DRAFT

Binational Strategy for HBCD Risk Management

March 2017

A document to assist in the engagement of key stakeholders and the public in strategy development

This draft prepared by the Environment and Climate Change Canada and the United States Environmental Protection Agency

Disclaimer

The purpose of this document is to provide hexabromocyclododecane (HBCD) risk mitigation and management strategies in accordance with Annex 3 of the Great Lakes Water Quality Agreement (GLWQA). The mention of trade names, commercial products, or organizations does not imply endorsement by the United States or Canadian governments.

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Acknowledgements

Executive Summary

The Canada – United States Great Lakes Water Quality Agreement (GLWQA) seeks to reduce the anthropogenic release of chemicals of mutual concern (CMCs), including hexabromocyclododecane (HBCD), into the air, water, land, sediment, and biota that may impair the quality of the Waters of the Great Lakes. HBCD is a manmade category of brominated flame retardants that has been found to have persistent, bioaccumulative, and toxic (PBT) characteristics. Due to the high stability of the compound, HBCD can be found within sediments, waters, biota tissues, wastes, and air in the region. Formal Federal risk mitigation measures and management activities have yet to come into effect within the United States. In Canada, HBCD is managed under the *Regulations Amending the Prohibition of Certain Toxic Substances Regulations, 2012* which came into force on January 1, 2017.

This document provides a Binational Strategy for HBCD to focus efforts of the Governments of Canada and the United States, in cooperation and consultation with State and Provincial Governments, Tribal Governments, First Nations, Métis, Municipal Governments, watershed management agencies, other local public agencies, and the public in implementing risk mitigation and management actions aimed at reducing HBCD in the Great Lakes region.

The binational objective of the HBCD Strategy, comprising joint and individual actions of the Parties, is to reduce the anthropogenic release of HBCD in the Great Lakes Basin ecosystem and better understand the presence, fate and transport of HBCD in the environment. Binational cooperation is needed to coordinate monitoring and surveillance efforts, maximize research initiatives to identify HBCD sources, and cost-effectively monitor and track HBCD concentrations in multiple media (air, water, soil, tissues, waste, etc.). Additional database refinement is needed to ensure all data regarding HBCD loadings and sources are accessible. Stakeholders committed to protecting and restoring the Great Lakes ecosystem are invited to identify, review, and prioritize the HBCD risk mitigation and management options outlined in this document. It is also anticipated that, through identification, review, and prioritization of risk mitigation and management options, stakeholders can begin to implement these options in the Great Lakes Basin and in their respective communities.

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Acronyms and Abbreviations

AOC	Areas of Concern
CMC	Chemicals of Mutual Concern
CSMI	Cooperative Science and Monitoring Initiative
EB	Executive Body
ECCC	Environment and Climate Change Canada
EPA	United States Environmental Protection Agency
EPS	Expanded Polystyrene
FEQG	Federal Environmental Quality Guideline
GLENDA	Great Lakes Environmental Database
GLLA	Great Lakes Legacy Act
GLNPO	Great Lakes National Program Office
GLRI	Great Lakes Restoration Initiative
GLWQA	Great Lakes Water Quality Agreement
HBCD	Hexabromocyclododecane
HIPS	High-Impact Polystyrene
ITT	Identification Task Team
LAMP	Lakewide Action and Management Plan
LC-PFCA	Long-Chain Perfluorinated Carboxylic Acid
LRTAP	Long-Range Transboundary Air Pollution
NGO	Non-Government Organization
P2	Pollution Prevention
PBDE	Polybrominated Diphenyl Ether
PBT	Persistent Bioaccumulative and Toxic
PCB	Polychlorinated Biphenyl
PFOA	Perfluorooctanoic Acid
PFOS	Perfluorooctane Sulfonate
POP	Persistent Organic Pollutants
SCCP	Short-Chain Chlorinated Paraffin
SiGL	Science in the Great Lakes
SNUR	Significant New Use Rule
SOLEC	State of the Lakes Ecosystem Conferences
TRI	Toxic Release Inventory
TSCA	Toxic Substances Control Act
UNECE	United Nations Economic Commission for Europe
U.S.	United States of America
USGS	United States Geological Survey
VE	Virtual Elimination
XPS	Extruded Polystyrene

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1. Introduction

Annex 3 of the Canada – United States Great Lakes Water Quality Agreement (GLWQA) seeks to reduce the anthropogenic release of chemicals of mutual concern (CMCs) into the Waters of the Great Lakes and its ecosystem. Under Annex 3, Canada and the United States are tasked to (1) identify CMCs that originate from anthropogenic sources and are harmful to human health and the environment, and (2) develop a Binational Strategy for each CMC in cooperation and consultation with State and Provincial Governments, Tribal Governments, First Nations, Métis, Municipal Governments, watershed management agencies, other local public agencies, industry, non-government organizations (NGOs), and the public. Binational strategies for CMCs may include research, monitoring, surveillance, and pollution prevention and control provisions. The United States Environmental Protection Agency (EPA) and the Environment and Climate Change Canada (ECCC) are the responsible agencies for coordinating the GLWQA between the two respective nations. Within the United States, the EPA's Great Lakes National Program Office (GLNPO) coordinates these efforts. Within Canada, ECCC's Ontario Regional Director General's Office coordinates these efforts.

In 2016, the first CMCs were designated by the two governments. These are:

- Hexabromocyclododecane (HBCD)
- Long-chain perfluorinated carboxylic acids (LC-PFCAs)
- Mercury
- Perfluorooctanoic acid (PFOA)
- Perfluorooctane sulfonate (PFOS)
- Polybrominated diphenyl ethers (PBDEs)
- Polychlorinated biphenyls (PCBs)
- Short-chain chlorinated paraffins (SCCPs).

The focus of this document is a Binational Strategy for HBCD. The objective of this Binational Strategy is not only to focus Canada and United States Federal Government efforts, also to assist individuals, and stakeholder groups in the public, private, non-profit, State/Provincial, or Tribal sectors to develop and implement HBCD mitigation and management (e.g., pollution prevention) and/or science (e.g., monitoring and/or research) actions. Environmental and Natural Resource Program Managers, community, non-governmental organization and industry leaders, their collaborators or others able to implement projects or maintain and refine existing programs, efforts, and projects aimed at reducing HBCD may find this document useful in setting priorities for HBCD risk management activities. An extensive summary of environmental data and other pertinent information considered as part of the process of designating HBCD as a CMC is available in the Binational Summary Report: Brominated Flame Retardants (PBDEs and HBCD) (Appendix A) produced by the Identification Task Team (ITT) (2015). Appendix B contains the EPA's final Action Plan for HBCD, prepared by the Existing Chemicals Program under the authority of the Toxic Substances Control Act (TSCA). Appendix C contains an alternatives assessment for HBCD as prepared by the EPA.

2. Chemical Profile

2.1 Chemical Identity

Hexabromocyclododecane (HBCD) is a brominated flame retardant consisting of a 12-membered carbon ring with 6 bromine atoms attached. HBCD is widely used as an additive to impart flame-retardant properties to plastics and textiles (Covaci, et al., 2006). HBCD is typically marketed as either a non-specific mixture of HBCD isomers (CASRN 25637-99-4) or as HBCD with bromine atoms at the 1, 2, 5, 6, 9, and 10 positions (CASRN 3194-55-6) (US EPA, 2014). There are 16 possible HBCD stereoisomers (Figure 2-1) (ECCC, 2016b). HBCD mixtures are often dominated by the γ-isomer (approximately 75-89% of the total) with lesser concentrations of α- and β-isomers (typically about 10-13% and 1-12%, respectively) (Letcher, et al., 2015).

Prior to 2013 when global HBCD phase-out efforts began, HBCD was one of the largest volume flame retardants manufactured globally (ECCC, 2016a).

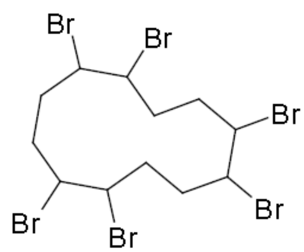

Figure 2-1. Representative Structure of HBCD.

2.2 Physical and Chemical Properties

HBCD is an off-white, lipophilic powder with low water solubility and a high affinity to particulate matter (ECCC, 2016b; NRC, 2000; UNEP, 2015). The hydrophobic nature and high octanol water partitioning coefficient (K_{OW}) of HBCD enable it to partition into organic phases (e.g., lipids and suspended solids) within the aquatic environment (Marvin, et al., 2011). Additional properties of HBCD are listed in Table 2-1.

Table 2-1. Physical and Chemical Properties of HBCD

Property	HBCD
Formula	$C_{12}H_{18}Br_6$
Molecular Weight	641.7
Color	White to off-white
Physical State	Solid/powder
Melting Point, °C	185-195
Water Solubility, mg/L at 25°C	0.0034, average
α-	0.00488
β-	0.00147
γ-HBCD	0.00208
Partition Coefficient	
Log K_{OW}	5.6 to 5.81
Log K_{OC}	5.1
Vapor Pressure, mm Hg at 25°C	$4.7x10^{-7}$
Henry's Law Constant, Pa-m^3/mol at 25°C	0.14 to 68.8

Sources: National Research Council (2000) and ECCC **(2016b**)

2.3 Environmental Fate and Transport

HBCD is environmentally ubiquitous, with evidence suggesting adverse environmental and health impacts, including bioaccumulative and biomagnification potential (Marvin, et al., 2011). HBCD is highly persistent and has been found within sediment, biota, air, and precipitation of the Great Lakes Basin. HBCD is subject to long-range transport from its source to remote areas, including the Arctic, where concentrations in the atmosphere have been found to be elevated (ECCC, 2011b). Once released into the environment, HBCD is considered to be persistent and may slowly degrade through abiotic reactions (US EPA, 2016a). In the environment HBCD is immobile in soil, strongly binds to sediments and suspended solids in water, and slowly volatilizes from moist soils and surface water (US EPA, 2016a). Monitoring studies document the presence of HBCD in the Great Lakes Basin with highest concentrations reported near urban and industrial sources. Analyses of sediment core samples collected worldwide show a clear trend of increasing concentrations of HBCD since the 1970s, and stability in deep sediments for periods of more than 30 years (ECCC, 2011b).

2.4 Sources and Releases of HBCD in the Great Lakes

HBCD does not occur naturally in the environment. Sources of HBCD exposure and release are anthropogenic and may come from domestic (Canada and the United States) or international sources via long-range transport (ECCC, 2011b).

2.4.1 Uses and Quantities in Commerce

The primary end-use application of HBCD is as a flame retardant in expanded polystyrene (EPS) and extruded polystyrene (XPS) thermal insulation foam boards for use in the construction industry (ECCC, 2016a; US EPA, 2010; US EPA, 2014). Both products are used in insulation materials in the construction industry. Other minor and historical uses of HBCD include its use in high-impact polystyrene (HIPS) for electrical and electronic parts, in polymer dispersion coating agents for residential, commercial, and military grade textiles (upholstered furniture, transportation seating, automobile interior textiles, wall coverings, and draperies), and in EPS and XPS foam for transportation applications (ECCC, 2016b; US EPA, 2014).

HBCD has been commercially available since the 1960s, and its use in insulation boards started in the 1980s (UNEP, 2010). Global demand for HBCD grew rapidly during the 1990s and early 2000s (UNEP, 2010), which may be due in part to the phase-out of other flame retardants such as PBDEs during this period (ITT, 2015).

In 2003, global demand was 43 million pounds (21,951 metric tons) (UNEP, 2010), and recent estimates indicate that the global market for HBCD in EPS/XPS foams is 66 to 77 million pounds (30,000-35,000 metric tons) (Burridge, 2014). In the United States, an estimated 10 to 50 million pounds (22,000 to 45,000 metric tons) of HBCD were produced annually in the years 1994, 1998, 2002, and 2006 (US EPA, 2016a). As of 2015, more than 66 million pounds (30,000 metric tons) of HBCD were being produced annually, with China being the world's dominant HBCD producer and consumer (Li, et al., 2016).

Market demand for HBCD may soon begin to decline. The amendment for listing HBCD as a prohibited substance under the Stockholm Convention on Persistent Organic Pollutants (POPs) entered into force in 2015. As signatory countries to the Stockholm Convention, Canada and China are beginning to phase out the use of HBCD. While the Unites States is not a signatory country to the Stockholm Convention, manufacturers of construction foams in the United States have started converting to alternative products (Burridge, 2014; US EPA, 2014).

The maximum concentration of HBCD for use in fabrics and textiles, and in rubber and plastic products ranges from 1-30% (US EPA, 2010). A majority of HBCD used in textiles is for upholstered furniture in order to meet fire safety laws (Morose, 2006). However, less than 1% of the total commercial and consumer use of HBCD was used for fabrics, textiles, and apparel (US EPA, 2010).

In addition, HBCD is used as a flame retardant in HIPS for electrical and electronic appliances such as audio-visual equipment, and some wire and cable applications (ITT, 2015; Morose, 2006). Less than 10% of all HBCD used in Europe is used in HIPS (ITT, 2015).

2.4.2 Release Sources

Release of HBCD into the environment may occur during production and manufacturing, processing, transportation, use, improper handling, improper storage or containment, point-source discharges, migratory releases from manufactured product usage and from disposal of the substance or products containing the substance. HBCD may be released to air, water, soil, and sediment (ECCC, 2011b). Table 2-2 outlines the major HBCD release sources (UNEP, 2015).

Table 2-2. HBCD Release and Exposure Sources

Source	Release Media	Examples of Waste Types
	HBCD Manufacture	
Production process	Solid waste, off-gas, waste water	Dusts, products residues, wastewater treatment sludge, waste products, discarded waste filter cloth, wastes from filtration
Products and packing process	Solid waste, dust particles	Waste products, packaging wastes
	HBCD Use (Process)	
Building materials production	Waste gas, waste water, solid waste	Dust, production residue, wastewater sludge, waste products, packaging wastes
Furniture manufacturing	Waste gas, waste water, solid waste	Dust, production residue, wastewater sludge, waste products, packaging wastes
Textile production	Waste gas, waste water, solid waste	Dust, production residue, wastewater sludge, waste products, packaging wastes, clothing
Production of High Impact Polystyrene (HIPS)	Waste gas, waste water, solid waste	Dust, production residue, wastewater sludge, waste products, packaging wastes
	Consumer Use	
Leaching and evaporation from products	Waste gas, wastewater, solid waste	Dust particles, waste residue
Fires	Waste gas, wastewater, solid waste	Waste residues, contaminated soil, hot spot
	Waste Recycling and Disposal	
Building material waste recycling	Solid waste	HBCD-containing EPS and XPS, wastes from recycling or from separation of HBCD from polymer
Waste plastic recycling	Solid waste	Waste HIPS and other plastics, electrical and electronic plastic shells, circuit boards, wire and polyurethane foams that are not recycled after dismantling
Incineration	Exhaust, solid waste, wastewater	Solid residues (ask, flue gas cleaning residues), exhaust gas
Landfill	Solid waste, leachate, air releases (fires)	Leachates, fumes from open burning

Source: UNEP (2015)

Over the service life of end products, HBCD may be released in vapor or particulates to air or by leaching to water. Releases are expected to be initially to air; however, settling and removal of particulates would ultimately result in losses to soil or water. Losses through abrasion and degradation of polymer end products may also occur. HBCD present in foam insulation is unlikely to be exposed to the weather once building construction is complete (e.g., polystyrene foam products in an installed state). However, prior to and during construction, as well as during demolition, the insulation may be subject to weathering, physical disintegration and wear, leading to the potential release of particulates containing HBCD. Once enclosed, these construction materials may undergo a small degree of disintegration over time, with the potential for subsequent release of HBCD. It is expected that release from encapsulated materials would be low, since dust and fragmentation would likely be minimal and volatilization of HBCD from products would be low. HBCD encapsulated within textile backcoating materials will have more opportunity for weathering and wear throughout the lifetime of the polymer product, including being washed and chemically cleaned. Losses will likely be primarily to solid waste and wastewater. In the case of construction materials, however, releases to the soil, with subsequent transport by air or runoff, could also occur. These losses apply to HBCD in products manufactured in Canada and the United States, as well as to HBCD in finished and semi-finished products imported into the respective countries (ECCC, 2011b).

Products and materials containing HBCD in landfill sites may be subject to weathering, releasing HBCD primarily to soil and, to a lesser extent, to water and air. Most of the HBCD released to soil during landfill operations would be expected to sorb to particles and organic matter, remaining largely immobile. Some limited surface transport in water may occur, due to scavenging in rainfall and runoff. However, the low vapor pressure of the substance suggests that volatilization from the surface of the landfill is unlikely. There is little information on the quantity of HBCD in landfill leachate; however, given the low water solubility of the substance, it is expected that leaching from the surfaces of polymer products in the landfill is limited (ECCC, 2011b). However, end-of-life disposal is likely a major source of HBCD emissions. It has been estimated that 75% of the United Kingdom's total HBCD emissions in 2030 will come from waste landfills (Li, et al., 2016).

Combustion of HBCD under certain uncontrolled conditions may lead to production of brominated analogues of polychlorinated polybrominated dibenzo-p-dioxins and dibenzofurans. Trace levels of these compounds and their precursors have been measured during combustion of flame-retarded polystyrene materials containing HBCD (ECCC, 2011b). These transformation products are widely recognized to be hazardous to human health and the environment (ECCC, 1990).

2.4.3 HBCD in Environmental Media

While HBCD monitoring within the Great Lakes Basin has been relatively limited, some data exist and are summarized below. HBCD has been detected globally in various environmental media, with the highest concentrations of HBCD being found near urban and industrial areas. HBCD has been measured in air and sediment samples in the Arctic, Scandinavia, North America, and Asia (ECCC, 2011b; Hoh and Hites, 2005; ITT, 2015; US EPA, 2010). However, based on the Great Lakes specific information that is available, it appears that the Canadian Federal Environmental Quality Guidelines (FEQG) for HBCD are not being exceeded within the Great Lakes basin (see Table 3-1).

2.4.3.1 In Air

The low volatility of HBCD likely results in significant sorption to atmospheric particulates; therefore, the long-range transport potential of HBCD may depend upon the transport behavior of the atmospheric particulates to which it sorbs (ECCC, 2011b). In 2002-2003, air samples collected from five locations in the East-Central United States were measured for HBCD. Two of the sampled locations were located within the Great Lakes Basin. Concentrations of up to 9.6 pg/m^3 were measured within the particle phase of the Great Lakes Basin air samples (Hoh and Hites, 2005). Of the five locations, the highest mean and median values of HBCD were observed at the Chicago site, and the lowest was seen at a remote location in Michigan (range 0.2 – 8.0 pg/m^3, mean 1.2). When remote locations in the United States were compared to background air concentrations of HBCD collected in Sweden, the Swedish concentrations were slightly higher (2 -5 pg/m^3). It has been suggested that the difference in observed HBCD background concentrations may be a reflection of HBCD replacing penta- and octa-BDE products earlier in Europe than in North America (Hoh and Hites, 2005).

2.4.3.2 In Precipitation

HBCD concentrations in precipitation have also been monitored at select locations around Lake Ontario. One study, in particular, compared HBCD levels at three locations with varying population densities between 2007 and 2008 (Melymuk, et al., 2011). The most densely-populated Toronto site was on average four times higher when compared to the other two less populated sample sites (Burlington, ON and Point Petre, ON); however the concentrations at all three sites were low, ranging from 0.15 ng/L to 4.40 ng/L (Melymuk, et al., 2011). These concentrations are well below the 0.56 ng/L Canadian FEQG for HBCD in water.

2.4.3.3 In Surface Water

HBCD has been detected in the surface waters of each of the Great Lakes ranging from 0.43 to 4.2 pg/L; nearly three orders of magnitude less than the Canadian FEQG for HBCD in water (Venier, et al., 2014). Lake Ontario contained the highest concentration of HBCD followed by Lake Superior > Lake Erie > Lake Michigan, and > Lake Huron (Venier, et al., 2014). Venier, et al. (2014) observed a positive correlation between PCB and HBCD concentrations, which led to the hypothesis that the HBCD sources within the Great Lakes may be related to PCBs.

In a 2004 study conducted on Lake Winnipeg, northwest of the Great Lakes Basin, the mean dissolved phase concentration of α-HBCD was 0.011 ng/L (ECCC, 2011b; ITT, 2015). Beta- and γ-HBCD isomers were not detected (detection limit 0.003 ng/L). Detection of only α-HBCD in dissolved phase sampling is consistent with its higher aqueous solubility when compared to β, and γ-HBCD isomers (Table 2-1). It is expected that a similar isomer pattern may be found within Great Lakes surface water samples.

2.4.3.4 In Sediments

HBCD released into wastewater streams would likely be transported to a treatment facility. High octanol-water and organic carbon-water partition coefficients suggest that most of the HBCD that reaches a wastewater treatment facility will be concentrated within sludge materials; leaving only a small amount in the final effluent discharges (ECCC, 2011b). In a similar manner, HBCD within surface waters will likely partition into bed sediments (ECCC, 2011b).

Suspended sediments collected along the Detroit River, that flows from Lake St. Clair to Lake Erie, showed a strong association between HBCD presence and urban/industrial activities. In 2001, the annual mean HBCD concentration within suspended sediments collected along the Detroit River ranged from

0.012 ng/g to 1.14 ng/g dry weight, with the highest levels being found downstream of the urban region surrounding the city of Detroit. The widespread occurrence of relatively low concentrations HBCD suggests that large urban areas may act as diffuse sources of HBCD (ECCC, 2011b; Letcher, et al., 2015; Marvin, et al., 2006).

Surface sediment samples collected within the Great Lakes region have been monitored through various initiatives. In 2007, 16 surface sediment samples collected throughout the Great Lakes were assessed for HBCD. The average HBCD concentration ranged from 0.04 – 3.1 ng/g- dry weight and was similar to worldwide values (<10 ng/g dry weight) obtained from locations with diffuse HBCD sources (Yang, et al., 2012). The HBCD load within sediments collected from Lake Erie and the Detroit River in 2004 was similar ranging from 0.10 to 1.60 ng/g dry weight (Letcher, et al., 2015). Both studies determined the HBCD sediment concentrations within the Great Lakes to be significantly less than the Canadian Federal Environmental Quality Guidelines for HBCD in sediment (1.6 mg/kg dry weight).

2.4.3.5 In Biota

In the Great Lake region, HBCD has been detected in fish, bald eagle plasma, falcon nestlings, and eggs from indigenous birds. Herring gull (*Larus argentatus)* eggs from 15 breeding colonies have been regularly assessed for nearly 40 years in the Great Lakes Basin (Yang, et al., 2012). HBCD has recently been added to the list of standard chemicals being monitored within the collected eggs. In 2012 the average total HBCD concentration within each of the Great Lakes breeding colony sites was 13.2 ng/g wet weight (Yang, et al., 2012). A 2004 study of pooled homogenates of herring gull eggs collected from six colonies around the Great Lakes noted a higher concentration of α-HBCD (ranging from 2.1 ng/g to 20 ng/g wet weight) in the eggs than γ-HBCD (ranging from not detected to 0.67 ng/g wet weight); this is a stark contrast to the ratios found within the original products (Gauthier, et al., 2007). The highest levels of α-HBCD were measured at Gull Island on northern Lake Michigan, likely a result of this lake being the most urbanized and industrialized of the Great Lakes. It should be noted, however, that the southern portions of the lake are more heavily industrialized as compared to the areas from which the samples were taken. These findings confirm the presence of HBCD in the aquatic food web associated with herring gulls in the Great Lakes, with mother gulls exposed via their diet and subsequent *in vivo* transfer to the eggs (ECCC, 2011b; Gauthier, et al., 2007).

Fish are annually collected from each of the Great Lakes and are regularly monitored for a number of chemical classes of interest, one of which is HBCD (US EPA, 2016b). One group focused on HBCD concentrations within Lake Ontario lake trout (*Salvelinus namaycush*, a top predator) and several of its major prey species (Tomy, et al., 2004). Alpha- and γ-HBCD were detected at all trophic levels, with the highest concentrations present in lake trout (mean total HBCD 1.68 ng/g wet weight). Concentrations of α-HBCD were consistently higher than those of γ-HBCD, while β-HBCD was below the method detection limit (estimated at 0.03 ng/g wet weight) in all the species tested (ECCC, 2011b; Tomy, et al., 2004). In another study, archival samples from Lake Ontario lake trout contained from 16 ng/g to 33 ng/g lipid weight (2 ng/g to 4 ng/g wet weight) total HBCD (ECCC, 2011b; Ismail, et al., 2009). When the archival samples were assessed temporarily, a significant decline in HBCD concentrations was noted between 1979 and 2004, with the α-isomer dominating the observed concentrations (ECCC, 2011b; Ismail, et al., 2009). It has been hypothesized that changes in lake trout diet, temporal variation in contaminant loadings, and/or voluntary emission-limiting measures undertaken by industry, may be factors in the observed downward trend in concentrations. Together these studies confirm the occurrence of HBCD biomagnification within the Lake Ontario pelagic food web (Yang, et al., 2012).

2.5 High Level Summary of Risks

HBCD is bioaccumulative; field studies show evidence that bioaccumulation and biomagnification occur within food webs (ECCC, 2011b; Yang, et al., 2012). Human exposure of HBCD is evidenced through measurable concentrations in breast milk, adipose tissue, and blood (US EPA, 2014). There is possible human health concern, as animal studies have indicated potential reproductive, developmental, and neurological effects to HBCD (US EPA, 2014). HBCD has demonstrated toxicity in both aquatic and terrestrial species, with significant adverse effects on survival, reproduction, and development reported in algae, daphnids, and annelid worms. Laboratory studies have shown that algae, fish, invertebrates, and soil-dwelling organisms exhibit adverse effects at environmentally relevant concentrations of HBCD (US EPA, 2012). Recent studies indicate acute toxicity to fish embryos, and sub-lethal impacts on the normal functioning of liver enzymes and thyroid hormones in fish at environmentally relevant concentrations (Deng, et al., 2009; Palace, et al., 2008; US EPA, 2012). In mammals, high dose studies have shown reproductive, developmental, and behavioral effects (ECCC, 2011b; US EPA, 2012).

The risk assessment of HBCD in Canada (ECCC, 2011b) indicated that the widespread presence of HBCD in the environment warrants concern in light of strong evidence that the substance is environmentally persistent and bioaccumulative. In addition, the analysis of risk quotients in Canada (2011b) showed that current HBCD concentrations in the Canadian environment have the potential to cause adverse effects in populations of pelagic and benthic organisms, but are currently unlikely to result in direct adverse effects to soil organisms and wildlife.

The primary human exposure to HBCD may be through inhalation of airborne dust, ingestion, dermal contact, and in very limited scenarios inhalation of vapor (US EPA, 2014). The textile applications of HBCD are expected to present a greater risk of human HBCD exposure than flame-retarded insulation. HBCD is an additive flame retardant that is not chemically bonded to the treated material, and therefore there is a potential risk for migration and human exposure (ECCC, 2011b; US EPA, 2014).

Currently, there is no readily available HBCD occupation exposure information for workers (US EPA, 2014).

3. Existing HBCD Management/Control Policies, Regulations, and Programs

3.1 United States

3.1.1 Existing Statutes and Regulations

The most notable regulation for HBCD in the United States is the TSCA. In March 2012, EPA proposed a significant new use rule (SNUR) for HBCD under section 5(a)(2) of TSCA. On September 23, 2015, this

SNUR became a significant new final rule. This rule designates "use in consumer textiles, other than for use in motor vehicles" as a significant new use. The rule required persons intending to manufacture, import, or process HBCD for use in consumer textiles to register their activities within 90 days before beginning their activities. The required notification provides EPA with the opportunity to evaluate the intended use and, if appropriate, to prohibit or limit that activity before it occurs (US EPA, 2016c).

On November 28, 2016, EPA finalized a rule adding a HBCD category to the Toxic Release Inventory (TRI) list of reportable chemicals with a 100-pound reporting threshold (US EPA, 2016d). An estimated 101 facilities from across the United States will begin collecting HBCD release information on January 1, 2017, with the first reports due July 1, 2018 (US EPA, 2016e). This rule will significantly increase the currently available HBCD release source information for the United States. No additional HBCD specific regulations currently exist within any of the Great Lakes Basin States.

3.1.2 Pollution Prevention Actions

Due to the limited knowledge base of HBCD use and release information in the United States, few pollution prevention actions have formally been conducted.

3.1.2.1 Pollution Prevention (P2) Programs

The EPA and individual States have active Pollution Prevention (P2) programs that seek to reduce, eliminate, and/or prevent pollution at its source. It is anticipated with the accumulation of HBCD data in TRI and flame retardant alternatives research, P2 programs in the United States will come into effect in the future.

3.1.2.2 Lakewide Action and Management Plans

The purpose of each Lakewide Action and Management Plan (LAMP) program is to coordinate efforts to assess, restore, protect, and monitor the ecosystem health for each of the Great Lakes (US EPA, 2004; US EPA, 2016f). As one of the CMCs, HBCD will be a priority for monitoring under the Lake Superior LAMP program (The Lake Superior Partnership, 2016).

3.1.2.3 Alternatives to HBCD

Due to the limited knowledge base for HBCD, the United States Federal government has been actively evaluating HBCD. In 2011, EPA formally began assessing and designing environmental alternatives to HBCD. EPA's assessment of flame retardant alternatives for HBCD was opened to public comment in 2013 before the Final Design document was published in 2014 (Appendix C). This document evaluates and compares potential hazards associated with HBCD and three proposed alternatives. Based upon the outlined criteria and guidance, the document identifies butadiene styrene brominated copolymer as a potential replacement to HBCD in EPS and XPS insulation manufacturing. While environmental studies are needed, butadiene styrene brominated copolymer is anticipated to be safer than HBCD for multiple endpoints (US EPA, 2014).

3.1.3 Risk Management Actions

The Great Lakes Restoration Initiative (GLRI) is a United States initiative launched in 2010 for providing funds for accelerating efforts to protect and restore the Great Lakes ecosystem. Under the GLRI, GLNPO assists in the removal of sediments containing pollutants under the Great Lakes Legacy Act (GLLA). The GLLA is a voluntary cost-share program in the United States designed to remediate contaminated sediments within the 43 designated Great Lakes Areas of Concern (AOCs). Between 2004 and 2015, GLLA has remediated over 4 million cubic yards (3 million cubic meters) of contaminated sediment (US EPA, 2016h). While HBCD contamination was not a targeted contaminant within these remediation efforts, HBCD has been shown to be co-located with some PCBs; therefore AOC remediation efforts may also address HBCD (Venier, et al., 2014).

3.1.4 Monitoring, Surveillance and Other Research Efforts

Environmental monitoring and surveillance of Great Lakes have been conducted through a number of United States parties. Local, regional, institutional, Tribal, and Federal entities have conducted independent and cooperative studies assessing the conditions and status of the Great Lakes for many years.

Much of the data collected has been placed in the Great Lakes Environmental Database (GLENDA). GLENDA is a database for the collection and storage of environmental data maintained by GLNPO. Air, water, biota, and sediment data are all compiled within the system for users of Great Lakes data (US EPA, 2016g). Science in the Great Lakes (SiGL) Mapper is an additional searchable database tool developed by the US Geological Survey (USGS) that allows Great Lakes stakeholders to coordinate and collaborate monitoring and restoration activities on the Great Lakes (US EPA, 2015). These databases enable researchers to use historic data from across the region to solve complex chemical, biological, and physical relationships that might lead to more advanced methods for pollution identification and remediation actions.

Great Lakes Specific Efforts. The EPA, through GLNPO, is mandated, via Section 118 of the Clean Water Act, “to establish a Great Lakes system-wide surveillance network to monitor the water quality of the Great Lakes, with specific emphasis on the monitoring of toxic pollutants.” As part of its core mission, GLNPO operates a number of monitoring programs for toxic chemicals in Great Lakes media (fish, air, sediment, water, tissues). These long-term programs are focused on the tracking of trends of environmental pollutants across the basin to assess environmental health. While HBCD has not been of interest in the past, future initiatives may expand the chemical agents of interest included in such projects.

Additionally, GLNPO supports work on toxic chemicals, including HBCD, with other partners via grants, interagency agreements, and collaborations to address chemical issues, as they relate to human health.

The reporting of results from GLNPO programs and projects is conducted through a variety of mechanisms, including the State of the Lakes Reports, LAMPs, and peer-reviewed literature. Data are made public via EPA websites and databases, such as GLENDA.

3.1.5 EPA Guidelines and Standards

To date there are no formal EPA Federal or State regulations in effect for HBCD or HBCD-containing wastes.

3.2 Canada

EPS and XPS foam in building and construction applications accounted for approximately 99% of HBCD use in Canada in 2012 (ECCC, 2016a). While HBCD is not manufactured in Canada, it is imported into Canada mainly for the production of intermediate and finished EPS and XPS products. A study conducted for ECCC estimated that in 2012 approximately 800,000 pounds (363 metric tons) of HBCD were imported for the production of XPS foam and EPS resin (ECCC, 2016a). Of this total, approximately 60,000 pounds (27 metric tons) of HBCD were exported within EPS resin, which translates to approximately 740,000 pounds (336 metric tons) of net HBCD consumption in Canada (ECCC, 2016a). This study also reported that there may be a low volume of imports of high-impact polystyrene and textiles into Canada containing HBCD in very niche applications (ECCC, 2016a).

While only a small amount of HBCD is expected to be released from in-place finished and semi-finished products, post-consumer end-of-life disposal of HBCD products is likely a major source of HBCD emissions (Li, et al., 2009). It is estimated that 92.4% of imported HBCD will eventually be landfilled as a component of EPS and XPS foams, and 7.5% of the imported HBCD was exported within EPS resin. The remaining 0.1% of imported HBCD was released during the manufacture of EPS and XPS foams and resins, or during use of EPS and XPS foams (ECCC, 2016a).

3.2.1 Existing Statutes and Regulations

Under the Chemicals Management Plan in Canada, an environmental objective is a quantitative or qualitative statement of what should be achieved to address environmental concerns identified during a risk assessment. The existing Canadian ultimate environmental objective for HBCD is virtual elimination (VE) of releases into the environment (ECCC, 2011b). Risk management objectives are expected to be achieved for a given substance by the implementation of regulations, instrument(s) and/or tool(s). The existing risk management objective for HBCD is to achieve the lowest level of release of the substance, which is technically and economically feasible, into the Canadian environment (ECCC, 2011a).

The *Regulations Amending the Prohibition of Certain Toxic Substances Regulations, 2012,* entered into force in December 2016, with the addition five substances, including HBCD (ECCC, 2016a). Prior to the amendments, there were no risk management instruments in place respecting preventative or control actions for HBCD in Canada. Under the amended regulations, the manufacture, use, sale, offer for sale or import of HBCD, as well as EPS and XPS and their intermediary products containing HBCD used in building / construction applications are prohibited as of January 1, 2017.

The Regulations do not prohibit:

- The import, manufacture, use, sale or offer for sale of products containing HBCD other than EPS and XPS (and intermediary products) for a building / construction application;
- The use, sale or offer for sale of HBCD manufactured or imported before January 1, 2017;
- The use, sale or offer for sale of EPS and XPS (and intermediary products) for a building / construction application, if manufactured or imported before January 1, 2017;

- The import, manufacture, use, sale or offer for sale of HBCD or EPS and XPS foam (or intermediary product) containing it, if HBCD is incidentally present.

The amended regulations do not apply to feedstock contaminants that are destroyed during processing, or to aspects that are regulated by or under any other act, such as hazardous wastes and pest control products. Furthermore, the amended regulations do not apply to HBCD or products containing HBCD that are to be used in a laboratory for analysis, in scientific research or as a laboratory analytical standard.

3.2.2 Pollution Prevention Actions

At this time, the Government of Canada is building its knowledge on end-of-life management practices addressing various substances in Canada, as well as on the presence and potential releases of toxic substances and other substances of concern, in waste management facilities in Canada.

The Government of Canada has been working with the automotive sector through non-regulatory measures to work towards achieving a full phase-out. As of October 2016, they have received letters of commitments from all Canadian automotive manufactures stating their intention to phase out HBCD. The letters state that Canadian manufactures have either already phased out HBCD or commit to doing so by 2020 at the latest.

3.2.3 Risk Management Actions

Canada plays a role with regards to HBCD in two international agreements related to POPs: the United Nations Economic Commission for Europe (UNECE) Convention on Long-Range Transboundary Air Pollution (LRTAP) and the Stockholm Convention. To ensure Canada meets its international obligations, the addition of HBCD to the *Export Control List* (Schedule 3 of CEPA 1999) will be evaluated to consider the implementation of export restrictions (ECCC, 2012).

3.2.4 Monitoring, Surveillance and other Research Efforts

The Government of Canada has been monitoring HBCD in the Canadian environment (since 2008) and landfill leachate (since 2009) under the Chemicals Management Plan. This monitoring information could be used to assess the progress and effectiveness of future risk management actions that may be taken by the Government of Canada and to better understand potential environmental exposure from these sources. The media being monitored include wildlife, fish, air, and sediment (ECCC, 2011a).

3.2.5 Environment and Climate Change Canada Quality Guidelines and Standards

In May 2016, Canada published Federal Environmental Quality Guidelines (FEQGs) for HBCD in water, sediment and mammalian wildlife diet (Table 3-1). FEQGs serve three functions: first, they can be an aid to prevent pollution by providing targets for acceptable environmental quality; second, they can assist in evaluating the significance of concentrations of chemical substances currently found in the environment (monitoring of water, sediment, and biological tissue); and third, they can serve as performance measures of the success of risk management activities.

The use of FEQGs is voluntary unless prescribed in permits or other regulatory tools. Thus, FEQGs, which apply to the ambient environment, are not effluent limits or "never-to-be-exceeded" values but may be used to derive effluent limits (ECCC, 2016b).

Table 3-1. Canadian Federal Environmental Quality Guidelines for HBCD

Water (μg/L)	Sediment* (mg/kg dw)	Mammalian Wildlife Diet (mg/kg food ww)
0.56	1.6	40

*Normalized to 1% organic carbon; dw = dry weight; ww = wet weight
Source: ECCC (2016b)

3.3 International

Several frameworks have been established at the international level to limit the availability, usage, discharge, and overall number of HBCD sources.

3.3.1 United Nations Economic Commission for Europe (UNECE) Protocol on Persistent Organic Pollutants (POPS)

In 1998, the Executive Body (EB) of UNECE adopted the Protocol on Persistent Organic Pollutants, and singled out 16 substances for elimination. In December 2009, the EB of the Commission agreed that HBCD also meets the criteria for being a POP under the Convention set out in EB decision 1998/2, that is: HBCD has the potential for long-range transport and is found in remote regions; it has the potential to adversely affect human health and/or the environment; it is persistent and bioaccumulates; and its release into the environment is wide-dispersive (UNECE, 2009). Therefore, potential risk management options are currently being considered (EEA, 2016).

3.3.2 The Stockholm Convention on Persistent Organic Pollutants

HBCD was listed in Annex A (Elimination) of the Stockholm Convention on Persistent Organic Pollutants (the Stockholm Convention) in May 2013 with the intention of eliminating its use worldwide. Upon ratification of the Convention, Parties (Canada, China, but not United States) will be required to prohibit and/or eliminate the production and use, as well as the import and export of HBCD (UNEP, 2015).

Annex A allows for the registration of specific exemptions for the production or use of listed chemicals. For HBCD, parties may request a five-year specific exemption for the production of HBCD for EPS and XPS foams in buildings and/or for the use of EPS and XPS containing HBCD in buildings. Each Party that has registered for an exemption for the production of HBCD for EPS and XPS in buildings must take necessary measures to ensure that EPS and XPS containing HBCD can be easily identified by labelling or other means throughout its life cycle (UNEP, 2015).

3.3.3 The Great Lakes Water Quality Agreement

One aspect of the GLWQA is the implementation of a Cooperative Science and Monitoring Initiative (CSMI) where each of the Great Lakes is assessed on a staggered five-year cycle through an intensive, management-related scientific examination. The Lakes are monitored for chemical, physical, and biological integrity, and results are used to assess the overall state of each Lake. As one of the CMCs, HBCD will be a Lake Superior priority for monitoring under the CSMI (The Lake Superior Partnership, 2016).

4. Gap Analysis

4.1 Gaps and Needs for Action

There are a number of unknowns within both Canada and the United States in regards to unquantified HBCD sources. Due to implementation of the *Prohibition Regulations* in Canada, the only remaining sources of HBCD to the environment from Canada will be imported products containing HBCD other than EPS and XPS used in building and construction (expected to be minimal in quantity) and all products (including EPS and XPS used in building and construction) that were sold or in use prior to January 1, 2017. As of October 2016, Canada has received letters of commitments from all Canadian automotive manufactures stating their intention to phase out HBCD. The letters state that Canadian manufactures have either already phased out HBCD or commit to doing so by 2020 at the latest. The United States does not have a phase-out deadline for HBCD, nor does the United States have environmental guidelines for drinking water, open waters, sediments or biota concentrations.

Emissions from HBCD-containing materials will be a potential long-term source to the environment. No information is available on the likely future emissions from such articles. The life span of polystyrene foam in buildings is reported to be 30-50 years (UNEP, 2011). Releases from these existing stocks of EPS/XPS may be more significant in the future; particularly from 2025 onwards, as buildings with EPS and XPS containing HBCD are refurbished or demolished (UNEP, 2011).

Although HBCD is targeted under international agreements, some countries continue to manufacture and use HBCD, and long-range transport is a likely continued source of HBCD to the Great Lakes Basin. HBCD in Great Lakes air, water, sediment, fish, and wildlife species is beginning to be monitored. Additional monitoring for HBCD in environmental media is needed in the Great Lakes Basin, in areas with the potential to affect the Great Lakes Basin (e.g., the remainder of State areas not within the Basin, transporters through the Basin, etc.), and nationally. Additional monitoring should acquire information on time series and scales that allow HBCD levels to be better known and modelled nationally, particularly in cases involving products or sources distributed in commerce, including but not limited to the Basin.

Furthermore, there is a need to ensure that chemical data collected by EPA, Canada, State, Provincial, Tribal, and other government programs are consistent, standardized, and structured to allow for improved binational monitoring for HBCD and HBCD-containing products. Working to ensure uniformity of data can be helpful in ensuring that independent data collection actions can be used collectively to address and identify HBCD concerns. Ideally, a repository in which data on a binational level can be cataloged by media (e.g., air, water, land, biota) and accessed by external stakeholders should be implemented.

Several gaps exist in current risk management actions for HBCD. Some areas that have been identified include:

- *Releases from Products in Use.* Addressing releases of HBCD from construction materials or other products currently in use. This source of release is relatively minor; however, it does remain a concern. This would include HBCD releases from:
    - HBCD within EPS and XPS building/ construction materials that are currently in place
    - HBCD within EPS and XPS but used in areas other than building/ construction
    - HBCD in products that are not EPS and XPS foams (e.g., specialty fabrics)
- *Releases from Waste Products*. There is a gap in understanding the extent to which HBCD will be released within waste streams (e.g., landfilled wastes, incinerators, etc.). The majority (over 90%) of HBCD contained in materials is expected to end up in landfills (ECCC, 2016a).
- *Monitoring Needs*. There is a need to initiate/continue activities to monitor long-term isomer-specific trends in water, air, sediment, and biota (top-predator fish and herring gull eggs) in the Great Lakes, in order to establish and continue to track long-term trends; track long-range atmospheric transport and deposition; establish environmental concentration standards, and evaluate the performance of existing and forthcoming risk management activities.
- *Environmental Standards*. There are currently no environmental water quality, biota/diet or sediment concentrations standards in effect in the United States.
- *Clarification of Product Disclosure Requirements*. Clarification is needed to assist importers and users of finished products on the disclosure requirements for HBCD content of finished products.

4.2 Exceedances of or Non-compliance with Environmental Quality Guidelines

Limited data from the Great Lakes Basin exist for HBCD; therefore, it is difficult to determine if relevant guidelines and/or benchmarks are being exceeded, and to establish whether spatial or temporal trends exist at this point in time. However, from the limited available information it appears that the Canadian FEQG levels are not being exceeded within the Great Lakes surface waters or sediments (Table 4-1).

Table 4-1. Canadian Federal Environmental Quality Guidelines for HBCD and Great Lakes Environmental Concentrations

Media	Canadian FEQG	Great Lakes Concentrations
Water	0.56 mg/L	0.00000000043 to 0.0000000042 mg/L (0.43 to 4.2 pg/L)
Sediment*	1.6 mg/kg dw	0.000012 to 0.00114 mg/kg dw (0.012 to 1.14 µg/kg dw)
Mammalian Wildlife Diet	40 mg/kg food ww	Not Available

***Normalized to 1% organic carbon; dw = dry weight; ww = wet weight**
Sources: ECCC(2011b); ECCC(2016B); **Venier**(2014)

5. Risk Mitigation and Management Options to Address Gaps

The actions highlighted herein represent both new and the continuation of current risk management and other actions that will address the gaps outlined and may result in measurable (either qualitatively or quantitatively) human health and/or environmental benefits, or enhanced understanding of HBCD sources, fate, and human health or environmental effects.

5.1 Regulations and Other Risk Mitigation and Management Actions

In Canada, HBCD is managed under the *Regulations Amending the Prohibition of Certain Toxic Substances Regulations, 2012* which came into force on January 1, 2017. In the United States, use of HBCD within textiles requires EPA notification, however a formal phase out schedule has not been proposed for HBCD use within the United States.

FEQGs have been established in Canada as benchmarks for environmental HBCD concentrations, however comparable environmental standards have not been established in the United States. Therefore, efforts should focus on developing both environmental standards and drinking water standards for the Unites States.

HBCD has also recently (November 2016) been added as a TRI reportable chemical. Beginning in 2017, facilities that manufacture, process, or otherwise use HBCD in amounts above the 100-pound reporting threshold level must report environmental releases and other wastes to TRI (US EPA, 2016d).

Alternatives to HBCD are being sought for use within EPS and XPS foams, and for use in specialty fabrics. Additional work is needed to ensure that the product performance of the suggested alternatives is appropriate and that all environmental impacts of the alternative chemicals are understood.

Summary of Regulations and Other Risk Mitigation and Management Actions

- Generate phase-out deadlines for HBCD usage at the Federal level (U.S.)
- Establish environmental and drinking water standards at the Federal level (U.S.)
- Evaluate alternatives to HBCD (CAN and U.S.)

5.2 Compliance Promotion and Enforcement

Promoting compliance with HBCD restrictions stated in the Canadian *Regulations Amending the Prohibition of Certain Toxic Substances Regulations, 2012* is needed for Canada to meet its international obligations. By restricting the manufacture, use, sale, offer for sale, and import of HBCD and products containing HBCD, Canada expects to meet its obligations to the LRTAP and Stockholm Convention (ECCC, 2011a).

Within the United States, HBCD has recently (November 2016) been added as a TRI reportable chemical. Beginning in 2017, facilities that manufacture, process, or otherwise use HBCD in amounts above the 100-pound reporting threshold level must report environmental releases and other wastes to TRI (US EPA, 2016d). Enforcement of such reporting is a critical step to understanding the location and extent of potential HBCD releases, and their potential end-of-life disposal routes.

Disposal of HBCD-containing products is of concern; therefore, methods are needed within both nations to evaluate the product life cycle and to determine the most appropriate disposal mechanisms. Alternatives to HBCD are being sought within both nations for use within EPS and XPS foams, and for use in specialty fabrics. Additional work is needed to ensure that the product performance of the suggested alternatives is appropriate, and that environmental impacts of the alternative chemicals are understood.

Summary of Compliance Promotion and Enforcement Actions

- Promote compliance with the *Regulations Amending the Prohibition of Certain Toxic Substances Regulations, 2012* (Canada)
- Promote compliance with EPA's TRI database reporting (U.S.)
- Identify, establish and promote safe disposal of HBCD-containing products (Canada and U.S.)

5.3 Pollution Prevention

User-friendly documents are needed to educate and engage the general public in efforts to reduce the potential for HBCD release or exposure and present safer alternative and/or chemical free products to use. Documents should highlight the potential for HBCD exposure and outline waste mitigation measures for ensuring proper waste handling procedures during renovation projects. Such documentation may help to prevent low-level HBCD pollution from being incorporated into general solid waste streams, and provide awareness regarding potential HBCD sources.

EPA's TRI database can be used to track industrial progress in reducing waste generation. The TRI database should be maintained and leveraged to maximize P2 activities being conducted by industries in the Great Lakes region. Highlighting pollution prevention successes in the Great Lakes Basin may be beneficial in increasing awareness, coordinating P2 efforts in similar sectors throughout the Basin, and furthering the reduction of HBCD in the environment. Waste reduction success stories may be noted in region-specific journals, websites, and/or at conferences.

Summary of Pollution Prevention Actions

- Increase public outreach and educate the public and facility staff on potential sources of HBCD and proper actions to follow should HBCD-containing materials be found (U.S.)
- Educate the public on safer alternatives and/or chemical-free products
- Encourage industries to use P2 activities and track their efforts in the TRI database (U.S.)
- Highlight and share P2 successes (U.S.)
- Enhance support to manufacturers that are seeking alternatives to brominated flame retardants, including HBCD (Canada and U.S.)

5.4 Monitoring, Surveillance, and Other Research Efforts

Existing research does not present a complete understanding of the status and trends of HBCD in the Great Lakes environment. The EPA and ECCC have coordinated efforts to publish and report research efforts (ECCC and US EPA, 2014). Additional monitoring and surveillance reports have been published in peer-reviewed journals, websites, and social media. Each form of reporting is designed to target specific audiences to maximize the application of the results. Results of future monitoring efforts should continue to be published in multiple formats to effectively communicate changes observed within multiple media (air, sediment, and biota [top-predator fish and herring gull eggs]) in the Great Lakes region.

The State of the Lakes Reporting is a binational undertaking where Great Lakes decision-makers and scientists have the opportunity to receive comprehensive, up-to-date, clear and concise information on the state of the Great Lakes (ECCC and US EPA, 2014). The addition of HBCD as a CMC may increase future HBCD-focused initiatives. The continuation of such efforts by the two nations will be invaluable for understanding the overall status of HBCD in the Great Lakes Basin. Monitoring efforts undertaken by both nations should be coordinated to aid in acquiring comparable analytical data that can be used to build a national and/or international decision-making framework.

The development of a cost-effective and useful means of collecting HBCD concentrations from a variety of sources is essential. Developing a passive sampler capable of monitoring HBCD levels could be used to better understand the spatial distribution and behavior of HBCD in the Great Lakes, and the region as a whole. Source tracking HBCD contamination may be a need in the future. Efforts such as Project Trackdown that uses a multimedia weight of evidence approach for tracing PCB sources within the Great Lakes may be a model system for future HBCD studies (Benoit, et al., 2016). In addition, future monitoring efforts should be designed such that the resultant data can be compared among research teams and to historical data. Newly developed sampling methods could be verified through the EPA, through another testing organization, or through a field study/demonstration to increase the perceived confidence in the resultant data. Newly developed sampling methods could be verified through the EPA, through another testing organization, or through a field study/demonstration to increase the perceived confidence in the resultant data.

Summary of Monitoring, Surveillance, and Other Research Actions

- Monitor HBCD in Great Lakes environmental media (air, sediment, waters, fish, and other wildlife) and publish results in a variety of publications (e.g. on-line and open data portals, government reports, and scientific journals) to maximize the intended audience (Canada and U.S.)
- Develop models to track long-range atmospheric HBCD transport and deposition into the Great Lakes Basin and degradation pathways of various HBCD stereoisomers found within the Great Lakes Basin (U.S.)
- Use monitoring and modeling to better characterize select HBCD sources as a basis for potential actions, measuring progress, and formulating an international decision making framework (Canada and U.S.)
- Use existing data sources and exposure data to inform future strategic directions and plans using an adaptive management approach (Canada and U.S.)
- Develop cost-effective tools for monitoring HBCD concentrations from various sources (Canada and U.S.)
- Develop structured data systems and plans for HBCD source, manifest, and product tracking (U.S)

5.5 Domestic Water Quality

Domestic waters include all water used for indoor and outdoor household purposes. Currently there are no HBCD drinking water standards within the United States or Canada.

Summary of Domestic Water Quality Actions

- Implement appropriate domestic water quality standards for drinking water and surface waters (U.S.)

Summary of the Canada-U.S. Strategy for HBCDs

Goal: to reduce the anthropogenic release of HBCDs into the air, water, land, sediment, and biota that may impair the quality of the Waters of the Great Lakes				
Category of Action				
Regulations and Other Risk Mitigation and Management Actions	**Compliance Promotion and Enforcement**	**Pollution Prevention**	**Monitoring, Surveillance, and Other Research Efforts**	**Domestic Water Quality**
Strategic Actions				
Generate phase-out deadlines for HBCD usage at the Federal level (U.S.)	Promote compliance with the *Regulations Amending the Prohibition of Certain Toxic Substances Regulations, 2012* (Canada)	Increase public outreach and educate the public and facility staff on potential sources of HBCD and proper actions to follow should HBCD-containing materials be found (U.S.)	Monitor HBCD in Great Lakes environmental media (air, sediment, waters, fish, and other wildlife) and publish results in a variety of publications (e.g. on-line and open data portals, government reports, and scientific journals) to maximize the intended audience (Canada and U.S.)	Implement appropriate domestic water quality standards for drinking water and surface waters (U.S.)
Establish environmental and drinking water standards at the Federal level (U.S.)	Promote compliance with EPA's TRI database reporting (U.S.)	Educate the public on safer alternatives and/or chemical-free products	Develop models to track long-range atmospheric HBCD transport and deposition into the Great Lakes Basin and degradation pathways of HBCD within the Great Lakes Basin	
Evaluate alternatives to HBCD (Canada and US)	Identify, establish and promote safe disposal of HBCD-containing products (Canada and U.S.)	Encourage industries to use P2 activities and track their efforts in the TRI database (U.S.)	Use monitoring data and modeling to better characterize select HBCD sources as a basis for potential actions, measuring progress, and formulating an international decision making framework (Canada and U.S.)	
		Highlight and share P2 successes (U.S.)	Use existing data sources and exposure data to continuously inform future strategic directions and plans using an adaptive management approach (Canada and U.S.)	
		Enhance support to stakeholders that are seeking alternatives to brominated flame retardants, including HBCD (Canada and U.S.)	Develop cost-effective tools for monitoring HBCD concentrations from various sources (Canada and U.S.)	
			Develop structured data systems and plans for HBCD source, manifest, and product tracking	

Goal: to reduce the anthropogenic release of HBCDs into the air, water, land, sediment, and biota that may impair the quality of the Waters of the Great Lakes				
Category of Action				
Regulations and Other Risk Mitigation and Management Actions	**Compliance Promotion and Enforcement**	**Pollution Prevention**	**Monitoring, Surveillance, and Other Research Efforts**	**Domestic Water Quality**
Strategic Actions				
			(U.S)	

6. Conclusions

Under Annex 3 of the GLWQA, HBCD has been identified as a CMC that originates from anthropogenic sources. The binational objective of the HBCD Strategy, comprising joint and individual actions of the Parties, is to reduce the anthropogenic release of HBCD in the Great Lakes Basin ecosystem and better understand the presence, fate and transport of HBCD in the environment.

Binational efforts are needed to reduce the risks that HBCD poses to human health and the environment. Binational cooperation is needed to coordinate monitoring and surveillance efforts, maximize research initiatives to identify HBCD sources, and cost-effectively monitor and track HBCD concentrations in multiple media (wastes, soil, water, air, tissues, etc.). Appendix D summarizes these activities, with roles and responsibilities.

A broad audience of Great Lakes stakeholders who are committed to protecting and restoring the Great Lakes ecosystem is encouraged to implement the risk mitigation and management options outlined in this document. Continued progress in seeking novel approaches and/or improving upon existing ways to mitigate and manage HBCD risks will improve the health of the ecosystem and residents of the Basin, and will preserve the quality of the Great Lakes for future generations.

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Appendix A - ITT Report

The Identification Task Team Binational Summary Report: Brominated Flame Retardants (PBDEs and HBCD) can be found on the worldwide web at: https://binational.net/wp-content/uploads/2015/05/EN-BFRs-BinationalSummaryReport.pdf.

[Appendix A_ITT PBDEs and HBCD Report_2015.pdf] to be inserted into pdf version of this report.

Appendix B – US EPA HBCD Action Plan

[Appendix B_US EPA 2010 HBCD Action Plan.pdf] to be inserted into pdf version of this report.

Appendix C – Flame Retardant Alternatives

[Appendix C_US EPA 2014_Flame Retardant Alternatives for HBCD.pdf] to be inserted into pdf version of this report.

Appendix D – Summary of Strategy Options

[Appendix D_Summary of the Canada and US Strategy Options for HBCD] to be inserted into pdf version of this report.

Summary of the Canada-U.S. Strategy for HBCDs

Goal: to reduce the anthropogenic release of HBCDs into the air, water, land, sediment, and biota that may impair the quality of the Waters of the Great Lakes				
Category of Action				
Regulations and Other Risk Mitigation and Management Actions	**Compliance Promotion and Enforcement**	**Pollution Prevention**	**Monitoring, Surveillance, and Other Research Efforts**	**Domestic Water Quality**
Strategic Actions				
Generate phase-out deadlines for HBCD usage at the Federal level (U.S.)	Promote compliance with the *Regulations Amending the Prohibition of Certain Toxic Substances Regulations, 2012* (Canada)	Increase public outreach and educate the public and facility staff on potential sources of HBCD and proper actions to follow should HBCD-containing materials be found (U.S.)	Monitor HBCD in Great Lakes environmental media (air, sediment, waters, fish, and other wildlife) and publish results in a variety of publications (e.g. on-line and open data portals, government reports, and scientific journals) to maximize the intended audience (Canada and U.S.)	Implement appropriate domestic water quality standards for drinking water and surface waters (U.S.)
Establish environmental and drinking water standards at the Federal level (U.S.)	Promote compliance with EPA's TRI database reporting (U.S.)	Educate the public on safer alternatives and/or chemical-free products	Develop models to track long-range atmospheric HBCD transport and deposition into the Great Lakes Basin and degradation pathways of HBCD within the Great Lakes Basin	
Evaluate alternatives to HBCD (Canada and US)	Identify, establish and promote safe disposal of HBCD-containing products (Canada and U.S.)	Encourage industries to use P2 activities and track their efforts in the TRI database (U.S.)	Use monitoring data and modeling to better characterize select HBCD sources as a basis for potential actions, measuring progress, and formulating an international decision making framework (Canada and U.S.)	
		Highlight and share P2 successes (U.S.)	Use existing data sources and exposure data to continuously inform future strategic directions and plans using an adaptive management approach (Canada and U.S.)	
		Enhance support to stakeholders that are seeking alternatives to brominated flame retardants, including HBCD (Canada and U.S.)	Develop cost-effective tools for monitoring HBCD concentrations from various sources (Canada and U.S.)	
			Develop structured data systems and plans for	

Goal: to reduce the anthropogenic release of HBCDs into the air, water, land, sediment, and biota that may impair the quality of the Waters of the Great Lakes				
Category of Action				
Regulations and Other Risk Mitigation and Management Actions	**Compliance Promotion and Enforcement**	**Pollution Prevention**	**Monitoring, Surveillance, and Other Research Efforts**	**Domestic Water Quality**
Strategic Actions				
			HBCD source, manifest, and product tracking (U.S)	