Addressing Polybrominated Diphenyl Ethers in the Great Lakes Basin: Searching for Solutions to Key Challenges

Prepared by the Great Lakes Water Quality Board
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Executive summary

This report provides the recommendations of the Water Quality Board to address the challenges in seeking alternatives to the use of polybrominated diphenyl ethers (PBDEs) as flame retardants, and avoiding the release of PBDEs during product use, recycling and disposal through the implementation of best management practices. This includes the role that Extended Producer Responsibility (EPR) might play.

Recommendation 1: The responsible governments (federal, provincial, state, Tribes, First Nations, Métis and municipalities) should ensure that product flammability standards for products and structures, toxicity standards for flame retardants, and use of redesign options are approached in an integrated way to ensure the best achievement of both protection from flammability problems and protection of the environment.

Recommendation 2: The IJC should undertake a trial run for a different style of regulatory development that breaks out of silos by integrating the three topics in Recommendation 1, by operating in a multi-stakeholder led process, and by working across the government borders in the Great Lakes ecosystem.

Recommendation 3: The responsible governments (federal, provincial, state, Tribes, First Nations, Métis and municipalities) should educate the public on the issues with PBDE-containing products in use in their homes and how they can reduce the associated risks.

Recommendation 4: The responsible governments (federal, provincial, state, Tribes, First Nations, Métis and municipalities) and industry should complete research to increase understanding of the implications of different recycling and disposal methods.

Recommendation 5: The responsible governments (federal, provincial, state, Tribes, First Nations, Métis and municipalities) should go beyond the requirement for an inventory of products containing PBDEs, as recommended in the IJC's 2016 report. It is recommended that this be expanded to make it easier for the consumer to be aware of the presence of PBDEs by requiring labels on all products and through mechanisms such as barcode scanning apps on phones.

Recommendation 6: The responsible governments (federal, provincial, state, Tribes, First Nations, Métis and municipalities) should encourage industry to work jointly with a full range of stakeholders to develop an EPR program for flame retardant-containing products. This would explore mechanisms for addressing not only products containing PBDEs but also for new products made with alternative flame retardants. This could become a model for EPR programs for other toxics-containing products.

Project background

History

The International Joint Commission (IJC) is a binational organization that prevents and resolves disputes over boundary waters of the United States and Canada, including the Great Lakes, and is served in an advisory capacity by the Great Lakes Water Quality Board (WQB). One of the responsibilities of the IJC is to provide advice and recommendations to the governments on matters related to the water quality of the Great Lakes, and approaches and options that governments may consider to improve effectiveness in achieving the purpose and objectives of the Great Lakes Water Quality Agreement (GLWQA).

PBDEs have been widely used as flame retardants since the 1970s, and have been added to a wide range of commercial and consumer products as a means for complying with consumer product safety standards and guidelines. Numerous studies have raised concerns about their toxicity, ability to bioaccumulate, persistence in the environment, and their presence in human and wildlife tissue. Over the past two decades Canada and the United States have phased out the manufacture and import of some PBDE chemicals and developed strategies to reduce their levels in the environment, which has been correlated with declining concentrations of PBDEs in various Great Lakes environmental media. However, substantial quantities of products that contain PBDEs are still in use in the basin. The use and end-of-product-life actions can be an ongoing source of PBDE contamination to the Great Lakes environment.

In 2015 the Water Quality Board formed the Legacy Issues Work Group (LIWG), which undertook a binational assessment of: (1) the handling of products containing PBDEs during and after use, and (2) the adequacy of actions by governments and other institutions to minimize the release and consequent presence of PBDEs in the Great Lakes basin. In March 2016 the WQB submitted its report to the Commission, which contained advice and recommendations on the development of strategies by the Governments of Canada and the United States, to manage PBDE-containing products in order to reduce the release of PBDEs to the Great Lakes environment. The IJC subsequently used the WQB report as the basis for its own report, which was released in November 2016.[1]

Workshop

On February 22-23, 2017 the LIWG convened a binational workshop that brought together approximately 20 participants who had extensive knowledge and experience on the science, policy and implications of PBDEs in the Great Lakes basin, representing a broad range of sectors including various levels of government, municipal/waste management sectors, industry,

[1] International Joint Commission (2016). Polybrominated Diphenyl Ethers (PBDEs) in the Great Lakes Basin: Reducing Risks to Human Health and the Environment

nongovernmental organizations, fire fighters and academia. The goal of the workshop was to draw upon their knowledge and expertise to further explore solutions to two major challenges: (1) finding alternatives to PBDEs (chemical substitution, product design change, flammability standards) and (2) avoiding PBDE release during product use, recycling and disposal through the implementation of best management practices and the role that Extended Producer Responsibility (EPR) might play. These stemmed from five of the recommendations in the IJC's 2016 report, with specific focus on recommendations 3, 3A, 3B, 4A and 4B (Figure 1). A summary of the workshop proceedings is provided in Appendix A.

Recommendation 3 - The federal governments should develop a plan for reducing and eliminating potential releases of PBDEs in products during the recycling and disposal stages. This plan should be developed in cooperation with a wide range of stakeholders.

Recommendation 3A - The federal governments should develop and promote guidance for industry, municipalities and the public -- incorporating best practices -- for product end-of-life management, such as recycling and disposal, which provides equal protections in all parts of the Great Lakes basin.

Recommendation 3B - The responsible governments (federal, provincial and state) should develop and implement EPR programs throughout the basin to require industry to be responsible for their products' after-use and to ensure that they are properly recycled and disposed, to be undertaken in two phases:
Phase 1: Electronics, appliances, carpets, mattresses, and furniture
Phase 2: Construction, renovation and demolition wastes

Recommendation 4A - Federal, provincial and state governments should develop and distribute guidance for industry on methods to assess PBDE substitutes and encourage use of methods for addressing flammability concerns that are less reliant on chemicals or avoid chemical use altogether.

Recommendation 4B - The federal governments should require industries, in advance of making a substitution, to demonstrate the basis for their decision and to obtain government approval for the substitution.

Figure 1 – Recommendations from the IJC's 2016 report *Polybrominated Diphenyl Ethers (PBDEs) in the Great Lakes Basin: Reducing Risks to Human Health and the Environment*

Findings and recommendations

The recommendations summarized below are based on the outcomes and feedback obtained through the workshop. These recommendations are offered as a supplement to those made in the IJC's 2016 report and address the two challenges noted in the previous report section (i.e., flame retardant alternatives and best management practices).

Challenge 1: Alternate flame retardants, product design, flammability standards

The IJC's PBDE report emphasized the need to ensure that PBDEs are not replaced with other chemicals that will end up themselves becoming serious contaminants in the Great Lakes ecosystem. A scientific report that came out after the IJC's report proved the validity of this concern.[2] The report concluded that, "*With the phasing out of polybrominated diphenyl ethers (PBDEs) during the 2000's, production and use of OPEs [organophosphate esters] as alternative flame retardants have increased significantly in recent years*."[3] The report showed that elevated levels of OPEs are now found in sediments, water, air and biota in the Great Lakes basin.[4] OPEs are classified as persistent organic pollutants and are, as a result, considered to be of concern in the Great Lakes basin.

The workshop discussion clarified the need to look at combining three major mechanisms to reduce the use of chemical flame retardants.

1. **Are flammability standards appropriate?** The flammability standards for products usually are set in broad categories that are not specific enough to reflect different situations, materials and products. As a result, some products may be "soaked" in flame retardants when that high level of retardant is not necessary to protect from fires. In other situations the high standard for flammability may be justified. As a result, there is a need to be more specific about flammability standards to ensure that higher concentrations of flame retardants are used **only** when necessary. Also, flammability standards are not updated frequently enough. For example, through advances in technology and design, the modern television is less flammable than older televisions. However, the more stringent flammability standards for older televisions are still applied to the same extent for modern televisions. The standards have not been amended to reflect the changes in design.
2. **Are standards for the allowable toxicity of flame retardants too weak to protect the Great Lakes?** An assessment should be carried out of existing flame retardant toxicity standards to determine whether they are sufficiently protective of the Great Lakes ecosystem and/or whether its use should be restricted to certain situations. In addition, the assessment should also ensure that standards are developed for any new flame retardants under consideration for use, and ones currently in use for which there is no toxicity standard are sufficiently protective of the Great Lakes.
3. **Can redesign of a product help meet flammability standards?** Instead of depending overwhelmingly on flame retardant chemicals, there should be a requirement that redesign

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[2] Cao, D., et al. (2017). Organophosphate Esters in Sediment of the Great Lakes. *Environmental Science & Technology*, 51(3), p. 1441-1449

[3] *Ibid*., p. 1441.

[4] Cao, *op. cit*.

options be considered and used if they can reduce the need for flame retardants, and in some cases actually eliminate the need for flame retardants.

In addition to the issues above, workshop attendees repeatedly noted the problem that these three mechanisms are developed and set in different government silos, without recognition that they are part of one unit that is essential to address flammability and environmental issues. The presence of silos or areas of responsibility related to consumer protection and environmental protection in the standard-making process means that the best standards are not necessarily being developed.

For example, flammability standards for products and structures are set by a mix of federal and provincial or state industry and/ or consumer departments, arms-length agencies of these departments, and in some cases by nongovernment bodies. Tribes, First Nations, Métis and municipalities may also have varying roles in the development of standards and legislating standards within their own jurisdictions. The approvals for toxic substances occur through federal environment and/or health departments. The redesign tool is usually not legislated and is prompted by a separate program in the environment departments devoted to design for the environment.

Another problem raised in this context, and which the IJC raised in its first report, was the need for consistency across jurisdictions when dealing with an ecosystem covering such a broad area and so many different jurisdictions as in the Great Lakes. This doesn't mean that standards have to be identical in all jurisdictions. In response to this challenge, workshop participants suggested and strongly supported that the Great Lakes could become an experiment on how to develop and implement all three tools described above, and across jurisdictions. This process should include the following characteristics: reach across jurisdictional boundaries to cover an ecosystem; address the different flammability needs by material, product and location with the objective of minimizing the need for flame retardants; and promoting design changes to help address the need for protection from fires. A multi-stakeholder process should be used for this process, including flame retardant chemical manufacturers, manufacturers of products that need to meet flammability standards, product consumers, fire safety professionals, fire fighters, health and environmental organizations, and government and regulatory agencies.

Participants further suggested that the IJC, given its unique role as an independent binational organization, set up such an experiment in the Great Lakes basin that could become a model for the rest of the continent and elsewhere in the world. This experiment would also have important lessons for other types of toxic substances.

Recommendation 1: The responsible governments (federal, provincial, state, Tribes, First Nations, Métis and municipalities) should ensure that product flammability standards for

products and structures, toxicity standards for flame retardants, and use of redesign options are approached in an integrated way to ensure the best achievement of both protection from flammability problems and protection of the environment.

Recommendation 2: The IJC should undertake a trial run for a different style of regulatory development that breaks out of silos by integrating the three topics in Recommendation 1, by operating in a multi-stakeholder led process, and by working across the government borders in the Great Lakes ecosystem.

Challenge 2: After-use management of PBDEs

The workshop focused on after-use management of PBDE-containing products. Some workshop participants emphasized that there is probably more release and exposure to PBDEs during the use phase of these products. For example, studies have found elevated levels of PBDEs in the dust of homes emitted from products such as furniture, carpeting, mattresses, and televisions.[5]

One of the challenges identified in addressing the after-use management of PBDE-containing products was education of the general public. Participants felt that the general public needs to be educated on which chemicals are used in products, why they are used, their potential impacts on human health and the environment, and how they can be properly managed at the end of their useful life. A similar challenge exists in regards to the use of products containing PBDEs.

Recommendation 3: The responsible governments (federal, provincial, state, Tribes, First Nations, Métis and municipalities) should educate the public on the issues with PBDE-containing products in use in their homes and how they can reduce the associated risks.

In its PBDE report in 2016, the IJC recommended that the federal governments develop and promote guidance for industry, municipalities and the public – incorporating best practices – for product end-of-life management (see Figure 1, Recommendation 3A).

This recommendation was based on the fact that even though PBDEs are for the most part no longer manufactured or put into new products, substantial quantities of PBDE-containing products are still in use in the Great Lakes basin.

Workshop participants listed barriers to achieving this recommendation. These include: lack of information on when PBDEs are in products; lack of information on the amount of release of PBDEs when products containing PBDEs are recycled, landfilled, incinerated; release of PBDEs via sewage treatment effluents and over the long term from landfills; lack of proper disposal and

[5] Stapelton, H. et. al. 2005. Polybrominated Diphenyl Ethers in House Dust and Clothes Dryer Lint. Environmental Science and Technology. (39) 4. pg. 925-931

recycling infrastructure and costs of using these facilities; and uncertainty about the best after-use management system. For example, some participants supported recycling as a way to keep PBDEs from being landfilled; others felt that recycling PBDE-containing products is counter-productive because it continues to circulate and spread PBDEs throughout the environment, lengthening the time before which PBDEs are taken out of use.

Recommendation 4: The responsible governments (federal, provincial, state, Tribes, First Nations, Métis and municipalities) and industry should complete research to increase understanding of the implications of different recycling and disposal methods.
Throughout the workshop discussions, there were repeated comments on lack of information for all sectors to understand whether they are dealing with PBDE-containing products properly and whether they are making wise decisions when they handle them. Also, participants felt it was difficult for consumers to make wise purchasing decisions because it is extremely hard to determine what products have PBDEs in them; "consumers" here means householders, government, businesses, industry, etc.

Recommendation 5: The responsible governments (federal, provincial, state, Tribes, First Nations, Métis and municipalities) should go beyond the requirement for an inventory of products containing PBDEs, as recommended in the IJC's 2016 report. It is recommended that this be expanded to make it easier for the consumer to be aware of the presence of PBDEs by requiring labels on all products and through mechanisms such as barcode scanning apps on phones.

Role of extended producer responsibility

In its 2016 report, the IJC recommendation 3B (see Figure 1) stated that the federal, provincial or state governments should develop and implement EPR programs to require industry to be responsible for their products' after-use and to ensure that they are properly recycled and disposed.

Workshop participants pointed out that the traditional EPR programs in North America would need adjustment to address the PBDE question. North American programs have generally been designed for recycling a product. This may be different from the matter of trying to deal with a substance that is within the product. Others said that adjustments could be made to EPR programs to add components specific to PBDE-containing products. In Europe, for example, EPR programs don't just focus on recycling but also focus on addressing toxics. For example, the European Union EPR program for electronics requires the phase-out of the use of PBDEs in electronics. Participants also stressed the need for complimentary tools to EPR, such as landfill disposal bans and procurement processes.

Some participants saw little value in making EPR part of the strategy for addressing PBDEs in products, as EPR programs are meant to be implemented at the early stages of a product's manufacture. Since PBDEs are no longer being manufactured and used in today's products this creates challenges in implementing an EPR program for these "legacy" products. The feeling was that EPR is meant for a different situation. Others felt that the PBDE concern should be addressed through adjustments to existing EPR programs (if they exist for that product) because these would be easier, quicker and cheaper to get underway.

A cooperative approach to EPR

Most workshop participants supported developing EPR programs through an industry-financed mechanism in which all stakeholders would play an equal role. Industry, in company with other stakeholders, would develop product-specific EPR programs. These EPR programs would have clear measurable goals that the multi-stakeholder group had jointly developed. In addition, companies would have to pay for third-party independent auditing to assess compliance with the program. All aspects of the program, including audit results, would be publicly available. If some companies did not comply, government would then adopt the EPR program to give it the force of law. Built into the law would be the power for government to ban a specific company from making or selling a product if they were non-compliant. Ontario passed such legislation in 2016 that gives the Minister of the Environment and Climate Change the power to ban the sale of a product.[6]

Recommendation 6: The responsible governments (federal, provincial, state, Tribes, First Nations, Métis and municipalities) should encourage industry to work jointly with a full range of stakeholders to develop an EPR program for flame retardant-containing products. This would explore mechanisms for addressing not only products containing PBDEs but also for new products made with alternative flame retardants. This could become a model for EPR programs for other toxics-containing products.

Conclusion

There are a variety of chemicals used in products found around the Great Lakes basin, of which PBDEs are one. This report provides a combination of approaches to prevent and reduce the release of PBDEs through the use phase and end-of-life management of the products that contain them. Although the recommendations contained in this report are specific to PBDEs, they are applicable to other chemicals used in products. As noted throughout the report, these recommendations will require the breaking down of silos and the collaboration of a multitude of groups for them to be successfully implemented. The IJC in particular has an opportunity to facilitate this collaborative process that works across borders and jurisdictions in the Great Lakes, to develop standards that consider the range of objectives a product must often meet (e.g.,

[6] Waste-Free Ontario Act, 2016

flammability, safety, environmental protection). Such a pilot process could become a model for other toxic substances as well as other regions in the world.

Appendix A - PBDEs in the Great Lakes Workshop Summary Report

PBDEs in the Great Lakes Workshop Summary Report

Addressing Polybrominated Diphenyl Ethers in the Great Lakes Basin: Searching for Solutions to Key Challenges

Great Lake Water Quality Board
Legacy Issues Work Group

June 22, 2017
Final Report

Acknowledgements

This report is the product of a binational workshop that involved experts from Canada and the United States, discussing the challenges posed by PBDE-containing products in the Great Lakes basin. The International Joint Commission's Great Lakes Water Quality Board expresses its sincere appreciation to the experts from multiple government, academic, nongovernmental organizations, and industry who participated in the workshop. Their efforts have provided advice and insights for the consideration of the Water Quality Board in providing advice to the Commission who may, in turn, provide advice to the Governments of Canada and the United States. This report is based on the workshop report prepared by Barb Sweazey (Stratos, Inc., Ottawa, Ontario), which was reviewed and modified by the Legacy Issues Work Group of the Great Lakes Water Quality Board. Revisions were made based on comments and feedback received on the report from workshop participants.

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1 Introduction

The International Joint Commission's (Commission) Great Lakes Water Quality Board (WQB) convened a two-day workshop on February 22-23, 2017 in Windsor, Ontario, with the goal of bringing together representatives from diverse sectors to better understand ways to manage products containing Polybrominated Diphenyl Ethers (PBDEs), particularly in the Great Lakes Basin. Prior to the workshop, participants were asked to review the November 2016 IJC report, *PBDEs in the Great Lakes Basin: Reducing Risks to Human Health and the Environment*, which contains a list of high-level recommendations provided by the IJC to the Governments of Canada and the United States for consideration. Throughout the workshop, participants explored selected recommendations from this report in order to advance a more detailed description and comprehensive understanding of these recommendations and related implications. The Water Quality Board and the Commissioners will consider the input from the workshop participants in providing further advice to the Governments of Canada and the United States to address the environmental challenges posed by PBDE-containing products in the Great Lakes basin.

The workshop, consisting of brief presentations and small group discussions, focused on exploring alternative methods to address flame retardant needs and identifying best management practices for after-use management of PBDE-containing products, including the role that Extended Producer Responsibility could play in the implementation of these best practices.

More specifically, through this workshop, subject matter experts:

- Provided insights on challenges and barriers that may inhibit both government and industry from adopting practices to better manage and ultimately eliminate products containing PBDEs within the Great Lakes basin, and
- Highlighted potential approaches for governments to consider in addressing the challenges and barriers associated with managing and eliminating products containing PBDEs within the Great Lakes basin.

There were 21 workshop participants from a broad range of sectors including government (federal, state/provincial and municipal), industry, nonprofit organizations, environmental nongovernmental organizations, fire fighters and academia. The participants had extensive knowledge and experience of the science, policy and implications of PBDEs in the Great Lakes basin. A contingent of Commission staff was also present to assist in notetaking and other workshop support.

The following workshop summary report provides an overview of the presentations, discussion highlights, barriers and potential solutions, and guidance to offer governments for further consideration or research. The report was written based on notes taken by Commission staff during the workshop. A full list of participants is provided in Appendix A. The workshop agenda and workshop background document is provided in Appendix B and Appendix C, respectively.

2 Setting the context

2.1 Overview and history of PBDEs

Presentation by John Jackson, Member Legacy Issues Work Group, Water Quality Board

Opening remarks provided by John Jackson, member of the IJC's Water Quality Board Legacy Issues Work Group, set the stage for the workshop. He highlighted the following concepts:

- PBDEs are persistent, bioaccumulative and toxic and these types of chemicals have been an ongoing concern of the IJC as they accumulate in the Great Lakes ecosystem. Despite ongoing decreases in concentrations, they are still present in all Great Lakes media (water, sediment, fish and humans)
- During the lifecycle of PBDE-containing products (manufacture, use, end-of-life management), PBDEs can be released to the environment
- PBDEs have been used as flame retardants in products since the 1970s in clothing, furniture, mattresses, plastics, and so on. Certain professions, such as fire fighters for example, can have a high exposure to these chemicals through the course of their professional duties
- Voluntary manufacturer phase-outs of PBDEs and regulatory requirements banning PBDEs in new products have taken place; however PBDEs remain in current use in products that were manufactured before these controls took place
- Some of the major concerns highlighted with PBDE-containing products, both in use and after-use phases, included:
  - Whether existing PBDEs regulations and restrictions include imported products containing PBDEs
  - What happens to PBDE-containing products still in use, and the potential rise in PBDE levels in the Great Lakes as these products are disposed/recycled
  - Restrictions and controls need to shift in focus from the manufacture and use of PBDEs to controlling and restricting the use of *products* that contain PBDEs
  - How can flammability standards be achieved if PBDEs are not used – including whether product design changes can be used rather than just chemical additives

Following the presentation, there were several thought-provoking inquiries. For example, one participant asked if there is one significant pathway PBDEs take that contributes greatest to the levels in the Great Lakes. Currently, there is limited data on the significance of different pathways, but some studies have found there is an equal contribution from the use of products (i.e., atmosphere) versus wastewater treatment effluents (i.e., as a result of laundering, cleaning, etc.).[7] Since PBDEs are non-chemically bonded to products, they are generally released by heat, abrasion and/or transfer to dust that comes into contact with the PBDE-treated material.

It was also noted that some work has been done by the New England states and Canadian provinces (Quebec and PEI) on approaches to manage mercury-containing products. Some participants suggested

[7] Melymuk, L., et al. 2014. *From the City to the Lake: Loading of PCBs, PBDEs, PAHs and PCMs from Toronto to Lake Ontario*. Environ. Sci. Technol., 48 (7), pp 3732–374

that the efforts and actions undertaken for mercury product restrictions could serve as a model for addressing products containing PBDEs.

Another participant asked if there is any evidence related to imported products containing PBDEs. Based on testing done by the State of Washington Department of Ecology on general consumer and children's products, results show there is no evidence of new products coming into North America with PBDEs in them[8]. However, participants noted that it is important to remain diligent in continually testing imported products to ensure that imported products are not a source of PBDEs. The Fire Fighters Association is working to get national legislation passed in the United States to ban the sale of products containing PBDEs (as some states do not have this type of legislation), due to concerns about imports. There is potential for product registries to include this information as well so consumers, including governments, know which products contain PBDEs.

3 Substitutes and alternate designs

3.1 History repeating itself – Could PBDEs break the trend?

Presentation by Mike Murray, National Wildlife Federation and Member of the IJC's Science Advisory Board, Science Priority Committee

Following the opening remarks, Mike Murray from National Wildlife Federation offered insights about the historical trends of using chemicals and their substitutes. Specifically, Dr. Murray described the historical use of flame retardants, followed by an overview of the evidence illustrating the trends in PBDEs use and presence in ecosystems (particularly highlighting studies on gull eggs in the Great Lakes). He explained how the gull egg data indicates that total PBDEs are declining, but that deca-PBDE is increasing. He further noted that alternate flame retardants to PBDEs (i.e., HBCDD and DDC-CO) have also been increasing, which is concerning as they have similar environmental risks to PBDEs.

Dr. Murray then offered an overview of the Alternative Assessment approach. It was noted that for a product to meet strict flammability standards, the use of chemical flame retardants may be the only option to meet that requirement.

In addressing chemicals and alternative approaches to dealing with chemicals using the Alternative Assessment approach, some principles to consider include:

- Great Lakes Water Quality Agreement principles of precaution and prevention
- Whether there is truly a need for flame retardants
- The impacts to human and ecological health
- Minimize the hazard
- Promote green chemistry

Following the presentation, participants shared questions and comments. For example, some participants noted that standards are not often captured in regulations. Other participants noted that the historic aspect is important, but some of the flame retardants noted as "emerging" (e.g., HBCDD and DDC-CO)

[8] State of Washington Department of Ecology reports found here: https://fortress.wa.gov/ecy/publications/SummaryPages/1404021.html and https://fortress.wa.gov/ecy/publications/summarypages/173334.html

are not brand new. High levels of organophosphate flame retardants are being used to fulfill the same functions as the brominated flame retardants. Industry is continually working to find alternatives. One of the participants also noted that in 2015, the State of Washington released a report on flame retardants and recommendations for restrictions or bans on their use in children's products and furniture. The report also contains a chapter on alternative assessments, which participants were encouraged to read for further understanding.[9]

3.2 Understanding the repeating cycle: List of barriers

Small group discussions

Following the presentations about context and history of PBDEs, participants were given a brief recap of IJC recommendations from the November 2016 IJC report entitled, *PBDEs in the Great Lakes Basin: Reducing Risks to Human Health and the Environment*. Specifically, recommendations 4A and 4B (see inset) were reviewed, to give the small groups context during their group discussions. Following the recap, participants were asked to brainstorm a list of barriers in small groups, using the following questions as prompts:

- *What has **prevented** us from **being successful** in adopting substitutes for harmful substances?*
- *Why does the cycle of replacing a toxic substance with another toxic substance **keep repeating** itself?*

The following is a list of barriers (15) compiled from the small group discussions:

IJC Recommendations Recap

***Recommendation 4A** - Federal, provincial and state governments should develop and distribute guidance for industry on methods to assess PBDE substitutes and encourage use of methods for addressing flammability concerns that are less reliant on chemicals or avoid chemical use altogether.*

***Recommendation 4B** - The federal governments should require industries, in advance of making a substitution, to demonstrate the basis for their decision and to obtain government approval for the substitution.*

1. **Functionality** – flame retardants must be functional in a product over time, noting there may be competing objectives, such as the goal of reducing flammability while also reducing toxins
2. **Weighing risks versus benefits of flame retardants** – it is a challenge to determine in what products and product components flame retardants are necessary. Risks versus benefits of flame retardants needs to be assessed as part of the process for developing flame retardant standards
3. **Open and collaborative process needed to find alternate solutions** – multiple perspectives and stakeholders need to be included in the standard setting process for acceptable toxicity of flame retardants and on flammability levels acceptable for products or processes
4. **Difficult to look for alternate "out of the box" solutions** - the process of developing an alternative has a lot of challenges. There is a tendency to keep thinking "in the same box" for solutions for science-based reasons
5. **Lack of data availability** – lack of registry, lack of information for general public, access to information for government/regulators/assessments,often due to proprietary Confidential Business Information and lack of disclosure requirements

[9] The State of Washington's 2015 report on flame retardants and recommendations available here: https://fortress.wa.gov/ecy/publications/documents/1404047.pdf

6. **Lack of supply chain information** – information is not available along the full supply chain, including if alternatives exist along the supply chain
7. **Science limitations** – it is challenging to know what is the "best" science to support finding alternatives; often there is competing science arguing both sides (flame retardant needs; ecosystem and health impacts, etc.)
8. **Legal and regulatory risk for manufacturers** – liability concerns for manufacturers who may be considering alternates to requirements; manufacturers of products containing flame retardants are seeking clear answers to their legal accountabilities and risks
9. **Support for new tools** - need to ensure that new tools, such as Canada's Chemical Management Plan, and the Lautenberg Chemical Safety Act amending the U.S. Toxic Substances Control Act, which require assessment of new chemicals and evaluation of alternatives, have the support to be implemented
10. **Tools still need improvement** – alternative assessment tools needed to support finding other solutions
11. **Lack of alignment** - need for alignment of state, regional, national and binational standards for acceptable toxicity of flame retardants and on flammability levels acceptable for products or processes
12. **Cost** –developing and evaluating alternatives has an investment risk
13. **Time lag in evaluating impacts** – it takes time to evaluate alternatives once they are in use, which means a time lag before problems may be discovered and/or understood
14. **Time to develop regulatory tools** – it often takes considerable time to develop regulations for chemical safety and management and standards for acceptable toxicity of flame retardants and on flammability levels acceptable for products or processes
15. **Prioritization of concern** – it may be a lower priority for key users of flame retardants to seek out alternatives / substitutes

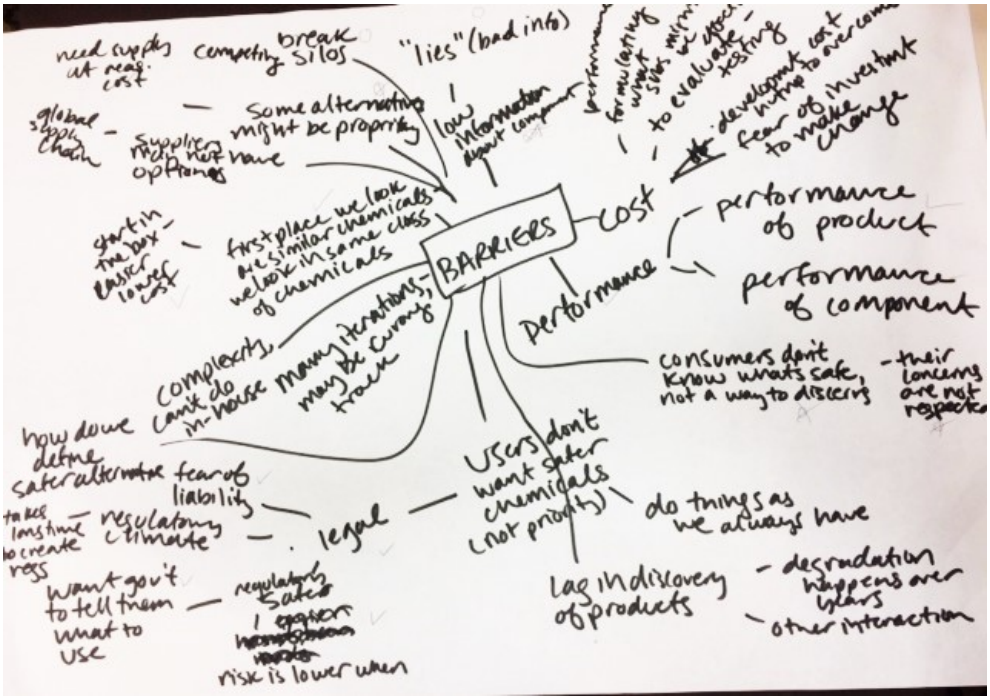

Figure 1: Mind Map of Barriers (Phone Group)

3.3 Understanding the repeating cycle: Deep dives of key barriers

Small group discussions

Following the co-creation of the list of barriers (summarized in Section 3.2), the workshop participants worked together to decide which from this list should be explored more fully. As a result, three priorities were selected for a "deep dive" discussion of the barrier and steps to overcome them:

- Binational flammability standards
- Data availability
- Benefits/requirement for flame retardants

A summary of the main highlights, as reported back in plenary, for each of these three barriers are provided below:

3.3.1 Barrier 1: Lack of binational standards for flame retardants

- **Challenge**: Flammability standards are developed and operate in jurisdictional silos. There is a need to broaden the standard-setting process to include a whole range of objectives and perspectives. Participants discussed the need for an open and collaborative standards development process that includes public input and multi-stakeholder perspectives.

- **Opportunity**: The participants considered using the Great Lakes as a "trial" for breaking down silos between issue area and geographic area for development of flammability standards.

  In particular, workshop participants saw an opportunity for IJC to convene a "trial" for developing an international standard on flame retardants (and/or on products containing PBDEs) using the Great Lakes as a pilot. This includes standards for acceptable toxicity of flame retardants and on flammability levels acceptable for products or processes. Given its multi-jurisdictional perspective, the IJC could be involved in promoting this collaborative approach to standards development using a binational approach.

3.3.2 Barrier 2: Lack of data availability

- **Challenge:** Workshop participants explored many facets related to the lack of data including: lack of a products registry; lack of information for general public to guide decision making in product consumption; and lack of access to information for governments, regulators and to conduct assessments.

  Participants also explored the limitations that confidential business information has on access to proprietary information. As a result, consumers often do not have a way to validate their concerns (and or influence their decisions) due to lack of information.

- **Opportunity:** Workshop participants explored several measures that could be taken to address this lack of accessible data:
  - **Identify what data is needed**. Participants identified several types of data needed to help inform the best management approaches for products containing PBDEs, including hazard data for alternatives, what chemicals in what instances, what kind of end products, and if not a drop-in replacement, what are impacts in specific uses?

- **Identify how various stakeholders could contribute in different ways**. Beyond information about flame retardants, identify what other chemicals can be used in other instances (e.g., in end products; use of product in the field and outcomes; etc.)
- **Identify and support trusted data sources** (referee/gatekeeper)
- **Involve companies** in setting up data-related standards (e.g., for providing and sharing product data and information throughout the supply chain), that are applicable and useful for them

Workshop participants then discussed the **range of players** that should be involved in identifying and implementing data accessibility solutions. For example, participants noted that governments are responsible for defining what data is needed. Universities can serve to support defining what data currently exists. Public-private partnerships could be used to coordinate these efforts and help reach agreement on what data is out there. And, product manufacturers need to be involved in finding and supporting data availability solutions.

To aid with creating more accessible data, participants suggested that the following additional elements would be helpful in creating solutions:

- Clear direction (Mandates, policy statements, and industry standards)
- Determining who bears the burden of cost of testing, maintaining/managing the data
- Develop requirements for manufacturers to provide information about their supply chain
- Consider creating a data registry. Although such a registry may present a challenge, if one is created, participants noted that there will need to be a difference between publicly available and agency available only data

3.3.3 Barrier 3: Competing understanding and perspectives on benefits/requirements for flame retardants

- **Challenge**: Participants explored this contentious issue from many angles. For instance, there was discussion about whether there is sufficient evidence to demonstrate that adding flame retardants to products is indeed needed in all cases. For example, in some instances the design of the product and the materials used in the product could dramatically reduce or eliminate the need for flame retardants to meet flammability requirements. There also was discussion about whether flammability standards, in some cases, are stronger than needed to avoid fire hazards. The flammability standard could vary both according to the products and the material used in them. This could mean that such high levels of flame retardants would not be required in many products and that non-chemical solutions (e.g., design changes) could meet the needs in some cases. The participants also talked about whether there is accurate, reliable evidence showing that flame retardants are actually reducing flammability risk. Investments in time and money are required to formulate and develop viable alternatives and to then evaluate them for performance effectiveness and compliance. Additionally, participants discussed questions around the efficacy of flammability standards. There was some discussion about the need for independence in conducting research related to this set of challenges.

- **Opportunity:** Participants noted an opportunity for government intervention in helping to resolve this issue. For example, building codes and standards for building materials could be starting points for addressing key fundamental questions about flame retardants requirements and standards (instead of trying to address thousands of separate product categories all at once at the outset).

4 After-use management of PBDEs

4.1 How to manage end-of-life products containing PBDEs?

Insights by Fe de Leon, Miriam Diamond and Peter Hargreave

To kick off the second day of the workshop, insights were offered by three selected workshop participants to provide inspirational ideas and perspectives for participants to consider in the subsequent discussion sections. A summary of these insights is provided below:

- There is movement towards a circular economy/life-cycle approach, particularly in the European Union. With this in mind, most issues should be addressed proactively in the design phase (upstream). Electrical and electronic equipment is an example of a product stream with high-usage of flame retardants (e.g., in plastic casings of computers, motherboards, plastic casings of TVs). For example, there are stringent flammability standards for TVs that were developed in the 1960s-70s (up to 15 percent of the casing can consist of flame retardants) due to incidents of "instant on" cathode ray TVs exploding and/or catching fire. However, with advances in TV design and technology (e.g., LED TVs), this flammability risk has greatly reduced. However, the standards have not been amended to reflect these design changes.
- PBDEs are already out there in products (downstream) and now we need to manage them within those products. However, there is no consensus on what is the best approach to deal with PBDE-containing products in the waste stream such as waste electrical and electronic equipment.
- When many products containing PBDEs reach their end of life, the materials in these products that contain PBDEs still pose potential risks that need to be managed. No standards currently exist for these materials as to how they should be processed or disposed of to mitigate environmental risks. The current options for end-of-life management have various impacts: landfill (emissions from shredding, leachate), incineration (cost issue and palatability to communities in which incinerator is located), recycling (PBDEs may still continue to be cycled through the system as they are reformed into new products).
- From the perspective of waste management there is a gap in research/knowledge on how to manage the risks associated with products containing PBDEs. Currently the work undertaken by the waste management sector and researchers/academics is not well coordinated. There is also a "disconnect" between manufacturers who design and produce the goods and the end-of-life management outcomes expected of the waste management sector.
- Some of the issues that need to be overcome when setting policies related to end-of-life management include:
  - Economic and behavioural considerations: gaps between the desired outcome and the alternatives available, such as the costs to dispose of or recycle the PBDE- containing wastes and convenience considerations (e.g., cheaper to landfill versus collection and recycling or further treatment)
  - Data oversight and enforcement: the need to be able to measure outcomes to allow for effective oversight that can assess risk and efficiently oversee it
  - Environmental standards: need for clear definitions and expectations for the proper end-of-life product management

- Extended Producer Responsibility (EPR) can be one good tool to overcome some of these gaps, but it may not necessarily be the only effective and efficient approach to achieve the desired outcomes in all cases. Despite its objective of supporting improvements in environmental product design, there is evidence that EPR does not necessarily get to the root of the problem of addressing pollution prevention. More often, EPR acts as a control to manage the issue by shifting costs of waste management from governments to producers and consumers and through the establishment of collection and recycling programs for designated products. But usually, unlike in the European Union, North American EPR programs do not include requirements on product design, such as materials that may be used, ease of disassembly, reuse of materials, longevity of the product, etc.
- A combination of tools may need to be used to help ensure materials and products are properly managed at the end of life, including environmental standards (e.g., Ontario's Guideline C-4, the R2 standard in the US); material bans, disposal bans; disposal levies; producer responsibility requirements, generator requirements (e.g., 3Rs regulations in Ontario). Each of these mechanisms can be effective in addressing issues and are often used in tandem. Their efficiency is often related to conditions associated with the specific jurisdiction they are being applied to.
- EPR is currently the "policy-du-jour" (i.e., popular but potentially short-lived approach) when dealing with end-of-life management issues in Canada. The idea is that if it costs more to deal with a chemically treated product this will incentivize manufacturers to re-design their products to minimize those end-of-life management costs. However, as illustrated in a 2016 OECD report[10] there is little evidence to prove this is actually occurring in Great Lakes jurisdictions because the associated costs are not high enough.
- Consumers (householders, government, institutions, businesses and industry) need to be better educated about the products they buy and what they contain. They can impact the products and materials/chemicals used in the manufacture of products with their buying power provided they are aware of the issues and products' components. The use of outreach, education and labeling are potential tools to address this.
- The flammability standard setting process is quite closed and not open to scrutiny. Participants agreed that involving a range of stakeholders in the development of flammability standards is challenging but important, in order to make the process more open and transparent.

[10] http://www.oecd.org/env/extended-producer-responsibility-9789264256385-en.htm

4.2 After-use management of PBDEs: Barriers and challenges

Small group discussion

Following the insights on after-use management of PBDEs outlined above, participants were given a brief recap of related IJC recommendations from the November 2016 IJC report entitled, *PBDEs in the Great Lakes Basin: Reducing Risks to Human Health and the Environment*. Specifically, recommendations 3, 3A, and 3B (see inset) from the IJC's report were reviewed. The recap was provided prior to the small group discussion to remind participants of high-level recommendations related to after-use management, and spur their thinking on details they could add to the recommendations at the end of this workshop.

IJC Recommendations Recap

Recommendation 3 *- The federal governments should develop a plan for reducing and eliminating potential releases of PBDEs in products during the recycling and disposal stages. This plan should be developed in cooperation with a wide range of stakeholders.*

Recommendation 3A *- The federal governments should develop and promote guidance for industry, municipalities and the public -- incorporating best practices -- for product end-of-life management, such as recycling and disposal, which provides equal protections in all parts of the Great Lakes basin.*

Recommendation 3B - *The responsible governments (federal, provincial and state) should develop and implement EPR programs throughout the basin to require industry to be responsible for their products after-use and to ensure that they are properly recycled and disposed, to be undertaken in two phases:*

Phase 1: Electronics, appliances, carpets, mattresses, and furniture

Phase 2: Construction, renovation and demolition wastes

The ensuing discussions occurred in three groups, where participants were divided into groups specializing by product stream:

1. Electronics and appliances
2. Mattresses, carpets and furniture (foam)
3. Both product stream groups 1 and 2 above (remote participant group)

Within each group, participants were asked to brainstorm challenges and barriers to overcome in the after-use management within this product stream, including consideration of both disposal and recycling. Each group then selected a couple of key barriers and explored the issues and possible solutions more fully (see details reported in Section 4.3).

As each group reported into plenary, a range of barriers were discussed as they considered the after-use management challenges associated with disposal and/or recycling. The following list is a compilation of these barriers and challenges:

<u>Electronics and Appliances</u>

1. **Disconnect** between manufacturers and waste management providers
2. **No formal measurement and impact assessment** – lack of clear quantitative data
3. **Canadian Environmental Protection Act** – focus is on use and does not address the legacy of the products / chemicals
4. **Waste Products not going to intended use that was agreed to as planned option –** for

example, e-wastes are often sent for reuse but instead are primarily recycled or disposed of especially when sent to another country

5. **Knowledge gap** - the issue exists, but do not know what mitigating factors could be used to reduce impacts
6. **Technical challenges** - No guidance on how to best manage these products and materials at end of life to mitigate environmental and human health risks. For example, both the appliance and scrap industry have limited or no standards.
7. **Disconnect between product standards and end-of-life standards** related to the environmental and human health risks of end-of-life management options (e.g., risks from landfilling compared to recycling)
8. **Need for better data, testing and research** of PBDEs in media such as leachate, sludge, air. There is no ongoing monitoring for these types of substances. One potential option is to make monitoring part of regulatory requirements (e.g., in Ontario, through Environmental Compliance Approval)

Furniture, carpet and mattresses

9. **Infrastructure** – need to have appropriate systems in place to capture and deal with these harder to dispose materials (i.e., furniture, carpets, mattresses) to help mitigate impacts to the environment. In Ontario, when dealing with these products, cost is a big factor as well as landfill capacity.
10. **Consumer education** – not just individuals, but also governments and industry (who are also consumers), to ensure all consumers know why this issue (and their choices) matter. Labelling is a critical part of the process, as well as government purchasing policies and other key procurement entities

Both product streams

11. **Knowledge gaps** in understanding the extent to which PBDEs are released to the environment via recycling/disposal to help inform the best end-of-life management options, in terms of costs versus benefits
12. **Lack of guidance on end-of-life management** - if PBDEs are found in a product, guidance is needed for the recycler/disposer as to correct pathway for disposal/ management of the product
13. **PBDE identification for recyclers/disposers** - Additional research and development is needed to help processors better and easily and quickly identify and manage materials. X-ray fluorescence may be one approach, to identify the presence of bromine, which can indicate whether further specific tests need to be done
14. **Difficult to get the right people to the table to find solutions** - green chemistry industry may be an in-road to initiate this
15. **Current use of waste haulers' knowledge minimally used** - haulers may have pertinent insights on sorting methods/processes for PBDE-containing products that could be leveraged for the identification of PBDE containing products
16. **Mandates for special management of PBDE-containing products (e.g., recycling and disposal) usually do not exist** - where they do exist, there is more clarity as to who the players are in the waste stream

4.3 After-use management of products containing PBDEs: Deep dives of key barriers

Small group discussion

As part of the small group discussions described in Section 4.2, each discussion group selected one or two key barriers to discuss more fully, including some exploration of suggested steps to overcome the barriers. The groups explored the following three issues independently and reported on them back to plenary:

- Infrastructure
- Consumer education
- Product identification at recycling stage

4.3.1 Barrier 1: Infrastructure (furniture, carpets and mattresses)

Participants explored the **challenge** more fully:

- Participants explored the challenge of not having proper or effective infrastructure systems in place to capture and deal with these harder to manage products (furniture, carpets and mattresses). As a result, it may be difficult for both consumers and for waste handlers to reduce the impact of products containing PBDEs entering the waste stream
- Participants noted that cost is a big factor as well as landfill capacity in Ontario. The cost to put in the infrastructure for proper disposal/recycling can be challenging if the market for the materials is not there. There is also a need for government policies to push the inherent value of the material and the circular economy. With this kind of policy in place, participants suggest that investments in infrastructure may be attracted
- Participants struggled with trying to identify alternatives to landfilling for the end-of-life management for furniture and mattresses. It was noted that the necessary data to determine what the emissions are for various end-of-life management options (e.g., landfill, recycle, incineration) to inform what the best infrastructure option may be, are not readily available

In terms of possible **solutions**, the participants presented the following considerations:

- **Create a commodity:** The recovered components of a product (particularly those containing PBDEs) need to be regarded as a commodity or resource, not as waste, as they have value. If these materials/products are shown to have value this would provide incentive to put the infrastructure in place for proper disposal/recycling. To have this accomplished, a policy may be needed due to a lack of obvious value of a material. In turn, this could drive value through entrepreneurship and innovation. Other participants believed that creating a commodity out of PBDE-containing items would be contrary to getting PBDEs out of the environment. For example, recycling a PBDE-containing product could spread PBDEs through a wider array of products and spread potential PBDE contamination
- **Use procurement tools:** Procurement tools could be used to drive changes in the design of products (e.g., hotel chain may require a supplier/manufacturer to meet specific standards/requirements such that flame retardants are not present in the products they manufacture). Such massive buying power can drive changes in the absence of policy. Such procurement methods are an under-utilized tool

- **Use voluntary standards**: Voluntary standards can be used in government procurement to help identity and purchase environmentally sustainable products and services[11]. Institutional purchases can also drive standards and eco-labels

4.3.2 Barrier 2: Consumer education (furniture, carpets and mattresses)

Participants explored the **challenge** more fully:

- Participants stressed that consumer education is required, not just for individual consumers, but also governments and industry. This broad educational coverage is required to ensure all consumers know which chemicals are used in products, why they are used, their potential impacts on human health and the environment and that their purchasing choices matter.
- As described in the solutions below, participants noted that labelling is a critical part of the process, as well as government purchasing policies and other key procurement entities

In terms of possible **solutions**, the participants presented the following considerations:

- **Education**: Education of not only the public consumers, but also governments and industry to help influence choices and management approaches. Recognize that flame retardants of the future may not have the same impacts/concerns as historically used chemicals. It was suggested that the public be informed as to why flame retardants were historically used (e.g., with TVs), why they are of concern, products they are found in, and how they can be properly managed at the end of their useful life
- **Cooperative partnerships:** Partnerships that are collaborative, between industry, government, public, nongovernment organizations and environmental groups, could help to educate consumers about PBDEs and labelling. Participants noted that any one single sector cannot do this on their own
- **Labelling:** Labels on products need to be written in a way that is easily understandable to consumers of all types, or they may have the opposite effect (e.g., people may think if no flame retardants were added to a product, their safety is at risk)
- **Technology:** The level of awareness of consumers could be raised through the innovative use of technology (e.g., barcode scanning apps on mobile phones)

4.3.3 Barrier 3: Product identification at recycling stage (both product streams)

Participants explored the **challenge** more fully:

- Both recyclers and disposers have difficulty identifying products that do (or do not) contain PBDEs that enter their handling systems and processes. This means that they may not realize the need for special handling of the product
- Absence of product identification makes it challenging to ensure effective and quality handling of products containing the substance

In terms of possible **solutions**, the participants presented the following considerations:

- **Past Models**: In the example of polychlorinated biphenyls, regulators developed tools and guidelines for identifying products containing polychlorinated biphenyls. Participants noted that this example could perhaps be adapted for PBDE

[11] US EPA Voluntary Recommendations for federal purchasers available here: https://www.epa.gov/greenerproducts/recommendations-specifications-standards-and-ecolabels-federal-purchasing

5 Extended Producer Responsibility programs

Later on the second day, each product stream group explored discussion questions around better understanding Extended Producer Responsibility programs and their possible role. Specifically, groups were invited to discuss what Extended Producer Responsibility programs may look like for products in their stream that contain PBDEs, as well as features of the program, who would be responsible, and other Extended Producer Responsibility programs to build upon. The challenges, specifically for government, were also tackled during the discussion by individuals in the phone group. An item of note is that participants recognized that PBDEs are no longer being manufactured and used in today's products, and the challenge of implementing an EPR program for these "legacy" products. However, the management of products containing PBDEs are a means of learning for future products containing chemicals. A summary of some of the key discussion highlights are outlined below:

- **Regulated Extended Producer Responsibility programs:** Many voluntary Extended Producer Responsibility programs are in place; however some participants voiced the need for regulated Extended Producer Responsibility programs. There are cost considerations for such programs, including staffing, funding and enforcement, which can be challenging to lay the groundwork and to achieve buy-in from the industry as well as the public. There is a strong need to demonstrate the benefits of an Extended Producer Responsibility program designed for PBDE-containing products, and also quantifying the costs versus benefits. Alternatively, some existing state programs could potentially build in Extended Producer Responsibility components for PBDE-containing products. Complementary tools to Extended Producer Responsibility such as disposal bans and levies and material bans could help to increase the benefits and ease of Extended Producer Responsibility implementation. Utilizing existing programs would reduce administrative costs associated with setting up a brand new program.
- **Voluntary programs – an alternate solution:** Alternative to the call for regulated Extended Producer Responsibility programs, some participants brought up the example of pesticide container recycling programs in Canada. In this case, industry voluntarily takes back containers prior to government regulation. This allowed industry to proactively determine how to deal with the management of their products, rather than being directed by regulatory bodies. Using industry leadership, standards for the life-cycle management of products to minimize impacts to human health and the environment through requirements such as percent collection rates of products containing PBDEs, how low levels of PBDEs must be in products containing PBDEs to qualify for recycling, etc. could be developed through open, multi-stakeholder processes, as well as independent third party auditing of the companies and their adherence to their developed standards leading to certification. A backup mechanism was proposed for companies who do not meet the standards; the government would require an Extended Producer Responsibility program if the industry standards are not met, with a last resort built in to allow the banning of the noncompliant product.
- **Multi-party solutions required:** Responsibility for addressing and avoiding problems with PBDE-containing products were identified as being shared by multiple entities, including designers, manufacturers, brand distributors, recyclers and governments. Some workshop participants felt that this multi-party responsibility makes it difficult, if not impossible, to use EPR programs for PBDE-containing products. However, this situation exists for most products. EPR programs generally choose the brand distributor (the one who puts it into the store and/or sells it as the responsible party. They are the ones who can put the requirements on their suppliers to redesign a product, to reduce or eliminate chemical use, etc.

- **Solutions at early life-cycle stages:** Participants voiced the need to interject earlier on in the supply chain, tying in waste management at the front-end and focusing on prevention. “Design for the environment” needs to be incorporated; however there are several challenges with competing objectives of safety, environment and human health. For example, flame retardant-treated furniture may protect a family in the event of a home fire, but at the same time cause harm to fire fighters with exposure to the PBDEs released during fires. EPR programs must have features that require design features that will avoid environmental problems during the use and after-use stages of the product’s life cycle.
- **Are the responsible producers still available:** As PBDEs are a legacy chemical, they are no longer being manufactured and it may be a challenge for an Extended Producer Responsibility program to capture and manage such products because the responsible party is not known, cannot be found or may no longer be in business. This is commonly an issue that is sorted out in EPR programs. Generally it is agreed that current producers of the type of products that have PBDE’s in them will divide up the responsibility among each other in addressing the problems.

6 Synthesis and reflection on guidance to offer governments

At the conclusion of the two day workshop, participants were asked to present key messages they felt needed to be heard on managing and eliminating PBDE-containing products. The roundtable of ideas shared by representatives from the diverse sectors at the workshop is summarized below. These concepts are intended as guidance for the Water Quality Board to consider in sending additional advice to the IJC for their consideration in sending advice to governments on moving forward with managing PBDE-containing products (and other similar chemicals) from the Great Lakes basin.

Call for leadership: There was a call for leadership from the federal governments, emphasizing a preventative approach to avoid issues with other similar persistent, bioaccumulative and toxic chemicals in the future. Some solutions suggested for federal leadership include:

- Shift from substance regulation to product regulation to deal with multiple chemicals at a time
- Shift from chemicals management plan to a chemicals and products management plan
- Employ a sector-specific approach, and
- Use new tools such as alternatives assessment approach or green chemistry to address the issue

Broader, integrated and multi-level approach: The participants also noted that federal leadership, while very important, is not necessarily sufficient on its own. Many participants flagged that there is a strong need for a broader, integrated and multi-level approach that does not solely rely upon one overarching governing body. Robust discussion also is needed with a complete set of stakeholders, including manufacturers of flame retardants and manufacturers of products with flammability concerns. This approach should also be fair, transparent and open, allowing stakeholders to share their perspectives as well as proper evaluation of need for flame retardants at the most basic level. With open collaboration, trust will need to be built across stakeholders, and recognition of the gap between what has been done in the past – and what can be done moving forward together.

Great Lakes could be a model: Some participants noted that the Great Lakes region provides a unique opportunity for binational collaboration, and has the potential to be a great model. There is potential to

build on previous work of legacy chemicals, tapping into already existing resources.

Innovative solutions are needed: There is a plethora of solutions moving forward, some innovative, and many pre-existing. Consideration must always be given to design for the environment and green chemistry – with the latter being a learning opportunity within the workplace for careers such as chemical engineering. This is not just an end-of-life management issue. The focus should be on prevention and toxics reduction or elimination issues, or a toxics reduction issue. For this reason, some participants wondered if Extended Producer Responsibility is the most suitable approach to employ, as North American Extended Producer Responsibility programs typically focus on the downstream and end-of-life issues. In Europe, however, Extended Producer Responsibility programs also include prevention and up-stream requirements such as requiring that products be made without certain chemicals in them, designing for disassembly, etc. Procurement processes are another part of the solution, as they can influence consumption habits and shift market behaviour.

Urgent need for data: In the context of PBDEs, many participants reiterated that there is still so much information and knowledge missing that is needed to fully understand the history as well as future trends of products containing PBDEs in the Great Lakes basin. An urgent need for data exists to grasp the scale, scope, and timeline to better manage the "backend" of dealing with a legacy chemical. Looking forward, it is critical to build a model that ensures the cycle of continuing to use harmful chemical substitutes is broken, and prevention of the use of persistent, bioaccumulative and toxic chemicals is at the forefront.

Education and open data-sharing: A common thread through the solutions proposed by workshop participants was further education and open data-sharing processes as being keys to solving this problem. Science-based data to address knowledge gaps will help to address the issue of flammability standards. Flammability standards in particular are core to the issue and there is a great opportunity for education here. As part of data gathering, monitoring is also necessary. Monitoring of biota and the environment will help to determine if progress is being made with the programs in place. For example, fish advisories may be a useful communication tool to raise public visibility of the issue of PBDEs, particularly if they are found in food sources. Another kind of monitoring that is very valuable at drawing public attention to the issue is monitoring levels of PBDEs and other toxic flame retardants in people's homes because of the release of flame retardant from furniture, draperies, etc. The general public's role is important due to strength in numbers and purchasing powers, with the IJC's role being to educate and outreach to the public on this issue.

7 Next steps

The two-day PBDEs in the Great Lakes workshop achieved its goal of bringing together representatives from diverse sectors and providing insights and advice which the WQB and IJC may use to help the governments of Canada and the United States address the challenges posed by PBDEs in the Great Lakes. Participants discussed and presented many barriers and challenges, as well as potential solutions for substitutes and alternate designs, and after-use management approaches.

At the close of the workshop, the following closing remarks were made regarding next steps:

- The workshop report will be shared with participants for their review, further insights and feedback, for the consideration of the Water Quality Board Legacy Issues work group
- The Legacy Issues Work Group will prepare a report with additional advice and recommendations

that builds upon the IJC PBDE report

- This report will be reviewed by the entire Water Quality Board and submitted to the Commission for its consideration
- The Commission will then decide whether to provide additional advice to the governments of Canada and the United States.

Appendix A – Participant List

Duncan	Bury	Duncan Bury Consulting
Holly	Davies	State of Washington Department of Ecology
Fe	de Leon	Canadian Environmental Law Association
Jessica	Dexter	Environmental Law and Policy Center (and IJC Water Quality Board member)
Miriam	Diamond	University of Toronto
Donalea	Dinsmore	Wisconsin Department of Natural Resources
Bradley	Grams	US Environmental Protection Agency Region 5, Chemicals Management Branch
Peter	Hargreave	Ontario Waste Management Association
Alister	Innes	Minnesota Pollution Control Agency
John	Jackson	IJC Water Quality Board Member
Christina	Marciano	Sussex Strategy Group on behalf of the Bromine Science and Environmental Forum
Chris	Marshall	Environment and Climate Change Canada
Betty	Matthews-Malone	City of Hamilton (and IJC Water Quality Board member)
Brad	Miller	Business and Institutional Furniture Manufacturers Association
Mike	Murray	National Wildlife Federation (and IJC Science Advisory Board, Science Priority Committee Member)
Paul	Parete	Environment and Climate Change Canada
Peter	Pettit	New York State Department of Environmental Conservation
Dale	Phenicie	Environmental Affairs Consulting (and IJC Science Advisory Board, Science Priority Committee Member)
Jo-Anne	St. Godard	Recycling Council of Ontario
Saskia	van Bergen	State of Washington Department of Ecology
Matt	Vinci	International Association of Fire Fighters
Barb	Sweazey	Stratos Inc. (Facilitator))

Antonette	Arvai	IJC Great Lakes Regional Office
Morris	Trish	IJC Great Lakes Regional Office (Director)
Serveiss	Victor	IJC Washington Office
Voglesong	Allison	IJC Great Lakes Regional Office
Warwick	Cindy	IJC Ottawa Office

Appendix B – Workshop agenda

PBDEs in the Great Lakes Workshop

Addressing Polybrominated Diphenyl Ethers in the Great Lakes Basin:
Searching for Solutions to Key Challenges

Day 1: Wednesday, February 22, 2017 (12:30 – 5:00 pm)
Day 2: Thursday, February 23, 2017 (8:00 am – 2:00 pm)

Location: Holiday Inn Hotel & Suites Windsor (Ambassador Bridge)
1855 Huron Church Road, Windsor, Ontario
LaSalle Meeting Room

Purpose of the Workshop: This workshop will bring together approximately 20-25 representatives from diverse sectors, with the goal of creating a more complete understanding of the ways to address problems with PBDEs in products. The Water Quality Board will use these as a basis to develop recommendations to the Commissioners. The Commissioners may use these to send further advice to the governments of Canada and the United States addressing the environmental challenges posed by PBDE-containing products in the Great Lakes basin. Specifically, the workshop will focus on: alternative methods to address flame retardant needs and identify best management practices for after-use management of PBDE-containing products, including the role that extended producer responsibility could play in the implementation of these best practices.

Workshop objectives:

- Identify challenges and barriers that may inhibit both government and industry from adopting practices to better manage and ultimately eliminate products containing PBDEs within the Great Lakes asin
- Generate a set of practical solutions for governments to consider in addressing the challenges associated with managing and eliminating products containing PBDEs within the Great Lakes Basin

Homework: We invite you to prepare for this workshop by reading and familiarizing yourselves with the following materials and consider the discussion questions provided in the attached agenda:

- PBDEs Workshop Background Document (attached)

- IJC report: *Polybrominated Diphenyl Ethers (PBDEs) in the Great Lakes Basin: Reducing Risks to Human Health and the Environment (available here:* http://www.ijc.org/files/publications/Polybrominated_Diphenyl_Ethers_Great_Lakes_EN.PDF)
- If you are interested, the detailed *PBDE Literature review* containing information on phase 1 products and extended producer responsibility programs, sourced from the Duncan Bury Consulting report: *Polybrominated Diphenyl Ethers in the Great Lakes Basin*. Please click here to read the full report: http://www.ijc.org/files/tinymce/uploaded/WQB/Appendix-A_WQB-PBDE_Consultants_Report.pdf

Day 1: February 22, 12:30 pm – 5:00 pm

#	Timing	Agenda Item
	12:30 – 1:00	**Registration**
1	1:00 – 1:15	**Welcoming Remarks**
2	1:15 – 2:00	**Introductions and Workshop Overview** • Roundtable of introductions • Review workshop agenda, objectives, housekeeping, and expectations
3	2:00 – 2:20	**Setting the Context** • Overview and history of PBDEs, and relevance to other substances
	2:20 – 2:45	**Break**
4	2:45 – 3:00	**History Keeps on Repeating Itself – Could PBDEs Break the Cycle?** • Brief overview of experience with and the environmental impact of harmful, persistent chemicals and their substitutes in the Great Lakes
5	3:00 – 3:05	**Recap of IJC Recommendations Related to Substitutes and Alternate Designs**
6	3:05 – 4:45	**Break-Out Group Discussions: Understanding and Breaking the Repeating Cycle** o *When we think about adopting substitutes for harmful substances such as PBDEs and/or looking for alternative product designs to serve a similar function to chemicals such as PBDEs, **what has prevented us from being successful**? Why does the cycle of replacing a toxic substance with another toxic substance keep repeating itself?* o *What steps need to be taken to overcome such barriers? Who must take those steps? What support would be needed?*
7	4:45 – 5:00	**Wrap Up of Day 1 and Overview of Day 2**

#	Timing	Agenda Item
	12:30 – 1:00	**Registration**
	6:30	**Social Function / Dinner** Holiday Inn Restaurant

Day 2: February 23, 8:00 am – 2:00 pm

#	Timing	Agenda Item
1	8:00 – 8:30	**Networking and Registration**
2	8:30 – 8:45	**Recap of Day 1 and Preparation for Day 2**
3	8:45 – 9:05	**How to Manage End-of-Life Products Containing PBDEs** • Idea Generators / Thought Sparkers
4	9:05 – 9:10	**Recap of IJC Recommendations Related to After-Use Management**
5	9:10 – 10:15	**Break-Out Group Discussion: After-Use Management of PBDEs** o *What are the **challenges** / problems / barriers we encounter in recycling and/or disposing of products containing PBDEs?* o *What are some of the **approaches, solutions** or **best management practices** that would help overcome these challenges, as it relates to these products?* o *How can those **best management practices** be **successfully implemented**? What **roles** do industry, government and/or the public play in the identified solutions?*
	10:15 – 10:30	**Break**
6	10:30 – 12:00	**Break-Out Group Discussion: Extended Producer Responsibility (EPR) Programs** o *What might extended producer responsibility programs **look like** for products that contain PBDEs? What would be the features of such EPR programs?* o *Who would be **responsible** for developing and implementing EPR programs?* o *What **other EPR Programs exist that the PBDEs program** could build upon? How could an EPR program be expanded to consider **other chemicals**?* o *What would be the **challenges**, particularly for government, in developing and implementing EPR programs for products containing PBDEs?*
	12:00 – 12:45	**Lunch (provided)**
7	12:45 – 1:45	**Reflecting on the Guidance to Offer Governments** o *Based on our discussion over the last two days, what are the top 2 -3 **messages** that need to be heard on managing and eliminating PBDE-containing products?* o *Based on our discussion over the last two days, what would be the top 2 – 3 **recommendations** you would suggest to manage / eliminate PBDE-containing*

#	Timing	Agenda Item
		products (and other similar chemicals) from the Great Lakes basin? o *Are there any key messages or recommendations that need to be heard that **we have not discussed** over the last 2 days?*
8	1:45 – 2:00	**Closing Reflections and Next Steps**

Appendix C – Workshop background document

GREAT LAKES WATER QUALITY BOARD

Addressing Polybrominated Diphenyl Ethers in the Great Lakes Basin:
Searching for Solutions to Key Challenges Workshop

BACKGROUND DOCUMENT

This document provides background material to help participants prepare for the workshop discussions. It contains information relevant to the workshop topic sessions including, chemical alternatives and substitutes to PBDEs; phase 1 PBDE-containing products; and Extended Producer Responsibility programs. The information in this document has been sourced from a consultant's report, prepared by Duncan Bury Consulting (October 30, 2015). This consultant's report was developed as a background document to inform the work that has been undertaken by the Water Quality Board. Participants may wish to review the detailed consultant report "Polybrominated Diphenyl Ethers in the Great Lakes Basin".

Chemical Alternatives and Substitutes

Relevant Workshop Session: History Keeps on Repeating Itself – Could PBDEs Break the Cycle? Substitutes and Alternate Designs

Numerous steps have been taken over the years to find alternative chemicals to PBDEs that allow products to meet flammability requirements, but that are of less concern from an ecological and human health perspective.[12] Manufacturers have been using alternatives to penta- and octa-BDEs for approximately a decade, and the atmospheric concentrations of some of these alternative compounds are approaching those of PBDEs in the Great Lakes area (for example the concentrations of TBB and TBPH).[13] In addition, two derivative substances of

[12] Murray, M.; Soehl, A.,Diamond, M., Abbasi, G. (2014). Great Lakes PBDE Reduction Project *Summary Paper No.2. PBDE Alternatives Assessment*.

[13] Ma. Y.N., Venier, M. & Hites, R.A. (2012). 2-Ethylhexyl Tetrabromobenzoate and Bis(2-ethylhexyl) Tetrabromophtalate Flame Retardants in the Great Lakes Atmosphere. *Environmental Science & Technology*, 46: 204-208.

TBBPA (another substitute to PBDEs) have been found to bioaccumulate in the herring gull food chain and transfer from gull to egg.[14]

These studies support growing concerns that we may be replacing one problem with another. Regulatory agencies in various countries, including Canada and the United States, have concluded that there is still insufficient data to ascertain whether alternative chemicals to PBDEs pose little or no risk, but some of the available alternative chemicals do appear to be safer than PBDEs.[15] While some of these products may be "safer," this does not mean that they have no environmental or health effects and that their use should be promoted. Alternatives to PBDEs should undertake a rigorous scientific risk assessment process before being used in the manufacture of consumer products. Given the very large number of possible alternatives, such an assessment process would require significant resources. In order to avoid replacing one problematic chemical with another, and avoid spending too much effort on long and complex substance assessment, it may be best to establish a novel approach for selecting alternatives, including considering the issue of flame retardants in a broader context that ensures that the desired functionality (fire safety) is maintained while minimizing risks to human and ecological health. The approach should also look beyond the mere replacement of PBDEs by other chemicals.

Chemical substitutes and alternative approaches

To illustrate the spectrum of possibilities, it is worth mentioning that the *Index of Flame Retardants*, an international guide, contains more than 1000 chemical flame retardant products (preparations and substances) listed by trade name, chemical name, application and manufacturer.[16] This index describes around 200 flame retardant substances used in commercial flame retardant products.

In essence, flame retardant chemicals can be divided into four main families:

- Inorganic flame retardants;
- Organophosphorus flame retardants;
- Nitrogen-based flame retardants;
- Halogenated flame retardants (these include PBDEs, are primarily based on chlorine and bromine and they react with flammable gases to slow or prevent the burning process).

[14] Letcher, R.J. & Chu, S. (2010). High-Sensitivity Method for Determination of Tetrabromobisphenol-S and Tetrabromobisphenol-A Derivative Flame Retardants in Great Lakes Herring Gull Eggs by Liquid Chromatography-Atmospheric Pressure Photoionization-Tandem Mass Spectrometry. *Environmental Science & Technology*, 44(22): 8615-8621.

[15] Norwegian Pollution Control Authority (SFT) (2009). Guidance on alternative flame retardants to the use of commercial pentabromodiphenylether (c-PentaBDE).

[16] Gower Index Series, (1997). The Index of Flame Retardants: An International Guide to More Than 1000 Products by Trade Name, Chemical, Application, and Manufacturer.

Keeping in mind the need to consider a broader approach, there are also a number of ways to provide a flame retardant effect that do not require chemicals and for which toxicity is not a concern. Examples include re-designing products to be less fire-prone, and the use of inherently fire-resistant fibers or lightweight metals. For example, barrier technologies have a wide immediate commercial applicability and involve layers of materials that provide fire resistance. These include boric acid-treated cotton materials used in mattresses, blends of natural and synthetic fibers used in furniture and mattresses and high performance synthetic materials used in firefighter uniforms and space suits.

In summary, the alternatives to the use of PBDEs as flame retardants may be grouped into three main categories:[17]

1. Substituting non-brominated chemical additives (chemical substitution) – basically replacement of PBDEs by another flame retardant without changing the base polymer;
2. Substituting product materials that don't require PBDEs (alternative materials) – i.e. the replacement of the base polymer containing PBDEs and other additives by another material; and
3. Changing design and construction of products so they are inherently less flammable (product redesign eliminating the need for a chemical) – this may include the replacement of a product by a different one or the fulfillment of the product function by the use of a different solution.

In terms of chemical substitution, the choice of a substitute to PBDEs depends on a number of factors such as the fulfillment of the fire safety standards, the level of hazard to human health and the environment, the physical and chemical properties of the product(s), ease of processing, costs, etc. To achieve the fire safety requirements, several substitutes may have to be used together. In general, there is not one specific substitute and case-by-case solutions have to be developed. Given the large number of potential chemicals, there are still major gaps in the understanding of the environmental and health effects of potential alternative chemicals.

Materials substitution includes the use of plastics that are inherently more resistant to ignition.[18] For textiles, the development of surface-active fibre systems (e.g. systems with graft copolymers having low flammability) is also a solution.[19] In some cases, it is possible to change plastics for other types of materials which are less flammable, such as wood and metals.[20]

[17] Genty, A. (2009). An Inventory and Assessment of Options for Reducing Emissions: Polybrominated Diphenyl Ethers (PBDEs). SOCOPSE Project (Source Control of Priority Substances in Europe).

[18] Corden, C. & M. Postle (2002). *Risk Reduction Strategy and Analysis of Advantages and Drawbacks for Octobromodiphenyl Ether*. Final Report. London: Department for Environment, Food and Rural Affairs. 117 pages.

[19] Posner, S. (2004). Survey and technical assessment of alternatives to decabromodiphenyl ether (decaBDE) in textile applications. Report 5/04. Swedish Chemicals Inspectorate. 29 p.

[20] OSPAR Commission (2004). Certain Brominated Flame Retardants – Polybrominated Diphenylethers, Polybrominated Biphenyls, Hexabromo Cyclododecane, OSPAR Priority Substances Series 135. London: OSPAR Commission. 24 p.

However, metal casings for laptop computers, for example, are more expensive and might be less acceptable to consumers (increase in size and weight).

Redesigning a product or fulfilling the product function by other means is a growing field of interest. This kind of solution is still considered more challenging from a technical feasibility and costs perspective. However, this may be the most promising avenue. The US Environmental Protection Agency (USEPA) is pursuing this type of solutions through its Design for the Environment Alternatives Assessment program.[21] For example to omit the use of flame retardants in foams, a simple solution is to increase the foam density, which can be sufficient to satisfy fire safety requirements. With electrical and electronic equipment, a possible design option for keeping fire safety without flame retardants is to move high-voltage and heat-generating parts of the products away from the outer casings or to introduce barriers (e.g. metal shields) between them.[22] Other design solutions exist, such as an increase in material thickness, the use of fuses to prevent short circuits, a decrease of operating temperatures and voltages, or the use of materials that conduct heat away from hot-spots.[23]

Phase 1 products containing PBDEs (electronics, appliances, carpets, mattresses and furniture)

Relevant workshop session: How to manage products containing PBDEs after-use?

Hazardous materials contained in waste products can be mobilized and released during various after-use processes including landfill, incineration and recycling.

Landfill Disposal and Leachate

Releases from landfills are a function of the concentration of PBDEs remaining in the products at their end of life, landfilling practices, use of leachate collection systems to prevent groundwater contamination, and, for those facilities that send leachate for treatment at municipal wastewater treatment facilities, the level of wastewater treatment utilized. Although very little testing appears to have been conducted on landfill leachate to look for PBDEs, testing that has been conducted has concluded that PBDEs are present and, depending on how the leachate is managed, there is a risk of release to the environment. Most of the work in this area has been driven by concerns about PBDEs contained in waste electronics and electrical equipment. Leachate is commonly collected from engineered landfills in Ontario and Great Lakes states, and is typically sent to a waste water treatment plant (WWTP) either by truck or by sanitary sewer depending upon location. WWTP's typically use screening and sedimentation, biological treatment and final filtration and sedimentation to remove and concentrate solids. Standard waste water treatment processes are not designed to capture chemicals such as PBDEs and as a result PBDEs have been detected in both sewage sludge and

[21] http://www2.epa.gov/saferchoice/design-environment-alternatives-assessments

[22] Lassen, C., S. Løkke, L. & I. Andersen (1999). *Brominated Flame Retardants: Substance Flow Analysis and Assessment of Alternatives*. Report 494. Copenhagen: Danish Environmental Protection Agency. 225 p.

[23] Pure Strategies (2005). Decabromodiphenylether: An Investigation of Non-Halogen Substitutes in Electronic Enclosure and Textile Applications. Lowell Center for Sustainable Production. University of Massachusetts Lowell. 69 p.

in the discharged waste water effluent.[24] These concentrated solids form sewage sludge and the remaining water is discharged to a surface water receiving body. Sewage sludge is mostly applied to agricultural land as a soil amendment in Ontario and in Great Lakes states and can therefore pose a risk of PBDE release through surface runoff. Sewage sludge can also be incinerated although it is unclear whether this is done in any of the Great Lakes states. It is not done in Ontario.

Incineration

There is very little information identified on the incineration of products containing PBDEs and the EPA reports that there has been no reported testing for PBDEs in emissions from MSW incinerators.[25] It is suggested by the Source Control of Priority Substances in Europe (SOCOPSE) report that controlled incineration – incineration without the production of dioxins and furans – will destroy PBDEs without the production of further PBDEs or other hazardous emissions.[26] Destruction of the PBDEs in a municipal solid waste (MSW) incinerator is dependent on the operating efficiency of the incinerator. The EPA suggests that MSW incinerators actually operate at 98 percent efficiency and thus suggest that 98% of any PBDE burned in such a facility would be destroyed. The 2 percent of PBDEs that would not be destroyed would be further reduced by dry scrubbers combined with fabric filters. It is unclear whether or not all currently operating incinerators in either the United States or Canada would meet the stated efficiency standards or stack emissions controls.

Recycling and processing

There is very little information identified on the actual or potential release of PBDEs during recycling and waste processing. There is a widespread concern that these processes are a potential release pathway and work in the areas of electronics and plastics has focused particular attention on measures to ensure that any such releases are minimized. Concern has also been expressed about the potential for releases during fires at recycling facilities which are unfortunately not that uncommon. It is widely noted that recycling of materials such as electronics and plastics which contain PBDEs and other persistent organic pollutants (POPs) makes sense from an environmental perspective and in many cases from an economic perspective. Manufacturing using secondary materials and energy recovery are often cited as positives but with the caution that they are acceptable only under conditions of environmentally sound management and best available technology (BAT) and best

[24] US EPA, National Center for Environmental Assessment, An Exposure Assessment of PBDEs, EPA/600/R-086F, May 2010

[25] US EPA, National Center for Environmental Assessment, An Exposure Assessment of PBDEs, EPA/600/R-086F, May 2010

[26] Source Control of Priority Substances in Europe 2009. Specific Targeted Research Project, Work Package 3 – D.3.1. An Inventory and Assessment of Options for Reducing Emissions: Polybrominated Diphenyl Ethers (PBDEs) SOCOPSE, 2009 page 36

environmental practices (BEP) designed among other things to minimize releases. The UNEP's Persistent Organic Pollutants Review Committee raised a number of major questions about recycling and secondary materials processing associated with wastes that contain PBDEs. Their report stated that "recycling articles containing POPs inevitably increases releases of POPs which can result in environmental and health risks" and that "the contamination of a wide range of product streams is now a practical and policy challenge that is likely to be exacerbated by recycling."[27] For example, the report notes that penta-BDE was mainly used in North America for the treatment of polyurethane foams (PUF) with recovered material being recycled into re-bonding for carpet padding, a process which has been shown to expose recycling workers and carpet installers.

Presented below is an overview of what is known about actual or possible releases of PBDEs during the life cycle of each of the identified phase 1 product categories which are known to contain or possibly contain PBDEs.

ELECTRONICS

In the United States, approximately 40 percent of electronics are recovered for reuse or recycling. In Canada, 500, 000 tonnes of end-of-life electronics have been diverted from landfills since 2004. Typically e-waste is shredded or manually dismantled for recycling. The total volume of recycled e-waste plastics is very low. Most e-waste plastics are likely landfilled. Estimates by the EPA indicate that 857,000 kg/yr of DecaBDE and 890,000 kg/yr of OctaBDE is disposed of in e-waste that is landfilled.

Printed circuit boards

Average life expectancy: 5-7 years

Printed circuit boards are made mostly of copper, protective coatings and adhesives, phenolic resins and epoxy resins or fibreglass. It is the resin that typically included a small amount of bromated flame retardants in circuit boards. Bromated flame retardants used in printed circuit boards include: tetrabromobisphenol A (TBBPA), polybrominated biphenyls; and polybrominated diphenyl ethers (PBDE). As of 2008, TBBPA was used in approximately 90 percent of printed circuit boards in the United States and efforts were already underway to utilize alternatives to halogenated BFRs. Environmental risk of PBDE releases from printed circuit boards in 2015 is

[27] UNEP, Persistent Organic Pollutants Review Committee (POPRC); Technical Review of the Implications of Recycling Commercial PentaBDE and Commercial OctaBDE; 2010 UNEP/POPS/POPRC.6/2 page 5

low in newer products. PBDEs are not chemically bound to plastic and can be released into the environment during recycling / processing of older circuit boards that still contain them. PDBE release risk is high from landfill leachate and medium from recycling / processing.

Laptop/computer casings/monitor casings/TV casings/fax casings

Average life expectancy: 3-10 years

Octa-BDE was used in high-impact plastic products such as casings for computer/laptop/monitors/TVs. These casings contain higher amounts of PBDEs than all other parts of a computer. In the EU, 95 percent of all Octa-BDE was used in electrical equipment casings. Uses include in Acrylnitrile-ButadieneStyrene (ABS) and High Impact Polystyrene (HIPS) –both used to make casings for electronics housings for televisions, audio and video equipment, mobile phones, remote controls, PCs, and PC monitors. Typical concentrations in these applications were between 12 wt percent and 18 wt percent prior to 2004. The computer monitor glass and interior does not contain PBDEs, only the casing for the monitor.

Computer monitors

Average life expectancy: 6 years for CRT, 5-7 for LCD

The computer monitor glass and interior does not contain PBDEs, only the casing for the monitor. The environmental risk of PBDE releases in the remainder of the monitor (not including the case) is nil.

Cell phones

Average life expectancy: 5-7 years

Mobile phones are comprised of a plastic case printed circuit Board, Liquid Crystal Display (LCD), keypad, microphone, a battery and a charger. The casing and circuit board would contain PBDEs. Other parts of the phone contain other hazardous materials but PBDEs are typically only present in the casing, circuit board, and plastic coated wire on the charger. The risk of PBDE release from cell phones is greatest in all jurisdictions that landfill used mobile phones and cordless phones. PBDE can leach out of this material as they are not chemically bound to plastic. As landfill leachate is collected and sent to municipal wastewater plants for treatment, remaining biosolids usually still contain PBDEs and biosolids are often applied to land as final

disposal. PBDE release is a risk during processing of end of life mobile phones, but not during normal use phase

APPLIANCES

With plastic being used during the manufacturing of many appliances, the concern for PBDE release from appliances is a risk since PBDEs are not chemically bound to plastic. As some studies have shown, amounts of PBDE can be elevated in indoor environments as dust collects on the casings of household appliances. There is also an identified potential for the PBDEs to escape from the casings through volatilization to the air when the equipment is running and the cases become warm. The main environmental risk for PBDE release from appliances is landfill leachate. However, the process of recycling also raises concern. During recycling, typical processes of most risk of release include: blending of PBDE polymers into new polymers; formation/release during accidental fires of articles containing PBDE; and release during the combustion of waste containing PBDE (in facilities and simple recycling operations).

Large appliances

Average life expectancy: clothes dryer- 13 years • clothes washer- 16 years • refrigerator- 9-13 years • dish washer- 9 years • gas oven/stove- 10-18 years • electric oven/stove- 13-15 years • freezer- 10-20 years

Large appliances are commonly shredded to facilitate recovery of metals. Markets for secondary metals drive the collection and recycling of large appliances. Residual non-metals are commonly sent for disposal.

Small appliances

Average life expectancy: microwave oven - 9 years • electric frying pan- 6-10 years • blender - 5 years • coffee maker- 4-10 years • toaster oven- 4-10 years • electric iron- 4-10 years • vacuum- 4-10 years • electric fan- 4-10 years • electric heater- 4-10 years

The value of materials recovered from small appliances is generally smaller than large appliances and insufficient to sustain a reliable market to offset the costs of collection, transportation and recycling.

CARPETS

Average life expectancy: residential 8-10 years • quality commercial carpet up to 20 years

Carpet padding is mostly made from polyurethane foam and can be made from recycled foam. PentaBDE was added to carpet backing as a fire retardant up until 2004. The average content of c-PentaBDE in polyurethane foam is reported to be around 3 to 5 percent for upholstery, cushions, mattresses, and carpet padding. Since PBDEs are not chemically bound to foam they can be released into the environment during use and recycling of older foam that still contains them. The main environmental risks of PBDE release for carpets include the potential for landfill leachate and the potential for release during the process of use and recycling. The potential for PBDE releases during recycling depends on the processing activities utilized by a facility, and the environmental management protocols required by a jurisdiction. The potential for PBDE releases during use is affected by the presence of dust. Carpet dust increases as carpet ages, and is also a function of applied force and relative humidity, resulting in an increased potential for PBDE release. The role of dust in increasing the potential for PBDE release can be considered a direct risk to children since most of this dust tends to concentrate in areas 18 inches and lower, of particular concern for children playing close to the floor.

MATTRESSES

Average life expectancy: 10 years • industry recommended replacement after 5-7 years

Similar to carpet, mattresses are mostly made from polyurethane foam. PBDE was added to mattresses as a fire retardant up until 2004. The average content of c-PentaBDE for polyurethane foam used in mattresses is reported to be around 3-5 percent. With indications that significant amounts of dust, with the potential to contain PBDEs, are released during the recycling period, PBDE release during the recycling of mattresses is an identified environmental risk. Other environmental risks of PBDE releases in mattresses include the potential for landfill leachate, and the possible vaporization of PBDEs into indoor air resulting from aging and wear of products.

FURNITURE

Average life expectancy: 8 years

With an estimated 2000-10,000 tonnes of pentaBDE in the Great Lakes basin, furniture foams make up 60-65 percent of that amount (1300-6500 tonnes). Until its discontinued use in 2004, polyurethane foam in furniture was typically made flame retardant with the use of pentaBDE. An average of 3 percent (range 2.9–3.2 percent) PBDE was found in this type of foam while one study reported a pentaBDE content as high as 30 percent by weight.

Foam used for furniture upholstery contains an average content of 3-5 percent c-PentaBDE. Since the typical end of life management of furniture involves disposal, one environmental risk of PBDE releases from foams contained in furniture is the potential for landfill leachate. It is also possible, as a result of aging and wear or product, for PBDEs in furniture to vaporize into indoor air during use. It is also important to note that scrap generated from upholstered furniture manufacturing presents the greatest challenges for end of life management. Trim scraps from cutting and shaping during the manufacture of furniture represents approximately 15 percent of the foam produced.

Estimated quantities of PBDEs in the Great Lakes basin

PBDE	Tonnage Range	Where found - % of total PBDE use	Quantities expected to enter waste phase or still be in use by 2020
Penta	2000t – 10,000t (2004)	Furniture foams 60-65 percent Vehicle foams 30-35 percent EEE 2-3 percent	All to leave the use phase
Octa	500t - 2,000t (2004)	EEE 90 percent Auto sector 10 percent	90 percent to leave the use phase
Deca	10,000t – 70,000t (2013)	Automotive 25 percent Textiles 25 percent Construction materials 25 percent EEE 115 percent	50 percent remain in use (of 2008 peak inventory)
Total PBDEs	15,000t – 80,000t (2004)		40 percent of the peak value (mainly deca) remain in use

Source: Great Lakes PBDE Reduction Project, Summary Paper No. 1, PBDE Product Inventory

Extended Producer Responsibility programs

Relevant workshop session: How to Manage Products containing PBDEs After-Use? Extended Producer Responsibility Programs

Extended producer responsibility programs (EPR) and "product stewardship" programs are used to manage products at their end of life. They function as a policy approach under which producers are given a significant responsibility – financial and/or physical – for the treatment or disposal of post-consumer products. Assigning such responsibility could in principle provide

incentives to prevent wastes at the source, promote product design for the environment and support the achievement of public recycling and materials management goals.

EPR programs are commonly made mandatory through legislation, but can also be adopted voluntarily (i.e. retail take-back programs) or even take the form of negotiated agreements between governments and industry. Legislated EPR programs are often adopted by jurisdictions when a designated waste stream is too costly or not profitable enough for producers or recyclers to voluntarily recover at the end of its useful life. Governments may adopt producer responsibility to achieve a greater recovery of secondary materials or as a means to divert materials from disposal. Legislated producer responsibility programs reflect the "polluter-pays-principle," since producers are made responsible for the waste management costs of their products.

To date, the concept of EPR has been used to ensure the proper end-of-life management of a broad and growing range of post-consumer products such as batteries, electronic equipment, ozone-depleting substances, paints, pesticide containers, pharmaceuticals, used oil, and used tires. Since its inception in Europe in the early 1990s, EPR and product stewardship initiatives have gained popularity rapidly, with programs in place throughout Europe, Japan, Korea, Taiwan, Australia, the United States and Canada.

More Information on EPR:
https://www.ec.gc.ca/gdd-mw/default.asp?lang=en&n=246D12C9-1
http://www.oecd.org/env/tools-evaluation/extendedproducerresponsibility.htm

North America

CANADA

- Canada-wide Action Plan for Extended Producer Responsibility (CAP-EPR) was approved by the Council of Ministers on October 29, 2009 with the goal of reducing the toxicity and environmental risks from products and product waste and improve the overall life-cycle performance of products, including reducing associated greenhouse gas emissions. To achieve this, the plan uses two product phases to shift responsibility of full life cycle cost accounting to the producers of products that contain hazardous chemicals.

  Phase One: Packaging • Printed materials • Mercury containing lamps • other mercury-containing products • Electronics and electrical products • Household hazardous and special wastes • Automotive products

Phase two: Construction materials • Demolition materials • Furniture • Textiles and carpet • Appliances, including ozone-depleting substances (ODS)
http://www.ccme.ca/files/current_priorities/waste/pn_1499_epr_cap_e.pdf

- Recycle My Cell is a free national industry-led recycling program for mobile devices. The program is run by the Canadian Wireless Telecommunications Association (CWTA) in conjunction with cell phone carriers, handset manufacturers and certified processors. Recycle My Cell has received regulatory approval from the province of Nova Scotia (October 2008) and British Columbia (November 2009). Recycle My Cell has also been formally recognized as the official cellular phone stewardship program within the provinces of Prince Edward Island and New Brunswick (March 2009), Manitoba (April 2009), Newfoundland and Labrador (July 2009), Saskatchewan (November 2009) and Alberta (June 2011). In all remaining provinces it operates on a voluntary basis.
http://www.recyclemycell.ca/

- Electronic Products Recycling Association (EPRA) is a not-for-profit organization managing government-approved programs that are established by manufacturers, retailers and other stakeholders to collect and responsibly recycle end-of-life electronics. EPRA is fulfilling this role on behalf of obligated stewards in eight provinces. (British Columbia, Saskatchewan, Manitoba, Ontario, Quebec, Newfoundland, PEI, Nova Scotia) Businesses selling regulated electronic products in these provinces can meet their compliance obligation by participating in the EPRA Program.
http://epra.ca/provincial-programs

- Refrigerant Management Canada (RMC) program was launched in 2000 and operated under the Heating, Refrigeration and Air Conditioning Institute of Canada (HRAI), is a voluntary industry-led extended producer responsibility program to ensure the collection and environmentally sound destruction of surplus ozone-depleting substances (ODS) from commercial stationary refrigeration and air conditioning equipment that have reached their end of life.
http://www.refrigerantmanagement.ca/

Ontario

- The Ontario Electronics Stewardship Recycling Program (OES) Program promotes the recycling and reuse of waste electronics to reduce the amount of "e-waste" disposed in landfills. Products accepted under the program include TVs, DVD players, computers, monitors, phones, radios, printers, and more. Since the program began in April 2009, over 395,000 tonnes of e-waste (or 30.72 kilograms per Ontario resident) have been collected, processed, and diverted in Ontario. Metals (including some precious metals), plastics and

glass are “mined” from electrical and electronic waste and safely recycled to manufacture new products. Substances of concern, such as heavy metals, are extracted from this waste to ensure they are managed in a safe and environmentally-responsible manner. Examples of these substances include lead, cadmium, beryllium, and mercury.

http://ontarioelectronicstewardship.ca/who-we-are/

British Columbia

- The Major Appliance Recycling Roundtable (MARR) is a not-for-profit stewardship agency, created to implement and operate a stewardship plan for end-of-life major household appliances in the province of British Columbia (BC) on behalf of major appliance “producers” who are obligated under the BC Recycling Regulation. Registration with MARR offers producers of major household appliances a turnkey solution for compliance with the BC Recycling Regulation.
  http://www.marrbc.ca/

Alberta

- Alberta’s end-of-life electronics recycling program is operated by the Alberta Recycling Management Authority (ARMA). There are over 360 collections sites across the province of Alberta where you can take your end-of-life electronics so they can be recycled in an effective, secure and environmentally safe manner.
  http://www.albertarecycling.ca/electronics-recycling-program

UNITED STATES

There are currently no federal laws for EPR.

- In 2014, Carpet America Recovery Effort (CARE) launched a nationwide temporary Voluntary Product Stewardship Program, designed to provide an alternative to EPR programs. As part of this program, CARE will, for a limited time, provide funds to carpet sorters to increase the volume of post-consumer carpet diverted from disposal. Sorters are not eligible to receive funds if they collect or sort carpet in states or local municipalities that have carpet EPR laws. They are also not allowed to support the development of such legislation.

  http://www.productstewardship.us/page/Carpet

Illinois

- In 2008, Illinois passed the Electronic Products Recycling and Reuse Act. This act establishes a statewide system for recycling and/or reusing a specific set of covered electronic devices that are discarded from residences by requiring electronic manufacturers to participate in the management of discarded and unwanted electronic products. **In addition, the Electronic Products Recycling and Reuse Act states that a consumer may not be charged a fee when bringing their item for recycling, unless a financial incentive of equal or greater value, such as a coupon, is provided. A fee for premium services such as curbside collection, home pick-up, or a similar method of collection is allowed.** http://www.epa.illinois.gov/topics/waste-management/electronics-recycling/

Indiana

- The Indiana Electronic Waste Law (2009) prohibits the disposal of electronic devices (including TVs, computers and computer peripherals, DVD players, digital photo frames, digital media players, and others) in a landfill or by incineration. The law also requires manufacturers to disclose whether any video display devices sold by the manufacturer to households exceed the limits for PBDEs under the restriction on hazardous substances (RoHS) Directive of the European Parliament and Council, and whether the manufacturer has received an exemption from these limits. State procurement and state contractors must comply with the Electronic Waste Law. https://dnr.mo.gov/env/swmp/facilities/docs/indianaregs.pdf

Michigan

- Michigan implemented an electronics-focused mandatory EPR program in 2008 with the establishment of the Electronic Takeback program. Supported by the Michigan Electronic Take Back Law (Michigan Natural Resources and Environmental Protection Act, Act 451 of 1994, Part 173 Electronics, 372.17301-17333) the program requires manufacturers to register with the Department of Environmental Quality, establish a free and convenient electronic recycling take-back program, and maintain a website to inform consumers. And submit annual information about their takeback program. http://www.michigan.gov/deq/0,4561,7-135-70153_70155_3585_4130-208087--,00.html

Minnesota

- The Minnesota Electronics Recycling Act (2007) targeting the collection and recycling of "video display devices" sold to households/consumers, including "televisions," "computer

monitors," and other select device. Manufacturers of video display devices (VDD) must annually register and pay a fee to the state, collect and recycle covered electronic devices (CED) from households/consumers in Minnesota, and file a report detailing the results of their collections for each program year.

https://www.pca.state.mn.us/quick-links/minnesota-electronics-recycling-act

New York

- The NYS Electronic Equipment Recycling and Reuse Act requires manufacturers to provide free and convenient recycling of electronic waste to most consumers in the state. Consumers eligible for free and convenient recycling include individuals, for-profit businesses, corporations with less than 50 full time employees, not-for-profit corporations with less than 75 full time employees, not-for-profit corporations designated under section 501(c)(3) of the internal revenue code, schools, or governmental entities located in NYS. For-profit businesses with 50 or more full time employees and not-for-profit corporations with 75 or more full time employees may be charged.
  http://www.dec.ny.gov/docs/materials_minerals_pdf/ewastelaw2.pdf

Ohio

- None identified.

Pennsylvania

- The Pennsylvania Covered Device Recycling Act (2010) establishes a recycling program for certain covered devices and imposes duties on manufacturers and retailers of certain covered devices (including desktop and notebook computers, computer monitors, computer peripherals, and TVs). Maufacturers of covered devices must register annually with the Department of Environmental Protection in order to sell their covered devices in Pennsylvania and establish, conduct and manage a plan to collect, transport and recycle a quantity of covered devices.
  http://www.dep.pa.gov/Business/Land/Waste/SolidWaste/HazardousWaste/Household/Pages/Covered-Device-Recycling-Act.aspx

Wisconsin

- The Wisconsin Electronics Recycling Law (2009) establishes a product stewardship program in which electronics manufacturers fund a statewide collection and recycling system. There are also requirements for consumers, electronics retailers and local government.

Consumers are responsible for recycling their used electronics. Retailers can only sell registered brands of electronics and must inform customers about electronics disposal bans and electronics recycling opportunities. Local government must inform their residents about electronics recycling and the electronics disposal bans. The law bans many consumer electronics from being landfilled and incinerated, including TVs, computers, computer monitors, computer peripherals, cell phones and video players.
http://dnr.wi.gov/topic/ecycle/wisconsin.html

California

- California is the first state to establish a private-sector designed and managed statewide carpet extended producer responsibility program. This program, managed by Carpet America Recovery Effort (CARE), started in 2011 and follows producer responsibility principles to ensure that over time discarded carpets become a resource for new products in a manner that is sustainably funded and provides jobs for Californians. Several carpet recycling facilities currently operate in California, offering jobs, and producing products and feedstock for products made from recycled carpet.
http://www.calrecycle.ca.gov/Carpet/Plans/default.htm

Connecticut

- In 2013, Connecticut became the first state to pass comprehensive mattress recycling legislation. Public Act 13-42 requires mattress manufacturers to establish a program to manage unwanted mattresses generated in Connecticut. When a consumer purchases a new mattress, there is an additional fee charged. The retailer then transfers this money to the mattress manufacturers who will use it to pay for transportation and recycling of unwanted mattresses. The government does not administer this program or control the funds collected. The mattress manufacturers were required to submit a plan to the DEEP by July 1, 2014. The Connecticut Mattress Stewardship Plan, submitted by the Mattress Recycling Council, was approved by the Connecticut Department of Energy and Environmental Protection on December 31, 2014.
http://www.ct.gov/deep/lib/deep/reduce_reuse_recycle/mattress/ct_mattress_stewardship_plan.pdf

Rhode Island

- In July 2013, Rhode Island General Law 23-90, which requires mattress manufacturers to create a statewide recycling program for discarded mattresses, was passed. The program began May 1, 2016 and is funded through a visible recycling fee collected at retail from customers on each mattress and foundation sold in the state. These fees fund the collection and recycling of mattresses and foundations used and discarded in Rhode Island.

The Mattress Recycling Council (MRC), a non-profit organization established by the mattress industry, manages the program.
http://mattressrecyclingcouncil.org/

Europe

EUROPEAN UNION

- Waste Electrical and Electronic Equipment (WEEE) [Directives 2002/96/EC and 2002/95/EC]: In January 2003, the EU passed two directives on WEEE: one on recovery of WEEE, the other on restricting the use of hazardous substances in WEEE. The goals of the program are identical to those just provided for end-of-life vehicles with the substitution of "waste electrical and electronic equipment" for "waste from vehicles". WEE includes large and small household appliances, IT and telecommunications equipment, consumer equipment (e.g., televisions, radios, hi-fi equipment), lighting equipment, electrical and electronic tools, toys, leisure and sports equipment, medical devices, monitoring and control instruments, and automatic dispensers.
  http://ec.europa.eu/environment/waste/weee/index_en.htm

Germany

- The new Electrical and Electronic Equipment Act [ElektroG] manages the putting on the market, recovery, and recycling of electrical and electronic equipment in Germany. Producers, Importers, and (under certain circumstances) Resellers are now more than before responsible for the products they put on the market during their complete life span. They have to take back and dispose of the "Waste of Electrical and Electronic Equipment" (WEEE) at their own charge. Financial guarantees for the event of insolvency, together with the appropriate trusteeship, should ensure that the state doesn't have to pay for the remaining WEEE of a bankrupt producer.
  http://elektrogesetz.com/

Asia

TAIWAN

- The Taiwan Environmental Protection Administration established and manages the Resource Recycling Management Fund (RRMF). Included in their products of concern are four electric and electronic appliances; refrigerators, washing machines, air conditioners (only unit-type), and television sets. These appliances were included in the list of the regulated recyclable waste in July 1997.
  http://recycle.epa.gov.tw/Recycle/en/NAV04Content.htm

JAPAN

- With the enactment of the Home Appliance Recycling Law in April 2001, a system was established to properly recover end of life home appliances and efficiently recycle them so that they can be reborn as raw materials. The appliances addressed by this law include air conditioners, refrigerators, televisions and washing machines. Take-back of computers was also fully enforced in October 2003 in a separate regulation. The Association for Electric Home Appliances (AEHA), a trade group, is responsible for "orphan" products — those that outlast their manufacturer, e.g. TV discarded 20 years after sale.
  http://nett21.gec.jp/Ecotowns/data/et_c-07.html

SOUTH KOREA

- The Act on Resource Recirculation of Electrical and Electronic Waste and End of Life Vehicles states the producers' and importers' duties and responsibilities for products including televisions, refrigerators, washing machines, microwaves and many other appliances. The duties and responsibilities outlines in the act include restricting the use of hazardous substances in products, collecting end of life products, and recycling them. The producers of these products may establish a waste collection facilitating center (Producer Responsibility Organization, PRO), which should compensate for the cost of waste collection borne by the local governments.
  http://www.aseic.org/ctt/CntntDtlR.do?pGbSeq=5&pageNm=map

South America

CHILE

- On 9 June 2015 the Senate of the Chilean Ministry of Environment approved a bill for the Law on the Promotion of Recycling. The law is now in the final stages of approval and a

period of indications has been opened until 3 August. The bill will promote reuse, recycling and recovery through the means of Extended Producer Responsibility. EPR will be introduced for nine priority products; including electrical and electronic equipment, batteries and packaging. Collection targets will be set for manufacturers and importers of priority products which will allow for the official development of the recycling industry within Chile.
http://www.b2bweee.com/publications/news/226-extended-producer-responsibility-in-chile

Africa

SOUTH AFRICA

- The Waste Act, passed in 2008, establishes Extended Producer Responsibility (EPR) as a regulatory mechanism. In South Africa, EPR applies to instances in which the nature of the waste from products is of sufficient threat to require producers to take responsibility for aspects of a products management beyond the point of sale.
https://www.environment.gov.za/sites/default/files/legislations/nema_amendment_act59.pdf