GreenScreen™ Assessment for *Tetrabromobisphenol A (TBBPA) CAS# 79-94-7*

Method Version: GreenScreen™ Version 1.2[1]

GreenScreen (GS) Assessment Type[2]: 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 Foam[3].

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 methods[5]. Any differences in interpretation are explained and justified in this GreenScreen report.

Certified GreenScreen® Assessment Prepared By:	**Certified GreenScreen® Assessment Quality Control Performed By:**
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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.

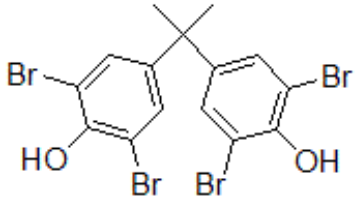
Chemical Name (CAS #):
Tetrabromobisphenol A (TBBPA) CAS# 79-94-7

[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/dfe/pubs/projects/flameret/ffr-update-complete.pdf, accessed 11/2014.
[4] Available at: http://www.epa.gov/dfe/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:
2 Tetrabromobisphenol A; TBBPA; TBBP-A; 4,4'-Isopropylidenebis(2,6-dibromophenol); 2,2-bis(3,5-dibromo-4-hydroxyphenyl) propane; 3,3',5,5'- tetrabromobisphenol-A; phenol, 4,4'-isopropylidinebis, (dibromo-); 4,4'-(1-methylethylidene)bis(2,6-dibromophenol); 2,2',6,6'-Tetrabromobisphenol A; 2,2-Bis(3,5- dibromo-4-hydroxyphenyl)propane; 2,2-Bis(4-hydroxy-3,5-dibromophenyl)propane

Suitable analogs or moieties of chemicals used in this assessment (CAS #'s):
No analog

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



Notes related to production specific attributes[7]:

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: A laboratory study using human skin indicates TBBPA is not well absorbed dermally. The results indicated 0.73% of the applied dose penetrated through the skin. The estimated bioavailability following oral dosing is 1.6%. Human volunteers had no detectable TBBPA in plasma following ingestion of low doses; however, TBBPA metabolites (TBBPA glucuronide, TBBPA-sulfate) were detected.

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]

Tetrabromobisphenol A (TBBPA) was assigned a **GS Benchmark Score of 1_{TP}**. According to the GreenScreen methodology an evaluated chemical is assigned the most conservative Benchmark score of any feasible or relevant transformation product. In this case BPA, with a Benchmark score of 1, has been identified as a transformation product of TBBPA. Without consideration of transformation products TBBPA would be a Benchmark score of 2 based on a moderate human health group I endpoints, very high ecotoxicity, and high persistence in addition to moderate group II human health endpoints. In a worst case scenario, without consideration of transformation products, Tetrabromobisphenol A (TBBPA) would continue to be a Benchmark 2 if any of the data gaps were determined to be a high hazard score.

Green Screen Hazard Ratings: Tetrabromobisphenol A																	
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										
M	**L**	**L**	**M**	**M**	**L**	NA	**L**	NA	*L*	**L**	DG	**L**	**M**	**vH**	**H**	**H**	**M**	*L*	*L*

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 the DfE report assesses repeated dose data for the same endpoint.

[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.

Environmental Transformation Products and Ratings[12]:
Identify feasible and relevant environmental transformation products (i.e., dissociation products, transformation products, valence states) and/or moieties of concern[13]

Functional Use	Life Cycle Stage	Transformation Pathway	Environmental Transformation Products	CAS #	Feasible and Relevant?	GS List Translator or Benchmark Score
			4-isopropyl-2,6-dibromophenol			**N/A**
			4-isopropylene-2,6-dibromophenol	167782-30-1		**N/A**
			4-(2-hydroxyisopropyl)-2,6-dibromophenol			**N/A**
			di- and tribromobisphenol A			**N/A**
			dibromophenol	608-33-3 626-41-5 615-56-5 28165-52-8 615-58-7 573863-80-9		**N/A**
			2,6-dibromo-4-(bromoisopropylene)phenol			**N/A**
			2,6-dibromo-4-(dibromoisopropylene)phenol			**N/A**
			tribrominated-BPA	6389-73-8 6386-73-8		**N/A**
			dibrominated-BPA	29426-78-6		**N/A**
			BPA	79-94-7		**LT-1**

[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 v 4.11 was used to estimate physical/chemical and environmental fate values in the absence of experimental data. Measured values from experimental studies were incorporated into the estimations. TBBPA is produced by bromination of bisphenol A (BPA). (HSDB, 2013).

Hazard Classification Summary Section:

Group I Human Health Effects (Group I Human)

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

Tetrabromobisphenol A 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 results observed within 2-year animal exposure studies. The moderate carcinogenic designation in the EPA's Alternatives Assessment is equivalent to a moderate designation within the GreenScreen. The score was based on experimental data and is therefore bolded within the GreenScreen assessment.

The summary provided within the EPA's Alternatives Assessment was as follows:
MODERATE: There is evidence of increased incidences of tumors of the uterus in female rats and interstitial cell adenoma of the testes in male rats orally exposed to TBBPA for up to 105 weeks. There were also increased incidences of tumors in male mice (hepatoblastoma and combined incidence of hepatocellular carcinoma or hepatoblastoma of the large intestine and hemangiosarcoma in all organs); however, there was no evidence of carcinogenicity reported in female mice. In addition, a marginal concern was estimated based on structure-activity relationships and functional properties. The mechanism of action of TBBPA carcinogenicity is not clearly understood. While there was some evidence of carcinogenicity in animals (in male and female rats and male mice, but not in female mice), there is inadequate evidence of carcinogenicity in humans.

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

Tetrabromobisphenol A 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 negative results in both *in vitro* and the *in vivo* test data. The low designation for mutagenicity in both GreenScreen and EPA's Alternatives Assessment are based on the same criteria. The score was based on test data within EPA's Alternatives Assessment and therefore is bolded within the GreenScreen assessment.

The summary provided within the EPA's Alternatives Assessment was as follows:
LOW: Experimental studies indicate that TBBPA is not genotoxic to bacterial, mammalian, or yeast cells in vitro. TBBPA was negative in a micronucleus test in mice in vivo.

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

Tetrabromobisphenol A was assigned a score of LOW for reproductive toxicity based on data provided within the EPA's DfE Alternatives Assessment. The EPA's classification is supported by a test data in animal models suggesting no significant toxicological effect on the reproductive system. 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 few reproductive effects within the DfE report's toxicity studies are not of toxicological significance (e.g. increased expression pattern of genes) and

therefore do not fulfill the requirements of a GHS category 2. The score was based upon sufficient study data included within the EPA's Alternatives Assessment and therefore is bolded within the GreenScreen assessment.

The summary provided within the EPA's Alternatives Assessment was summarized as follows:
LOW: Experimental studies indicate TBBPA, administered orally to rats, produces no adverse effects on reproductive performance or outcomes at levels up to 3,000 mg/kg-day. In some studies, there were changes in testis weights at low doses; the significance of these changes on testicular function is unclear given the limitations of the studies.

Developmental Toxicity incl. Developmental Neurotoxicity (D) Score (H, M or L): M
Tetrabromobisphenol A was assigned a score of MODERATE for developmental toxicity based on data provided within the EPA's DfE Alternatives Assessment. 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 effects (i.e. increased hearing latencies, increase in interneurons in the dentate hilus-expressing reelin and cholinergic effects observed in neonatal NMRI mice) do not fulfill the level of confidence required to assign a GHS category 1 developmental 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 included within the EPA's Alternatives Assessment and therefore is bolded within the GreenScreen assessment.

The summary provided within the EPA's Alternatives Assessment was as follows:
MODERATE: Based on several studies reporting potentially adverse effects in the range of moderate to high hazard designations with effects on kidney, liver, thyroid and brain endpoints. Some of the studies with effects in moderate to high hazard range have limitations in experimental design and/or statistical methods but cannot be completely dismissed. A number of studies indicate no effects up to relatively high oral or dietary doses of TBBPA. Based on this weight of evidence, a moderate hazard designation is assigned.

Evidence of potential for moderate or high developmental toxicity:
Nonstandard experimental studies indicate TBBPA, administered orally, produces adverse hepatic effects (very slight focal hepatocyte necrosis and enlargement of hepatocytes) at 140.5 mg/kg-day (NOAEL = 15.7 mg/kg-day) in mouse pups and kidney effects (polycystic lesions associated with the dilatation of the tubules) at 200 mg/kg-day (NOAEL = 40 mg/kg-day) in rats postnatally exposed from PND 4-21. Increased hearing latencies (most likely related to impairment of the development of the upper (apical) part of the cochlea) were reported in a dietary 1-generation study at a BMDL10 of 8 mg/kg-day. There were also changes in plasma thyroid hormone levels (decreased TT4 at BMDL10 of 30-60 mg/kg-day, and increased TT3 at BMDL10 of 5 mg/kg-day) in rat fetuses. Alterations in pup development were observed following administration of TBBPA in the diet to pregnant rats at a dose of 10,000 ppm (NOAEL = 1,000 ppm). These effects included increase in interneurons in the dentate hilus-expressing reelin suggestive of aberration of neuronal migration. Cholinergic effects were observed in neonatal NMRI mice administered TBBPA at doses up to 11.5 mg/kg body weight (highest dose tested) on postnatal (PND) 10.

Evidence of low developmental toxicity:

Six oral exposure studies with rats and one with mice using standard exposure scenarios showed no effects in a range of endpoints including body weight, clinical signs, organ weights, alterations in development of the fetus, neonatal viability and growth, onset of puberty, estrous cycles, organ histology and brain morphometry at doses ranging from 1,000 to 10,000 mg/kg-day. Two studies with rats using oral exposure to relatively low doses (<10 mg/kg-day) of TBBPA showed no changes in thyroid and sperm endpoints.

Endocrine Activity (E) Score (H, M or L): M
Tetrabromobisphenol A was assigned a score of MODERATE for endocrine activity based on evidence of endocrine activity without clear evidence of related human health effects. The score was based upon study data included within the EPA's Alternatives Assessment and therefore is bolded within the GreenScreen assessment.

The summary provided within the EPA's Alternatives Assessment was as follows:
Both whole animal and in vitro studies indicate that TBBPA may exhibit thyroid endocrine activity. In a one-generation reproduction study in rats, TBBPA decreased circulating thyroxine (T4) and increased circulating T3 levels in males. TBBPA was negative for agonistic and antagonistic estrogenic responses following oral exposure and subcutaneous injection at doses up to 1,000 mg/kg-day in an uterotrophic assay with adult female ovariectomized mice. TBBPA has a high potency in competing with thyroxine (T4) for binding to transport protein transthyretin (TTR) in *in vitro* animal studies. In addition, TBBPA exhibited significant thyroid hormonal activity towards rat pituitary cell line GH3, which releases growth hormone in a thyroid hormone-dependent manner. TBBPA produced only mild effects during long-term treatment on larval development using the amphibian Xenopus laevis; however, short-term exposure revealed indirect evidence that TBBPA can function as a TH antagonist. There were no adverse effects on tail resorption in tadpoles that were microinjected with TBBPA during development. TBBPA did not induce Vitellogenin in immature rainbow trout after intraperitoneal injection.

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
Tetrabromobisphenol A 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 are based on the same criteria. The acute mammalian toxicity score was based on test data and therefore is bolded within the GreenScreen assessment.

The summary provided within the EPA's Alternatives Assessment was as follows:
LOW: Experimental studies indicate TBBPA, administered orally to rats and mice at levels up to 50,000 and 10,000 mg/kg, respectively, and TBBPA administered dermally to rabbits at levels up to 10,000 mg/kg does not produce substantial mortality. Data from located inhalation studies are not sufficient to consider for the hazard designation.

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 by DfE in this evaluation and is assigned an 'NA'.

(ST-repeat) Group II* Score (repeated dose: H, M, L): L
Tetrabromobisphenol A was assigned a score of LOW for repeated exposure systemic toxicity/organ effects based on a low hazard score within the EPA's DfE report. The low designation for repeated exposure systemic toxicity/organ effects in both GreenScreen and EPA's Alternatives Assessment are based on the same criteria. Data within the DfE report that minor effects after repeat dose occur at concentrations >100 mg/kg. The score was based on study data and therefore is bolded within the GreenScreen assessment.

The summary provided within the EPA's Alternatives Assessment was as follows:
LOW: Based on a weight of evidence indicating that effects occur at doses >100 mg/kg-day. Mice administered 500 mg/kg-day TBBPA for 3 months were reported to have increased liver weight and kidney effects in males (NOAEL=100 mg/kg-day). There was decreased serum alanine aminotransferase and sorbitol dehydrogenase activity at week 14 in male and female rats at 100 mg/kg-day following oral exposure for 3 months. Increased liver weights and decreased spleen weight were reported in male rats in the 500 and 1,000 mg/kg-day dose group, though no treatment-related histopathologic lesions were observed. Experimental studies indicate that TBBPA, administered orally to mice, produced effects on the liver (inflammatory cell infiltration) at ≥ 350 mg/kg-day (lowest dose tested). In a dietary study in mice, changes in hematology and clinical chemistry (decreased red blood cells, hemoglobin, hematocrit, serum triglycerides and total serum proteins) and decreased body weight gain occurred at 2,200 mg/kg-day (NOAEL: 700 mg/kg-day) while mortality was reported at the highest dose tested (7,100 mg/kg-day). In a 2-year oral gavage carcinogenicity study in mice, renal tubule cytoplasmic alteration and effects on the forestomach (ulcer, mononuclear cell cellular infiltration, inflammation, and epithelium hyperplasia) were observed at ≥ 250 mg/kg-day (lowest dose tested). Mean body weight was reduced by at least 10% in this study at 1,000 mg/kg-day. In a 2-year oral gavage carcinogenicity study in rats, mean body weight was reduced by at least 10% following exposure to ≥ 500 mg/kg-day and at 1,000 mg/kg-day. Thymus weight was reduced and liver weight was also increased in this study. Clinical signs of toxicity (excessive salivation and nasal discharge) were evident in rats following inhalation exposure at levels of 6 mg/L (NOAEC: 2 mg/L). Very slight dermal erythema was present in rabbits following application of 100 mg/kg-day TBBPA; however, this occurred in the absence of any systemic effects (NOAEL: 2,500 mg/kg-day).

In addition for immunotoxicity:the data located had limited experimental details. TBBPA inhibits expression of CD25, which is essential for proliferation of activated T lymphocyte cells, at concentrations > 3 μM. In a disease challenge study, TBBPA administered to mice (1% in diet for 28 days; approximately 1,800 mg/kg-day) produced irregular changes in cytokine production and immune cell populations, which were suggested to cause exacerbation of pneumonia in respiratory syncytial virus-infected mice. Determination of significance of the response to RSV infection is limited by the study design having only one, particularly high, dose of TBBPA. In an in vitro study, TBBPA decreased the level of cell surface proteins, possibly interfering with NK cell function.

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. It should be noted that the DfE report includes a poorly reported acute exposure study which suggests a possibility for neurological effects associated with TBBPA exposures. However due to lack of a dose-response relationship within this acute study and lack of exposure details, it has not been used herein. This endpoint was not assessed by DfE in this evaluation and is assigned an 'NA'.

(N-repeat) Group II* Score (repeated dose: H, M, L): *L*
Tetrabromobisphenol A was assigned a score of LOW for repeat dose neurotoxicity based on a test data and a low score within the EPA's DfE Alternatives Assessment. The low designation in both GreenScreen and EPA's Alternatives Assessment are based on the same criteria. While the repeat dose neurotoxicity score was based on test data available within EPA's Alternatives Assessment, an additional poorly reported acute exposure study suggests a possibility for neurological effects associated with TBBPA exposures. Therefore the low hazard score for this endpoint has been determined using expert judgment is reported in italics within the GreenScreen assessment.

The summary provided within the EPA's Alternatives Assessment was as follows:
LOW: An experimental study in rats produced no adverse neurotoxic effects in adults at levels up to 1,000 mg/kg-day. In an acute exposure study, TBBPA, administered orally to mice, resulted in neurobehavioral effects; these effects were not clearly dose-dependent. Although one study with limitations appears to result in neurobehavioral effects, a well-designed subchronic duration study did not identify any adverse neurological effects. Based on study quality, a Low hazard designation was assigned.

Skin Sensitization (SnS) Group II* Score (H, M or L): L
Tetrabromobisphenol A was assigned a score of LOW for skin sensitization based on a low score within the EPA's DfE Alternatives Assessment. The low designation for skin sensitization in both GreenScreen and EPA's Alternatives Assessment are based on the same criteria. The score was based on study data within EPA's Alternatives Assessment and therefore is bolded within the GreenScreen assessment.

The summary provided within the EPA's Alternatives Assessment was as follows:
LOW: TBBPA is not a skin sensitizer in humans or guinea pigs.

Respiratory Sensitization (SnR) Group II* Score (H, M or L): DG
Tetrabromobisphenol A 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): L
Tetrabromobisphenol A was assigned a score of LOW for Skin Irritation/Corrosivity based on a low score within the EPA's DfE Alternatives Assessment. While the DfE's low dermal irritant score corresponds to a moderate score under GreenScreen Skin Irritation/Corrosivity, the presence of human data indicating TBBPA is not an irritant was used to determine the appropriate GreenScreen score. In addition mild non-persistent irritation was only observed after 21-day exposures in only one

non-standard irritation study. The score was based on study data within EPA's Alternatives Assessment and therefore is bolded within the GreenScreen assessment.

The summary provided within the EPA's Alternatives Assessment was as follows:
LOW: Slightly irritating to rabbits in a 21-day dermal repeated dose study.

Eye Irritation/Corrosivity (IrE) Group II Score (vH, H, M or L): M
Tetrabromobisphenol A was assigned a score of MODERATE based on a data and a moderate score within the EPA's DfE Alternatives Assessment. The DfE score is based on study reporting TBBPA as slightly irritating in rabbits with transient effects in rabbits typically resolved 72 hours post-administration. The DfE moderate hazard score for eye irritation corresponds to a moderate score under GreenScreen Eye Irritation/Corrosivity. The score was based on test data within EPA's Alternatives Assessment and therefore is bolded reported in italics within the GreenScreen assessment.

The summary provided within the EPA's Alternatives Assessment was as follows:
MODERATE: Slight pain, conjunctivitis and corneal damage lasting for three days were reported in rabbits administered TBBPA in a 10% solution. In addition, moderate conjunctival erythema, clearing within 72 hours, was also reported following application of TBBPA to the eyes of rabbits.

Ecotoxicity (Ecotox)

Acute Aquatic Toxicity (AA) Score (vH, H, M or L): vH
Tetrabromobisphenol A was assigned a score of VERY HIGH for acute aquatic toxicity based on a very high within the EPA's DfE Alternatives Assessment. The very high designation for acute aquatic toxicity in both GreenScreen and EPA's Alternatives Assessment are based on the same criteria. The score was based on study data and therefore is bolded within the GreenScreen assessment.

The summary provided within the EPA's Alternatives Assessment was as follows:
VERY HIGH: Based on measured LC50 values <1 mg/L in fish, daphnia and algae.

Chronic Aquatic Toxicity (CA) Score (vH, H, M or L): H
Tetrabromobisphenol A was assigned a score of HIGH for chronic aquatic toxicity based on data provided within the EPA's DfE Alternatives Assessment. The high designation for chronic aquatic toxicity in both GreenScreen and EPA's Alternatives Assessment are based on the same criteria.. The score was based on study data and therefore is bolded within the GreenScreen assessment.

The summary provided within the EPA's Alternatives Assessment was as follows:
HIGH: Based on experimental LOECs and/or NOECs <1.0 mg/L in fish and daphnia.

Environmental Fate (Fate)

Persistence (P) Score (vH, H, M, L, or vL): H
Tetrabromobisphenol A was assigned a score of HIGH for persistence based on a high persistence score within the DfE report. The score was based on experimental aerobic and anaerobic biodegradation studies in soil and sediment indicate that the aerobic primary biodegradation half-life is less than 180 days, but not less than 60 days. Persistence classification based on half-life in soil and sediment in both the EPA's DfE and GreenScreen are based on the same criteria. The hazard

score is based measured half-life value within EPA's Alternatives Assessment and therefore is bolded within the GreenScreen assessment.

The summary provided within the EPA's Alternatives Assessment was summarized as follows:
HIGH: Experimental aerobic and anaerobic biodegradation studies in soil and sediment indicate that the aerobic primary biodegradation half-life is less than 180 days, but not less than 60 days. Mineralization under both aerobic and anaerobic conditions in soil and sediment is low, indicating that persistent degradation products are formed. An experimental photolysis half-life of 24 minutes at pH 7.4 in water indicates that TBBPA may photolyze rapidly to 4-isopropyl-2,6-dibromophenol, 4-isopropylene-2,6- dibromophenol and 4-(2-hydroxyisopropyl)-2,6-dibromophenol; however, it is not anticipated to partition significantly to water. Although adequate experimental data are not available, degradation of TBBPA by hydrolysis is not expected to be significant as the functional groups present on this molecule do not tend to undergo hydrolysis. The atmospheric half-life for the gas phase reactions of TBBPA is estimated at 3.6 days, though it is expected to exist primarily as a particulate in air.

Bioaccumulation (B) Score (vH, H, M, L, or vL): M
Tetrabromobisphenol A was assigned a score of MODERATE for bioaccumulation based on a moderate score and data provided within the EPA's DfE Alternatives Assessment. The moderate designation for bioaccumulation in EPA's Alternatives Assessment is equivalent to a moderate score in GreenScreen. The score is based on study data and environmental monitoring data therefore is bolded within the GreenScreen assessment.

The summary provided within the EPA's Alternatives Assessment was as follows:
MODERATE: The measured fish BCF and estimated BAF values are greater than 100 but less than 1,000.

Physical Hazards (Physical)

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

World Health Organization, 1995. International Programme on Chemical Safety, Environmental Health Criteria 172-Tetrabromobisphenol A and Derivatives, '[TBBPA]…*does not react chemically with the other compounds*…', accessed 11/26/2014.

Sigma-Aldrich, Material Safety Data Sheet (MSDS), Tetrabromobisphenol A, Revision 1.5, Updated 5/7/2009, 5 pages, Section 3-Hazrds Identification '*HMIS Rating-Reactivity: 0; NFPA Rating-Reactivity: 0',* Section 10-Stability and Reactivity: *'Stable*', accessed 11/26/2014.

Fluorochem Safety Data Sheet (SDS), Tetrabromobisphenol A, Product Code BR1202, Revision 1.0, Modified 10/24/2011, 7 pages, Section 10-Stability and Reactivity: *No unusual reactivity, stable under normal conditions*', accessed 11/26/2014.

ICL Industrial Products Safety Data Sheet (SDS), Tetrabromobisphenol A, Product Name FR-1524, Product ID 8353, Revision 9, Revision date 12/18/2013, 9 pages, Section 10-Stability and Reactivity: *'Stable under normal conditions*', accessed 11/26/2014.

Expert judgment:

Tetrabromobisphenol A is a halogenated compound caused by the halogenations of the compound bisphenol A (BPA). The New Jersey Department of Health Right to Know Fact Sheet assigns BPA a reactivity of '*0'* in its Hazard Summary. The Sigma-Aldrich BPA Material Safety Data Sheet assigns BPA HMIS and NFPA Ratings of '*Reactivity: 0*' in Section 3-Hazards Identification. The addition of four bromine atoms to the BPA structure would have the effect of making TBBPA even less reactive than BPA. For these reasons, TBBPA 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: [*Chemical Name*]																			
	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†										
oral																				
dermal																				
inhalation																				

Appendix C
Modeling Results

Attach:

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