefore is reported in italics within the GreenScreen assessment.

The summary provided within the EPA's Alternatives Assessment was as follows:

MODERATE: Estimated based on positive results for skin sensitization following exposure to components of commercial mixtures containing TBB. It is not certain which component or components caused the reported effects.

Respiratory Sensitization (SnR) Group II* Score (H, M or L): DG

Benzoic acid, 2,3,4,5-tetrabromo-, 2-ethylhexyl ester was assigned a score of data gap for respiratory sensitization. This conclusion was made based on no data located.

Skin Irritation/Corrosivity (IrS) Group II Score (vH, H, M or L): M

Benzoic acid, 2,3,4,5-tetrabromo-, 2-ethylhexyl ester was assigned a score of MODERATE for Skin Irritation/Corrosivity based on a low score within the EPA's DfE Alternatives Assessment. The DfE's low dermal irritant score corresponds to a moderate score under GreenScreen Skin Irritation/Corrosivity. The score was based on a commercial mixture containing TBB and TBPH within EPA's Alternatives Assessment and therefore is reported in italics within the GreenScreen assessment.

The summary provided within the EPA's Alternatives Assessment was as follows:

LOW: Estimated to have mild skin irritation based on a closely related confidential analog, experimental data reporting mild irritation to components of a commercial mixture, and professional judgment.

Eye Irritation/Corrosivity (IrE) Group II Score (vH, H, M or L): M

Benzoic acid, 2,3,4,5-tetrabromo-, 2-ethylhexyl ester was assigned a score of MODERATE based on a low score within the EPA's DfE Alternatives Assessment. The DfE score is based on mild eye irritation in rabbits. The DfE low hazard score for eye irritation corresponds to a moderate score under GreenScreen Eye Irritation/Corrosivity. The score was based on a commercial mixture containing TBB and TBPH within EPA's Alternatives Assessment and therefore is reported in italics within the GreenScreen assessment.

The summary provided within the EPA's Alternatives Assessment was as follows:

LOW: Estimated to have mild eye irritation based on a closely related confidential analog, experimental data reporting mild irritation to components of a commercial mixture, and professional judgment.

Ecotoxicity (Ecotox)

Acute Aquatic Toxicity (AA) Score (vH, H, M or L): L

Benzoic acid, 2,3,4,5-tetrabromo-, 2-ethylhexyl ester was assigned a score of LOW for acute aquatic toxicity based on a low score within the EPA's DfE Alternatives Assessment. The low designation for acute aquatic toxicity in both GreenScreen and EPA's Alternatives Assessment is based on the same criteria. The score was based on professional judgment stating that no aquatic effects would occur due to the low water solubility of TBB. The score is therefore reported in italics within the GreenScreen assessment.

The summary provided within the EPA's Alternatives Assessment was as follows:

LOW: Based on an estimated log K_{ow} of 8.8 and the fact that the experimental effect levels in fish, daphnia, and algae were well above the estimated water solubility (0.00001 mg/L), NES are predicted for this endpoint.

Chronic Aquatic Toxicity (CA) Score (vH, H, M or L): *L*

Benzoic acid, 2,3,4,5-tetrabromo-, 2-ethylhexyl ester was assigned a score of LOW chronic aquatic toxicity based on a low score within the EPA's DfE Alternatives Assessment. The low designation for chronic aquatic toxicity in both GreenScreen and EPA's Alternatives Assessment is based on the same criteria. The score was based on professional judgment stating that no aquatic effects would occur due to the low water solubility of TBB. The score is therefore reported in italics within the GreenScreen assessment.

The summary provided within the EPA's Alternatives Assessment was as follows:

LOW: Based on estimated chronic toxicity values for fish, daphnid, and algae that indicate no effects at saturation (NES).

Environmental Fate (Fate)

Persistence (P) Score (vH, H, M, L, or vL): *H*

Benzoic acid, 2,3,4,5-tetrabromo-, 2-ethylhexyl ester was assigned a score of HIGH for persistence based on a high persistence score within the DfE report. The score was based on an estimated half-life of 120 days in soil where fugacity models indicate that TBB is expected to partition. The hazard score is based on estimated half-life values within EPA's Alternatives Assessment and therefore is reported in italics within the GreenScreen assessment.

The summary provided within the EPA's Alternatives Assessment was summarized as follows:
HIGH: The persistence hazard designation for TBB is based on estimated rates of removal in soil and the persistence of degradation products. Confidential experimental biodegradation studies reported half-lives of 3.5 days in water and 8.5 days in sediment with a shake flask die-away test and 6% degradation after 28 days in a closed bottle test. TBB has an estimated half-life of 120 days in soil where fugacity models indicate that it is expected to partition. Although TBB may undergo hydrolysis under basic conditions, the resulting hydrolysis products are expected to have high persistence. TBB has the potential to undergo photodegradation, under laboratory conditions when dissolved in organic solvents, however the importance of this process under environmental conditions cannot be determined. The vapor phase reaction half-life of TBB with atmospheric hydroxyl radicals is estimated at < 1 day, although it is expected to exist primarily in the particulate phase in air.

Bioaccumulation (B) Score (vH, H, M, L, or vL): **H**

Benzoic acid, 2,3,4,5-tetrabromo-, 2-ethylhexyl ester was assigned a score of HIGH for bioaccumulation based on a high score within the EPA's DfE Alternatives Assessment. The high designation for bioaccumulation in EPA's Alternatives Assessment is equivalent to a high score in GreenScreen. The DfE score is based on environmental monitoring data and therefore is reported in bold within the GreenScreen assessment.

The summary provided within the EPA's Alternatives Assessment was as follows:

HIGH: The bioaccumulation hazard designation is estimated based on the estimated BAF and monitoring data reporting detections in many different species including those higher on the food

chain. In addition, the stable metabolite and degradation product of TBB is expected to have a moderate Bioaccumulation designation based on an estimated BAF value.

Physical Hazards (Physical)

Reactivity (Rx) Score (vH, H, M or L): *L*

Benzoic acid, 2,3,4,5-tetrabromo-, 2-ethylhexyl ester was assigned a score of LOW for reactivity based upon data found in Material Safety Data Sheets and expert judgment related to its structure and chemical composition. DfE does not assess reactivity and this data is added to the information found in the DfE Alternatives Assessment. As this conclusion was based on limited documentation and expert judgment, it is reported in italics.

Flammability (F) Score (vH, H, M or L): *L*

Benzoic acid, 2,3,4,5-tetrabromo-, 2-ethylhexyl ester was assigned a score of LOW for flammability based its use as a flame retardant . This conclusion was based on expert judgment and is reported in italics.

Reactivity References:

Santa Cruz Biotechnology, Inc. Material Safety Data Sheet (MSDS), 2,3,4,5-Tetrabromobenzoic Acid 2-Ethylhexyl Ester, Product Number SC-391826, Revision 2, published 10/22/2014, 6 pages, Section 10. '*Reactivity: Not applicable. Stability: Stable under recommended storage conditions*', accessed 11/16/2014.

Expert judgment:

Benzoic acid, 2,3,4,5-tetrabromo-, 2-ethylhexyl ester is a halogen organic compound. Halogenated organics especially chlorinated organics became widely used as a replacement for flammable liquids because of their lack of volatility and reactivity. For this reason, benzoic acid, 2,3,4,5-tetrabromo-, 2-ethylhexyl ester is expected to be non-reactive based upon professional judgment.

**APPENDIX A: Hazard Benchmark Acronyms
(alphabetical order)**

- (AA) Acute Aquatic Toxicity
- (AT) Acute Mammalian Toxicity
- (B) Bioaccumulation
- (C) Carcinogenicity
- (CA) Chronic Aquatic Toxicity
- (Cr) Corrosion/ Irritation (Skin/ Eye)
- (D) Developmental Toxicity
- (E) Endocrine Activity
- (F) Flammability
- (IrE) Eye Irritation/Corrosivity
- (IrS) Skin Irritation/Corrosivity
- (M) Mutagenicity and Genotoxicity
- (N) Neurotoxicity
- (P) Persistence
- (R) Reproductive Toxicity
- (Rx) Reactivity
- (SnS) Sensitization- Skin
- (SnR) Sensitization- Respiratory
- (ST) Systemic/Organ Toxicity

Appendix B
Optional Exposure Stratified GreenScreen Hazard Summary Table

Exposure Route		GreenScreen Hazard Ratings: [<i>Chemical Name</i>]																			
		Group I Human					Group II and II* Human								Ecotox		Fate		Physical		
		C	M	R	D	E	AT	ST		N		SnS*	SnR*	IrS	IrE	AA	CA	P	R	Rx	F
								single	repeated	single	repeated*										
oral																					
dermal																					
inhalation																					

Appendix C Modeling Results

Attach:

- **EPISuite Results for Chemical Name (CAS #)**
- **ECOSAR Results for Chemical Name (CAS #)**
- **Other**