Per- and Polyfluoroalkyl Substances in Food Packaging Alternatives Assessment

Developed under Chapter 70A.222.070 RCW

Hazardous Waste and Toxics Reduction Program

Washington State Department of Ecology

Olympia, Washington

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State of Washington

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Alternatives assessment contributors

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Related Information

- Documents related to this project are available in Ecology's PFAS in Food Packaging Alternatives Assessment website.[1]

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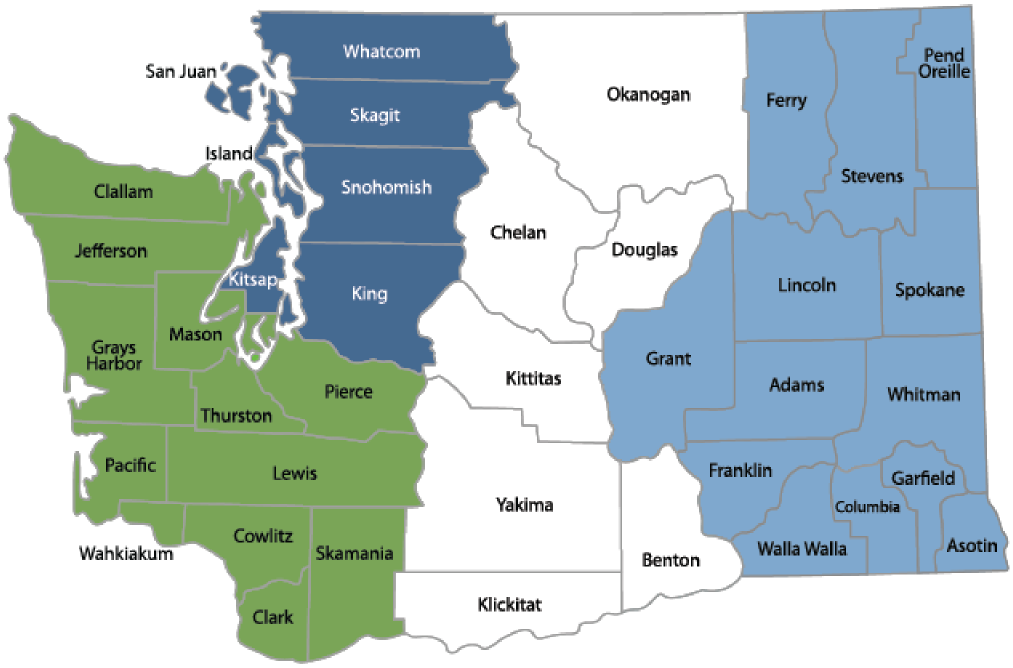
Department of Ecology's Regional Offices

Map of Counties Served



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Acronyms

Table 1. Acronyms found in this alternatives assessment.

Acronym	Definition
AA	Alternatives assessment
CAP	Chemical Action Plan
CASRN	Chemical Abstracts Service Registry Number
CBI	Confidential Business Information
CFR	Code of Federal Regulations
DiPAP	Polyfluoroalkyl phosphoric acid diester
DTSC	Department of Toxic Substances Control
Ecology	Washington State Department of Ecology
EVOH	Ethylene vinyl alcohol
FCM	Food contact material
FCN	Food Contact Notification
FDA	U.S. Food and Drug Administration
FTOH	Fluorotelomer alcohol
IC2	Interstate Chemical Clearinghouse
MW	Molecular weight
NAS	National Academy of Sciences
NEWMOA	Northeast Waste Management Officials' Association
NGO	Non-governmental organization
OGR	Oil and grease resistance
PE	Polyethylene
PET	Polyethylene terephthalate
PFAA	Perfluoroalkyl acid
PFAS	Per- and polyfluoroalkyl substances
PFHxA	Perfluorohexanoic acid
PLA	Polylactide or Polylactic acid
PVOH	Polyvinyl alcohol
SCIL	Safer Chemical Ingredients List
EPA	U.S. Environmental Protection Agency

Executive Summary

Overview

The Washington State Department of Ecology (Ecology) alternatives assessment (AA) fulfills the requirements of RCW 70A.222.070,[4] which restricts the manufacture, distribution, and sale in Washington of "food packaging to which per- and polyfluoroalkyl substances (PFAS) chemicals have been intentionally added in any amount" if safer alternatives to PFAS in food packaging are identified. PFAS are intentionally added to some paper food packaging to provide oil and grease resistance, water repellency, and leak resistance.

RCW 70A.222.070 provides a process for identifying available safer alternatives. A safer alternative is an alternative material or chemical that both meets improved hazard and exposure considerations, and can be practicably and economically substituted for the original chemical. When safer alternatives are identified for PFAS in a specific food packaging application, the manufacture, sale, or distribution of products that contain PFAS within that application will be prohibited starting two years from the date Ecology submits a report to the Legislature with appropriate findings. Until safer alternatives are identified for each food packaging application, Ecology must continue reviewing alternatives to PFAS in any non-restricted applications.

As required by RCW 70A.222.070(2), Ecology, in partnership with the Washington State Department of Health (collectively, "we"), conducted an alternatives assessment that:

- Evaluates less toxic chemicals and nonchemical alternatives to replace the use of PFAS;
- Follows the guidelines for alternatives assessments issued by the Interstate Chemicals Clearinghouse (IC2); and
- Includes, at a minimum, an evaluation of chemical hazards, exposure, performance, cost, and availability.

The AA must consider alternatives to PFAS in food packaging that are "intended for direct food contact and are comprised, in substantial part, of paper, paperboard, or other materials originally derived from plant fibers" (RCW 70A.222.010[5]). For this alternatives assessment, we selected ten food packaging applications from three food packaging categories:

- Food contact paper:
    - Wraps & liners.
    - Bags & sleeves.
- Dinnerware:
    - Plates.
    - Bowls.
    - Food boats.
    - Trays.

[4] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.222.070

[5] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.222.010

- Take-out Containers:
    - Pizza boxes.
    - French fry cartons.
    - Clamshells.
    - Interlocking folded containers (also called food cartons or food pails).

For all the food packaging applications included in this AA, Ecology is only considering alternative products that are used to hold and serve freshly prepared food (see the Introduction for details and definitions). Ecology identified safer alternatives for four out of ten food packaging applications assessed. We submitted a draft of this AA, including a preliminary identification of safer alternatives, for peer review with the Washington State Academy of Sciences. Feedback from this peer review was incorporated into our final edits as appropriate.

Alternatives assessment approach

Alternatives assessments provide a framework to compare a currently used substance or product to potential alternatives in a way that prioritizes reducing chemical hazards and avoiding regrettable substitutions.

RCW 70A.222.070[6] requires that Ecology use guidance from the Interstate Chemicals Clearinghouse Alternatives Assessment Guide Version 1.1 (IC2 AA Guide; IC2, 2017) to determine if safer alternatives for PFAS in the identified food packaging applications exist. In addition, the statute requires that "the safer alternatives must be readily available in sufficient quantity and at a comparable cost, and perform as well as or better than PFAS chemicals in a specific food packaging application" (RCW 70A.222.070[7]).

The IC2 AA Guide recommends, at minimum, evaluating alternatives for hazard and exposure concerns as well as performance and cost and availability. Considering other aspects of chemical management besides hazard and exposure (such as product performance, availability, and cost) further reduces the chance of selecting a regrettable substitute. Unlike risk assessments, under an alternatives assessment, exposure is considered after identifying the least hazardous options. See the Introduction for more detail on the structure and composition of alternative assessments.

We used five modules in this AA:

- Stakeholder Involvement Module
- Hazard Module
- Exposure Assessment Module
- Performance Evaluation Module
- Cost and Availability Module

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[6] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.222.070
[7] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.222.070

In the four assessment modules (hazard, exposure, performance, and cost and availability), we compared alternative materials and substances, and PFAS-free products that use those alternative materials and substances, to PFAS. Currently, the Food and Drug Administration (FDA) permits 19 PFAS for use in packaging that is in contact with food. To facilitate the comparison of potential PFAS hazard or exposure concerns, a single PFAS chemical, its impurities, and the products of its break down were identified and assessed (see Section 2). For the performance and cost and availability modules, Ecology compared products that contained any PFAS to PFAS-free products containing a known alternative material or substance.

Time and budget limitations meant it was infeasible to evaluate every possible alternative for each food packaging application considered. We chose the alternatives we assessed based on input from stakeholder engagement and research into alternative chemicals and materials that are available in the marketplace. Find more details on this process in Section 3.

Additionally, for the alternatives we identified as candidates for this AA, we were limited to information that was either publicly available or volunteered by a stakeholder or manufacturer. When we did not have enough information to evaluate a candidate alternative in an assessment module, the alternative was designated as having "insufficient data." This report makes no assertion regarding the safety or feasibility of PFAS alternatives we did not evaluate, nor about those that were determined to have insufficient data.

Under the statute, if Ecology does not find an available safer alternative for all food packaging applications, we must review and report on alternatives to the remaining food packaging applications (based on available staffing and resources) until we identify safer alternatives.

Decision framework

We selected the Simultaneous Decision Framework from the IC2 AA Guide to organize our data collection and analysis. In a simultaneous decision framework, the four assessment modules are performed in parallel. The results of these four modules are then analyzed using a multi-parameter analysis. In this AA, we evaluated the results to determine if an alternative met the criteria for a favorable alternative in all four assessment modules—we refer to the collective criteria as the criteria for safer. For each food packaging application, each candidate alternative was determined to 1) meet the criteria for safer, 2) not meet the criteria for safer, or 3) have insufficient data in one or more modules, preventing a determination. See Section 8 for the criteria for safer used for the simultaneous analysis and our findings of which alternatives meet the criteria for safer.

Stakeholder Involvement Module

Incorporation of stakeholder interests is an important component of the AA process. The process for stakeholder engagement followed guidelines in the Stakeholder Involvement Module of the IC2 AA Guide. We conducted an IC2 Level 2 Stakeholder Involvement Module to ensure stakeholders were considered in the AA process and to provide information so concerned parties could understand our decision-making and provide input into that process. There are a diverse number of parties that have a stake in the transition from PFAS to non-PFAS alternatives in food packaging. Stakeholders had the opportunity to participate in the development of methodology and decision rules for different portions of the assessment. We identified and addressed or mitigated stakeholder concerns where possible.

Hazard Module

To assess PFAS-free alternatives, we based our hazard evaluation on the Level 2 Hazard Module in the IC2 AA Guide. The guide recommends using the GreenScreen® for Safer Chemicals hazard assessment tool (GreenScreen®)—a free, transparent, and publicly available hazard assessment tool. GreenScreen® identifies chemicals on a "benchmark" scale: Benchmark-1 (BM-1) are chemicals of highest concern and BM-4 are chemicals of lowest concern.

Each alternative we evaluated went through an initial screening to identify chemicals of low concern or high concern—those that were neither were evaluated using GreenScreen®.

The following questions summarize the outcomes of this hazard assessment:

1. Was PFAS evaluated for hazard concerns?
    - Answer: Yes. The evaluation showed that two key chemicals that are found in food packaging that uses the comparator PFAS scored as BM-1 ("Avoid—Chemical of High Concern").
2. Were alternatives identified as low concern (listed on the EPA Safer Chemical Ingredients List, or untreated paper)?
    - Answer: Yes. We identified several alternative materials and treatments as low concern.
3. Were alternatives identified using GreenScreen® assessment that were less hazardous than PFAS?
    - Answer: Yes. We identified PLA as consistent with BM-3 ("Use but Still Opportunity for Improvement") through a hazard assessment of its chemical components.
4. Were alternatives identified using GreenScreen® assessment that were not less hazardous than PFAS?
    - Answer: Yes. A hazard evaluation found the alternative candidate siloxane to be BM-1 ("Avoid—Chemical of High Concern").

We were unable to identify sufficient information to assess the remaining candidate alternative substances using GreenScreen® assessments. The hazard module is discussed in more detail in Section 4.

Exposure Assessment Module

To evaluate potential exposure risk, we completed a Level 1 Basic Comparative Exposure Assessment based on the IC2 AA Guide. This evaluation is a qualitative assessment based on readily available data that aims to "identify whether material differences exist between the chemical of concern and potential alternatives." If an alternative is considered low or high concern based on the results of the hazard assessment model, then it is not necessary to evaluate exposure risk, according to the IC2 AA Guide. We used preliminary questions to determine, based on hazard concerns, if an alternative should be considered in the exposure assessment module.

The following questions summarize the outcome of the exposure assessment:

1. Were alternatives identified that are of low hazard concern compared to the chemical of concern?
    - Answer: Yes. We identified several alternative materials and treatments as being of low concern or BM-3 in the hazard evaluation. These did not require an exposure assessment.
2. Were alternatives identified that have persistence, bioaccumulative, and/or toxic properties of concern?
    - Answer: Yes. The candidate siloxane chemical was found to be BM-1 and ranked very high for persistence and very high for bioaccumulation. Therefore, this alternative did not require an exposure assessment and could not be considered a safer alternative.

Those candidate alternative substances that could not be evaluated in the hazard module also could not be evaluated in the exposure module. As a result, we did not perform a qualitative exposure assessment for any of the candidate alternatives.

This module also highlights Washington populations who may be exposed to higher levels of PFAS—due to increased fast food consumption, medical conditions, or non-food packaging exposure from other sources. Find the Exposure Assessment Module in Section 5.

Performance Evaluation Module

We completed a Level 1 Basic Performance Evaluation following the IC2 AA Guide to determine whether products using alternative substances under assessment "perform as well as or better than PFAS chemicals in a specific food packaging application" (RCW 70A.222.070). In this AA, Ecology used performance requirements that 1) a number of stakeholders identified as high priority, and that 2) were broadly applicable to the food packaging types identified. The approach used promotional materials to determine whether the alternative products met the performance requirements of oil and grease resistance and leak resistance.

The following questions summarize the outcomes of the performance assessment module:

1. Based on the available information, is the alternative:
    a) Being used for the same or similar function?
    b) Available on the commercial market?
    c) Published in promotional materials as having the desired function?
    d) One that has favorable performance (based on the responses to a, b, and c)?

    Answer:
    - We identified all PFAS-free alternatives, except for polyethylene (PE)- and polyethylene terephthalate (PET)-coated products, in commercially available products used to perform similar functions to PFAS-containing food packaging.
    - For a small subset of the alternative products we evaluated that were made from PFAS-free molded fiber or polylactic acid (PLA) plastic, some

research findings indicated limited performance for high heat or very oily substances.
    - Promotional materials that discussed oil and grease resistance or leak resistance could not be identified for clay-coated pizza boxes or French fry cartons, or uncoated paper plates or clamshells.
2. If the answer to question d is no or is uncertain:
    e) Has an authoritative body demonstrated the alternative functions adequately?
    f) Are there indications that the alternative does not perform as well?
    g) Has an expert identified the alternative as unfavorable for performance?
    Answer:
        - Stakeholder input indicated that PLA plastic and PFAS-free molded fiber products provide oil and grease resistance and leak resistance (i.e., perform as well as PFAS) for foods under most conditions.
        - We did not perform an additional evaluation for clay-coated pizza boxes or French fry cartons, or uncoated paper plates or clamshells.

Find more detail on the outcomes of the Performance Module in Section 6.

Cost and Availability Module

To assess PFAS-free alternatives, Ecology conducted a Level 1 Basic Cost and Availability Evaluation based on the IC2 AA Guide. RCW 70A.222.070[8] directs Ecology to consider that "the safer alternative must be readily available in sufficient quantity at a comparable cost." Ecology gathered product testing data and information about the manufacturers and unit prices of products that contain either a candidate alternative or PFAS.

The following questions summarize the outcomes of the cost and availability evaluation:

1. Is the alternative currently used in the application of interest?
    - Answer: Yes. The candidate alternatives are currently used in the food packaging applications we considered in this assessment.
2. Is the alternative currently offered for sale for the application of interest? Will it be relatively easy to obtain the alternative from a supplier, and if that supplier cannot meet demand are there other options?
    - Answer: It depends on the food packaging application. PFAS-free food packaging alternative products are currently offered for sale in all food packaging applications we considered. We identified PFAS-free food packaging alternative products that are available in sufficient quantities for some food packaging applications.
3. Is the price of the alternative close to the current (defined as a price increase of 10% or less)?
    - Answer: It depends on the food packaging application. PFAS-free food packaging alternative products are currently offered for sale in all food packaging applications we considered. We identified PFAS-free food packaging alternatives that are price

[8] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.222.070

comparable with similar PFAS-containing products for some food packaging applications.

In the Cost and Availability Module, we also considered whether reusable versions of dinnerware and take-out containers met our criteria for cost and availability. Section 7 reviews the Cost and Availability Module outcomes in more detail.

Determination of safer alternatives

Section 8 presents the results of each assessment module for each alternative and food packaging application assessed. It also notes when there was either insufficient data to evaluate an alternative, or some restriction on the use of an alternative.

The criteria for safer are also listed in Section 8. After conducting the reviews required by RCW 70A.222.070(2) and directed by the IC2 AA Guide, Ecology determined the following alternative substances met the criteria for safer alternatives for one or more food packaging applications:

Table 2. Summary of safer alternative substances identified for specific food packaging applications.

Food packaging application	Uncoated (non-chemical)	Wax-coated	Clay-coated	Reusable version	Total number identified
Wraps & liners	No	Yes	No	No	1
Plates	No	No	Yes	Yes	2
Food boats	No	No	Yes	Yes	2
Pizza boxes	Yes	No	No	No	1

In the following food packaging applications, Ecology did not identify any alternatives that met the criteria for safer without restrictions at this time:

- Bags and sleeves
- Bowls
- Trays
- French fry cartons
- Clamshells
- Interlocking folded containers

Future alternatives assessments of PFAS in food packaging will reevaluate the food packaging applications for which no safer alternatives were identified. Some alternative chemicals and materials that we identified in the assessment could not be evaluated due to a lack of available chemical, material, or product information. In future AAs, we may return to the same alternative substances we assessed here, in order to review new market data or chemical or material information.

Introduction

In 2018, the Washington State Legislature passed legislation banning the use of per- and polyfluoroalkyl substances (PFAS) in "specific food packaging applications" if safer alternatives are available (RCW 70A.222.070[9]). This law requires the Washington State Department of Ecology (Ecology) to conduct an alternatives assessment (AA) to evaluate "less toxic chemicals and nonchemical alternatives" and determine whether safer alternatives are "readily available in sufficient quantity and at a comparable cost, and perform as well as or better than PFAS chemicals."

RCW 70A.222.010[10] defines PFAS as "a class of fluorinated organic chemicals containing at least one fully fluorinated carbon atom." PFAS have been in commercial use since the 1950s. In food packaging, PFAS are used to provide oil, grease, and water resistance to paper, paperboard, and molded fiber products (ITRC, 2020).

Although these applications typically use polymeric PFAS, these polymers may include impurities and breakdown products such as 6:2 fluorotelomer alcohol (FTOH) and perfluorohexanoic acid (PFHxA) (Buck, 2015). 6:2 FTOH and PFHxA have been detected in food packaging material in the U.S., and can migrate into food (Schaider et al., 2017; Yuan et al., 2016).

Some state, federal, and international governments are acting to restrict the use of PFAS in food packaging.

- In 2019, Maine passed L.D. 1433 (H.P. 1043), which would prohibit intentionally added PFAS in food packaging beginning January 1, 2022, provided the Maine Department of Environmental Protection can identify readily available safer alternatives.
- The California Department of Toxic Substance Control (DTSC) is proposing to list one or more PFAS-containing plant-fiber based food packaging products as Priority Products under the Safer Consumer Products regulation (DTSC, 2020a).
- In 2020, New York passed a ban on all food packaging that contains intentionally added PFAS (S.8817 and A.4739-C) beginning in 2023.
- Denmark enacted a ban on PFAS in food packaging beginning July 1, 2020, based on a limit of 20 micrograms of organic fluorine per gram of paper. PFAS may still be used in the plant-fiber if there is a functional barrier between the PFAS-containing material and food (DVFA, 2020).
- In July 2020, the Food and Drug Administration (FDA) announced some manufacturers of PFAS agreed to a three-year voluntary phase out of all 6:2 FTOHs in food packaging (both the chemical and all polymer compounds that incorporated 6:2 FTOH) beginning January 1, 2021 (FDA, 2020a).

[9] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.222.070
[10] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.222.010

Alternatives assessment

We completed this AA using the Interstate Chemical Clearinghouse Guidelines v1.1 (IC2 AA Guide). The guide was developed by an expert committee and is maintained by the Northeast Waste Management Officials' Association (NEWMOA). The IC2 AA Guide standardizes the AA process by:

- Allowing for flexibility to meet a wide range of user needs.
- Fostering the replacement of toxic chemicals and avoiding regrettable substitutes.
- Including reasonable criteria to conduct an AA.
- Recommending a minimum data set needed to conduct an AA.

According to IC2, the intent of an alternatives assessment is "to replace chemicals of concern in products or processes with inherently safer alternatives, thereby protecting and enhancing human health and the environment." An AA differs from traditional chemical risk assessment, which estimates exposure and compares this to a hazard-based limit. AAs focus more on reducing chemical hazards and avoiding regrettable substitutions to reduce risk. In an AA, exposure is considered after identifying the least hazardous options. Considering other aspects of chemical management (such as stakeholder concerns, product performance, and cost and availability) further reduces the chance of selecting a regrettable substitute. The AA process as outlined by the IC2 AA Guide follows five distinct steps:

1. Identify chemicals of concern.
2. Initial evaluation.
3. Scoping.
4. Identification of alternatives.
5. Evaluate alternatives.

RCW 70A.222.070 takes the places of steps one and two, by identifying PFAS as the chemical of concern and directing Ecology to perform an AA. In step three, scoping is used to identify the framework of the AA (see "Simultaneous Decision Framework" below) and the degree to which stakeholder involvement is needed (see Section 1). Scoping as used by the IC2 AA Guide is distinct from the scope of the AA. The scope of the AA refers to the logistical and legal boundaries identified in statute or determined by Ecology for the purposes of guiding this alternatives assessment.

As a part of scoping, we initiated a Level 2 Stakeholder Involvement Module. This module ensures stakeholders and concerned parties can understand what and why decisions are being made, and can provide input on the process. We recruited and engaged with stakeholders from across the food packaging supply chain. Stakeholders from non-governmental organizations, local governments, other state governments, federal agencies, universities, and trade associations were also involved in the AA process.

In step four, we identified potential alternatives (see Section 2 and Section 3). Section 2 details information on PFAS in food packaging and the process of identifying a comparator PFAS for use in the hazard and exposure evaluations. Section 3 contains information on Ecology's process identifying food packaging applications and alternatives to PFAS for this AA.

For the purposes of this AA, alternatives can be defined at two levels.

- The **chemical/material level** considers an alternative substance, which includes both an alternative chemical that replaces PFAS in plant fiber-based food packaging, and an alternative material that replaces the plant fiber-based packaging itself, which contains PFAS.
- By contrast, the **product level** is defined by the combination of an alternative substance and a food packaging type.

For example, while a foam clamshell and a foam plate are the same on the chemical/material level, they are distinct on the product level. The level at which we evaluated an alternative depended on the assessment module.

Finally, in step five, the alternatives are evaluated using assessment modules. We completed four assessment modules for this AA to meet the requirements of RCW 70A.222.070.[11] The levels at which we performed these assessment modules reflect Ecology's recommendations for government organizations conducting AAs (Ecology, 2015) and are sufficient to evaluate the alternatives:

- IC2 Level 2: Hazard Module. The goal of the Hazard Module is to determine what hazards exist for the chemical of concern and how they compare to potential alternatives (chemical/material-level assessment).
- IC2 Level 1: Exposure Assessment Module. The goal of the Exposure Assessment Module is to evaluate potential exposure scenarios and determine if alternatives pose a greater exposure risk to human health and the environment (chemical/material-level assessment).
- IC2 Level 1: Performance Evaluation Module. The goal of the Performance Evaluation Module is to ensure the alternatives under consideration meet the necessary performance requirements (chemical/material-level and product-level assessment).
- IC2 Level 1: Cost and Availability Module. The goal of the Cost and Availability Module is to evaluate whether alternatives are cost competitive and whether they are available in sufficient quantity to meet demand (product-level assessment).

Find additional information regarding the assessment module levels in the section for each module.

[11] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.222.070

Simultaneous Decision Framework

The IC2 AA Guide recommends three possible decision frameworks for conducting an alternatives assessment:

- Sequential decision framework.
- Simultaneous decision framework.
- Hybrid decision framework.

For this AA, Ecology used a simultaneous decision framework, illustrated in Figure 1. In a simultaneous decision framework, data for all potential alternatives are collected from all modules and then evaluated at the same time. Ecology determined that this approach would provide the most information for decision-making, both now and in future assessments.

In all three frameworks, the scope of the AA is determined before data collection begins. Once the scope of the project is determined, data collection begins. Following the simultaneous decision framework, an initial hazard screen was performed to identify chemicals with hazards that are significant enough to warrant being removed from consideration (see Section 4 for additional details). The remaining alternatives were then evaluated using the remaining four assessment modules—hazard, exposure, performance, and cost and availability—simultaneously.

The process and results of the four assessment modules are detailed in Sections 4 through 7. We used results of these four modules to evaluate whether an alternative product made from a candidate alternative substance met the criteria for safer, detailed in RCW 70A.222.070 and the IC2 AA Guide. Rather than identify preferred alternatives, we identified each alternative as either safer, not safer, or having insufficient data. Section 8 details these criteria and the results of this simultaneous decision analysis .

Figure 1. Alternatives assessment process using a simultaneous decision framework.

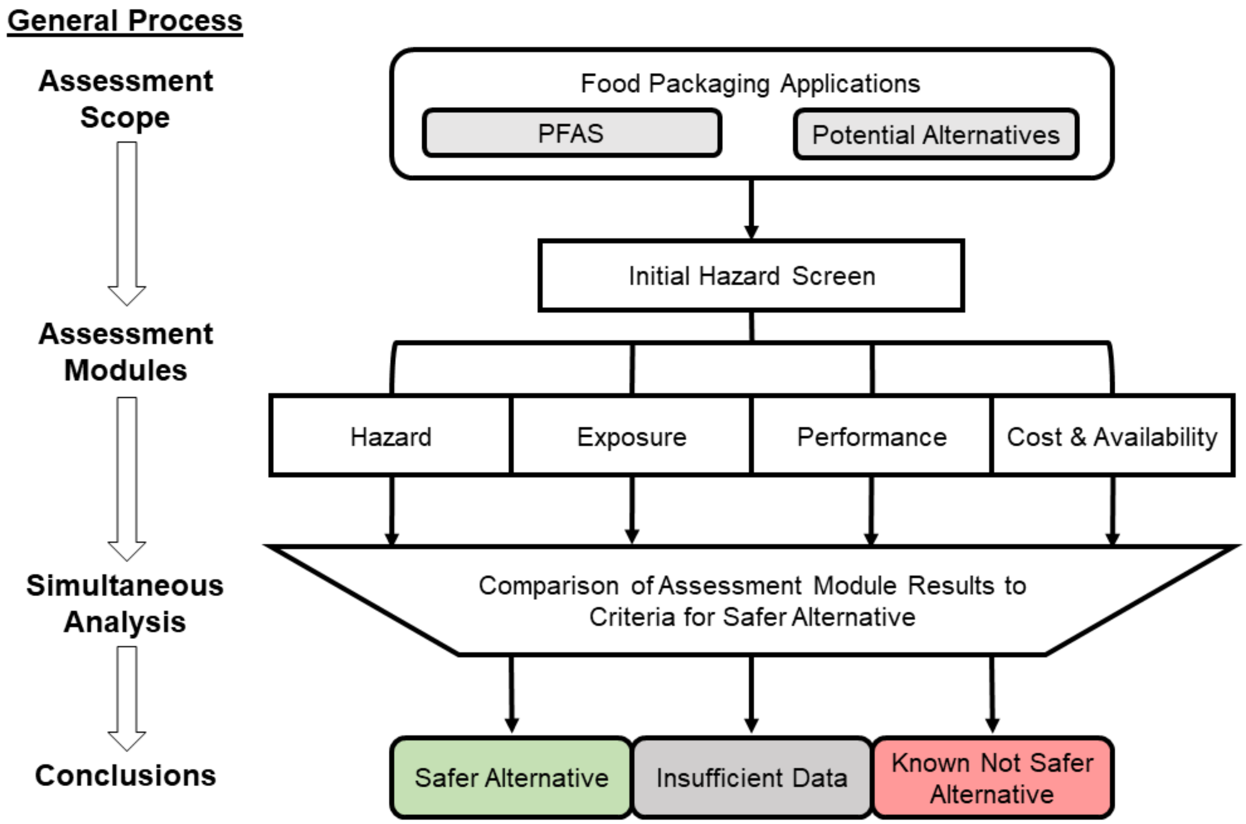

Figure notes:

- Access an accessible text description of this graphic.[12]

Categories

This AA considers alternatives to PFAS in food packaging that is "intended for direct food contact and is comprised, in substantial part, of paper, paperboard, or other materials originally derived from plant fibers" (RCW 70A.222.010[13]). The food packaging market is a multibillion-dollar market including products designed for quick service, foodservice, and consumer packaged goods (Freedonia, 2017). The products, which are used to hold or serve food during foodservice, can cover everything from deli wraps to take-out boxes to plates. Products can be grouped into food packaging categories, which can then be grouped further into food packaging applications.

In the initial phase of the AA, we completed a scoping exercise to focus on food packaging categories with the highest potential impact, while also managing the finite resources allotted

[12] https://www.ezview.wa.gov/Portals/_1962/Documents/PFAS-Food/TextDescriptions_Figures_PFAS_FoodPackaging_AA.pdf
[13] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.222.010

for this assessment (see Section 3). From these food packaging categories, we selected ten food packaging applications based on impact and data availability.

For the purposes of this assessment, a food packaging application is defined as products of a similar physical structure that package food in a similar manner (for example, a clamshell is a self-closing hinged container used to transport food). Each of these applications includes food packaging products, as defined by RCW 70A.222.010, to which manufacturers intentionally add PFAS to provide oil and grease resistance and leak resistance. Each of the applications also includes products that do not contain PFAS.

For the purposes of this AA, we define each food packaging application as follows:

- **Category 1:** Food contact paper.
    - **Wraps & Liners:** Sheets that are used to either wrap food for food service (wraps) or line other serviceware to act as an additional barrier protection against food (liners).
    - **Bag & Sleeves:** A flat-bottom bag used to transport food from a foodservice establishment (bag) or a sealed-end bag that can hold food for either service or to transport food from a foodservice establishment (sleeve). Sleeves may also be referred to as pinch-bottom bags.
- **Category 2:** Dinnerware.
    - **Plates:** Flat serviceware, which can be single or multi-compartment, used for serving or holding food items during food service.
    - **Bowls:** Serviceware with wide openings and a bottom that allows spooning of food.
    - **Trays:** Flat serviceware that may have one large surface or multiple compartments to separate food items during food service. This includes cafeteria-style trays.
    - **Food boats:** A type of tray with tall, lipped edges and no compartments.
- **Category 3:** Take-out containers.
    - **Pizza boxes:** Folded boxes, typically made from corrugated paperboard, used for serving, holding, or transporting different sizes of pizza or pizza slices.
    - **French fry cartons:** Open-top paperboard containers with an angular bottom used in quick-service establishments typically to serve, hold, or transport fried foods. These may be pre-formed or fold flat before and after use.
    - **Clamshells:** A self-closing hinged container used to serve, hold, or transport food. The lid and base are two halves joined at the hinge.
    - **Interlocking folded container:** Food container with an angular bottom, a structure that is formed from folding segments and interlocking top flaps to form a lid. It is used for serving, holding, and transporting food during foodservice. Also called food containers, food boxes, food pails, and oyster pails.

The alternative substances and materials identified for these food packaging applications and prioritized for evaluation in this assessment are all approved by the FDA for use as food contact materials (FCMs; see Section 3). However, this assessment does not evaluate all possible alternatives that are available on the market. For food packaging applications where Ecology was not able to identify at least one alternative substance or chemical that met all of the statutory criteria for safer (i.e., improved hazard and exposure considerations, ready availability in sufficient quantity and at comparable cost, and equal or better performance to PFAS in the specific application), we may evaluate other alternatives in future assessments.

Consideration of customized products

Our definitions for each of the food packaging applications listed above were further qualified to include only versions of those products that are intended for serving or short-term storing or holding of freshly prepared food. We worked with stakeholders to understand the general performance requirements of food packaging products that serve and hold freshly prepared food.

This AA does not cover food packaging intended to hold food for long-term storage or transport, nor does it cover food packaging used to cook or reheat food. The FDA and FoodSafety.gov recommend discarding leftover prepared food after three to four days—we consider any length of time beyond four days to constitute long-term storage of food (FoodSafety.gov, 2019).

Customized or specially designed products fall outside the purview of this AA if they are used to hold or serve freshly prepared food under highly specialized circumstances or in special environments, such as extreme temperatures, that go beyond the general performance requirements evaluated in this AA.

Customization is common in the food packaging industry. Packaging producers work with buyers (who are often large companies like national restaurant chains) to develop customized products. An evaluation of every possible performance requirement for each of the ten food packaging applications is beyond this AA. Therefore, we consider food packaging products that have been customized to meet a limited, highly-specialized instance of holding or serving food (such as holding food while it is cooked on a grill or within a freezer) to be outside the definition of the food packaging applications we address in this AA.

Challenges

Readers should consider the following recurring issues when reviewing this AA. Under this law, Ecology does not have the authority to require information from manufacturers of PFAS, alternative substances, or food packaging products. All information used was either publicly available or voluntarily provided by manufacturers or stakeholders.

Stakeholder involvement

During this process, we engaged many different stakeholder groups that provided diverse opinions and perspectives. We consider this both a strength and a challenge of this project. For example, certain stakeholders stated that consumer concerns over PFAS have been driving increased interest in PFAS-free food packaging. Conversely, some alternatives producers noted that consumer interest on this issue was not strong enough to warrant significant investment in new product development. We noted these contradictory, yet equally valid, perspectives and others in the assessment where possible.

Ecology aimed to involve consumers and end users in this AA. Consumer and end user input is important because this group is directly exposed to PFAS from food packaging, and will be directly impacted by potential changes (cost, availability, performance, etc.) related to the transition to non-PFAS alternatives. Participation by consumers and end users was limited.

Ecology worked with non-governmental organizations (NGOs) and local governments within our stakeholder group to identify end users interested in participating. We focused our efforts to recruit end users on brands, retailers, grocers, small business purchasers, state, military, and institutional buyers. We contacted brands that recently announced a phase out of PFAS in their food packaging, but unfortunately, responses were limited.

Active ingredient identification

Manufacturers are not required to publicly list the chemicals used in food packaging. Therefore, for this AA, we relied on research, stakeholder input, and product inventories and databases that report, at a minimum, the base material and whether the product contains fluorinated compounds. Although this requirement limited the data available for this AA, we identified a sufficient quantity of information to evaluate many alternative products in both the performance and cost and availability modules.

Additionally, even when a PFAS-free alternative product was identified, the exact chemical composition of the alternative substance used was not always available. In particular, many alternative products are labeled as “poly-coated,” which is a common but ambiguous term used in the food packaging industry. This umbrella term includes substances such as polyethylene (PE), polyethylene terephthalate (PET), polyvinyl alcohol (PVOH), ethylene vinyl alcohol (EVOH), polypropylene, polyacrylate, or some combination thereof. Manufacturers use these substances to coat plant fiber-based food packaging. The term is not likely to refer to polylactic acid (PLA), however, as producers often want to promote those as distinct products. When we could not clarify the exact alternative substance used on a product, we did not use it in our assessment.

Data limitations

Product producers were apprehensive to disclose their chemical identity, formulation, and use of both PFAS-containing and PFAS-free products. This was due to concerns about competitive market advantage, potential damage to the brand, or potential future liabilities. Ecology developed a Confidential Business Information (CBI) protocol that allowed interested parties to apply for confidential treatment of data (under Chapter 43.21A[14] RCW) to encourage the sharing of information and to alleviate those concerns.

While several industry stakeholders expressed interest in submitting CBI about formulations for alternative substances, we did not receive it within the assessment timeframe. As a result, we

[14] https://app.leg.wa.gov/RCW/default.aspx?cite=43.21A

used the best publicly available information about alternatives to conduct the Level 2 Hazard Module.

In some cases, we used impurities such as precursors and breakdown products to assess hazards. Since these chemicals can migrate into food, their hazards are relevant to human health (Bhunia et al. 2013; Till et al. 1987; 21CFR 176.17). These compounds would have been evaluated as part of the GreenScreen® of the alternative substance, unless they were below the minimum concentration defined by the GreenScreen® methodology. When we were not able to identify or assess impurities or breakdown products for an alternative substance, we determined that there was insufficient data to conduct a hazard evaluation for the substance.

Additionally, many manufacturers considered pricing information to be confidential and hesitated to share it with us. Prices are often negotiated in contracts and, in many cases, are not publicly available. This meant that Ecology could not use some alternative products to assess cost comparability. When price information is available, it may fluctuate over time or between suppliers. These data limitations prevented a more thorough assessment of available alternatives to PFAS in food packaging.

Molded fiber packaging

Molded fiber or molded pulp is a type of paperboard packaging where an aqueous slurry of plant-fiber pulp is formed into products using a three-dimensional, screened mold (Robertson, 2012). PFAS-free molded fiber food packaging is a developing market—substituting PFAS in these products is a challenge, requiring innovations in product manufacturing and design (Footprint, 2020).

Third-party verification demonstrated that most molded fiber products on the market contain PFAS (Chiang et al., 2018). PFAS may be intentionally added to provide oil, grease, and moisture resistance to the product, or as a manufacturing process aid to prevent the product from sticking to the mold (DTSC, 2020b). These factors complicated our ability to identify alternatives using molded fiber as a base material.

When PFAS is added as a mold release agent during the manufacturing process, it may transfer to molded fiber products. Although this could constitute an intentional addition of PFAS, the alternatives evaluated in this assessment were largely alternative chemical coatings that could be applied to paper and paperboard. Therefore, this AA does not specifically address PFAS used as a processing aid. If Ecology evaluates alternatives that are specific to molded fiber products, we may decide it is necessary to evaluate the performance of mold release agents at that time. The state of PFAS-free molded fiber products is rapidly evolving—with existing options likely expanding and new options emerging soon.

Impact of COVID-19

We encountered challenges conducting this AA due to the COVID-19 pandemic, particularly when trying to engage with small businesses. Outreach efforts for small business restaurants, including food trucks, were complicated by COVID-19. Small business restaurants that purchase and use food packaging products were closed (or adapting to a take-out-only operation) due to COVID-19 restrictions, meaning they were unavailable to respond to outreach.

In response to the COVID-19 pandemic, the state of Washington placed restrictions on indoor and outdoor dining for most of 2020. As a result, many food service businesses shifted to focusing on takeaway and delivery. Businesses that did so may be more impacted by a ban on PFAS in food packaging. However, data on COVID-19 impacts to the food packaging market were not available during the preparation of the cost and availability assessment.

Section 1. Stakeholder Involvement Module

Overview

Ecology conducted an IC2 Level 2 Stakeholder Involvement Module for this AA. It aimed to ensure we considered stakeholders in the AA process, and to provide a framework to inform concerned parties about decision-making and receive input in return.

There are a variety of parties who have a stake in the transition from PFAS to non-PFAS alternatives in food packaging. They include chemical manufacturers (PFAS and non-PFAS), food packaging manufacturers, suppliers, non-governmental organizations (NGOs), government agencies, trade organizations, retailers, purchasers and users, and end-of-life managers.

Incorporating stakeholder interests is an important component of the AA process. In accordance with RCW 70A.222.070(2)(b),[15] this AA must use the IC2 AA Guide. Ecology's process for stakeholder engagement followed guidelines in the Stakeholder Involvement Module of the IC2 AA Guide. Stakeholders had the opportunity to participate in developing methodology and decision rules for different portions of the assessment.

Stakeholder involvement progressed from an initial screen of potential interested parties, to increased input and involvement as the AA developed. We identified and addressed or mitigated stakeholder concerns where possible.

Choice of an IC2 AA Guide level

The IC2 AA Guide describes three levels that can be used in the Stakeholder Involvement Module:

- Level 1 Internal exercise: Identifies potential stakeholders, their concerns, and how their concerns may be addressed in the AA. There is little external stakeholder involvement, unless specific questions are posed where external input is required or recommended.
- Level 2 Formal stakeholder process: Identifies potential stakeholders and seeks their input in a formal and structured process. Pertinent AA information is provided for stakeholder review and comment. All comments are collected and responded to.
- Level 3 Open stakeholder process: Identifies potential stakeholders invited to participate in all aspects of AA process. Involvement includes all aspects from scoping, development, participation in formal committees (steering, advisory, technical, etc.), and review of final product.

Ecology chose to perform a Level 2 Stakeholder Involvement Module. It provides a clear structure for Ecology to receive information and comments from a diverse group of stakeholders, while still maintaining decision-making power. This decision is consistent with Ecology's previous recommendations for government organizations performing AAs (Ecology, 2015).

[15] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.222.070

Methodology

The IC2 AA Guide for a Level 2 stakeholder involvement process includes five questions or steps:

1. Identify potential stakeholders who might be interested and concerned with the chemical, product, or process being considered.
2. Identify potential concerns of stakeholders.
3. Can the concerns identified be addressed or mitigated?
4. Incorporate stakeholder concerns into the decision-making process. Document how this has been done.
5. Are the concerns identified serious enough to identify the alternative as unfavorable?

Although not explicitly in the method, part of our outreach focused on increasing our stakeholders' familiarity with AAs. AA is an emerging field, and examples of AA implementation in regulatory contexts are limited. Stakeholders asked many questions about the process and their role in the assessment. Much of our outreach focused on assessment progress and future topics of discussion, or responded to questions about the AA process.

Stakeholder process

Identify potential stakeholders

Appendix A lists the organizations that agreed to be publicly acknowledged for their participation in this AA. Many stakeholders did not respond or did not agree to be acknowledged, and therefore were not included. During initial recruitment, we prioritized stakeholders with an interest or concerns with PFAS, PFAS-free alternatives, alternative packaging products, and the process in general.

We recruited stakeholders through various methods, including:

- Direct invitations through an initial survey (see Appendix B).
- Solicitations via Ecology's Chemical Action Plan (CAP) website[16] (and subsequently, the PFAS in Food Packaging Alternatives Assessment website[17]).
- Online surveys.
- Recommendations and referrals from other stakeholders.

Recruiting additional stakeholders was a continuous, open process.

During initial recruitment, 47 parties expressed interest in participating as a stakeholder. This included 33 parties who completed the initial survey along, with 14 additional contacts suggested by stakeholders. Representation after initial recruitment showed the following stakeholder groups:

- Non-governmental organizations: 27%

[16] https://www.ezview.wa.gov/?alias=1962&pageid=37105
[17] https://www.ezview.wa.gov/site/alias__1962/37610/pfas_in_food_packaging_alternatives_assessment.aspx

- Trade organizations: 19%
- Product manufacturers: 19%
- Government: 16%
- Suppliers: 8%
- Academia/researchers: 6%
- Other: 5%

After initial recruitment, it was clear that we needed more representation from consumers, purchasers, retailers, and manufacturers of chemical alternatives. Subsequent recruitment prioritized these groups. We contacted the initial recruitment group via email to arrange phone discussions. During one-on-one phone discussions with these stakeholders, we collected preliminary information related to PFAS and the AA modules (hazard, performance, cost and availability), and answered questions from interested parties. Due to budget and time constraints, we had limited resources for conducting numerous in-depth one-on-one discussions. Individual interactions were generally limited to targeted topics, or held at the request of the stakeholder.

We encouraged our engaged stakeholders to recommend new stakeholders and to forward information and webinar announcements to contacts who may be interested in participating. Presentations by Ecology and the project contractor (SRC, Inc.) at scientific conferences and workshops also helped recruit and engage stakeholders. Conferences included:

- Society of Environmental Toxicology and Chemistry 2019 annual conference.
- California Department of Toxic Substances Control (DTSC) workshop, "Perfluoroalkyl and Polyfluoroalkyl Substances and their Alternatives in Food Packaging."
- 2020 American Chemical Society Virtual Green Chemistry & Engineering Conference.

Often, interested parties reached out directly to express interest in engaging as a stakeholder. We contacted these parties via phone, directed them to the PFAS in Food Packaging website and email list for project updates, and encouraged them to provide feedback and information.

Ninety companies and organizations participated as stakeholders in this AA. Table 3 shows the number of stakeholders by type. Some companies and organizations had more than one person interested in this AA. Stakeholders include manufacturers and producers of both PFAS and PFAS-free products. Several stakeholders followed the progress of the AA but were not directly involved in providing feedback. They are also included in the current representation.

Table 3. Current stakeholder representation.

Stakeholder type	Number of organizations
Government	10
Packaging product manufacturer	17
Supplier	2
Chemical manufacturer	7
Foodservice packaging supplier	2
Paper producer	11

Stakeholder type	Number of organizations
Product coating applicator	2
Trade organization	11
Purchaser/user	6
NGO	14
Composter, recycler, waste manager, consultant.	8

End users are represented by:

- State/local government agencies from Washington, Oregon, and California.
- Institutional purchasers.
- Military purchasers and the Department of Defense.
- Brands, retailers, and grocers.
- NGOs, consumer organizations, and public education organizations.
- Trade organizations representing grocers, restaurants/food trucks, and hospitality industries.

Efforts to recruit end users focused on brands, retailers, grocers, small business purchasers, and state, military, and institutional buyers. We recruited end users with input from NGOs, foodservice suppliers, Washington public health agencies (King County), and trade organizations (restaurant and hospitality organizations) currently engaged in this issue.

Ecology made an effort to reach out to major brands in the food industry that recently announced a phase out of PFAS in their food packaging (Sweetgreen and Chipotle;[18] Taco Bell Yum! Brands, Inc.;[19] Whole Foods Market, Trader Joes, Kroger, and Panera Bread[20]) and contacted brands that had previously transitioned to PFAS-free products (i.e., Taco Time).

We highlighted the need for increased consumer engagement during the February 11, 2020 webinar. Following the webinar, an article[21] in Bloomberg Law Environment & Energy repeated the call for end user and consumer engagement. Subsequently, the April 14, 2020 webinar (focusing on the performance assessment) was well attended and included national and global brands that were new to the AA process.

Identify stakeholder concerns

We identified potential stakeholder concerns in several ways, including through interactive webinars, newsletters, websites, surveys, submitted comments, and phone calls. Identified stakeholder concerns included (but were not limited to):

- Project communication and transparency.
- The comparator selection and assessment processes.
- Product scoping.

[18] https://thecounter.org/sweetgreen-chipotle-pfas-free-compostable-bowls-by-2020/
[19] https://chemicalwatch.com/88548/us-food-chain-taco-bell-to-phase-out-pfas-phthalates-and-bpa
[20] https://retailerreportcard.com/2019/11/key-findings-2019/#finding2
[21] https://news.bloomberglaw.com/environment-and-energy/washington-state-eyes-plant-based-food-wrappers-to-replace-pfas

- Assessment methodologies.
- Proprietary information submittal.
- End user representation.
- Social impact concerns.
- Importance of recyclability and compostability.

General communication with stakeholders

Ecology's Chemical Action Plan (CAP) website[22] was initially utilized to communicate information for the PFAS in Food Packaging AA. In January 2020, we developed a dedicated website for the PFAS in Food Packaging Alternatives Assessment[23] to separate the PFAS in Food Packaging AA project from the PFAS CAP. This website contains general and background information for the project, current and archived updates and information, and contact information for the PFAS AA team. Past webinar presentation slides and recordings are also available.

Other important methodology and technical documents are also shared on the website for stakeholders to review and provide input. In May 2020, an eComment[24] page was added to the PFAS in Food Packaging AA website where comments, memos, and letters submitted from stakeholders are archived for public review. We invited stakeholders to submit comments as an alternative to reaching out directly to the PFAS AA team.

The website includes a link to the email list, which archives stakeholder email updates. We implemented email list updates, focused group calls, and monthly webinars to streamline interactions. Our newsletters shared project updates, timelines, progress, and approaches, and announced scheduled webinars, focus groups, and online surveys. We sent newsletters on the following dates:

- January 7, 2019: January 2019 update[25]
- February 13, 2019: February 2019 update[26]
- July 1, 2019: Scoping Survey communication[27]
- July 25, 2019: July 2019 update[28]
- August 23, 2019: August 2019 update[29]

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[22] https://www.ezview.wa.gov/?alias=1962&pageid=37105
[23] https://www.ezview.wa.gov/site/alias__1962/37610/pfas_in_food_packaging_alternatives_assessment.aspx
[24] http://hwtr.ecology.commentinput.com/comment/extra?id=a8U4i
[25] https://www.ezview.wa.gov/Portals/_1962/Documents/PFAS-Food/PFAS%20AA%20January%202019%20update.pdf
[26] https://www.ezview.wa.gov/Portals/_1962/Documents/PFAS-Food/PFAS%20AA%20February%202019%20update.pdf
[27] http://listserv.ecology.wa.gov/scripts/wa-ECOLOGY.exe?A2=CHEMICAL-ACTION-PLAN;8124f010.1907&S=
[28] https://www.ezview.wa.gov/Portals/_1962/Documents/PFAS-Food/PFAS%20AA%20July%202019%20update.pdf
[29] https://www.ezview.wa.gov/Portals/_1962/Documents/PFAS-Food/PFAS%20AA%20August%202019%20update.pdf

- September 24, 2019: September 2019 update[30]
- October 7, 2019: October 2019 update[31]
- November 6, 2019: November update[32]
- November 11, 2019: November 2019 update[33]
- January 17, 2020: January 2020 update[34]
- February 6, 2020: February webinar announcement[35]
- February 25, 2020: Update and March webinar announcement[36]
- March 25, 2020: Update and April webinar announcement[37]
- April 7, 2020: April webinar announcement[38]
- May 14, 2020: Update and May webinar announcement[39]
- June 18, 2020: Performance methodology update[40]

Surveys

We developed an end-user/consumer questionnaire and shared it on the PFAS in Food Packaging AA website on February 12, 2020. It aimed to gather information on purchasing and performance considerations for food packaging products (Appendix C).

We solicited stakeholder input to help prioritize assessment requirements under the IC2 AA Guide, given the project budget and time constraints. For example, we conducted a survey (Appendix D) to inform alternative product scoping strategies (Section 3). At the time of this survey, three scoping strategies were under consideration: prioritizing products by either market share size, packaging application, or whether the product was made from molded fiber. The survey ran from July 1 to July 31, 2019 with mostly open-ended questions to gain insight from stakeholders. Twenty-two stakeholders responded (Appendix E).

Webinars

We hosted webinars to update stakeholders on the AA progress, discuss decisions, request information for data needs, solicit feedback to develop methodologies, and provide a platform for discussion and for addressing questions. We increased the frequency of webinars to

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[30] https://www.ezview.wa.gov/Portals/_1962/Documents/PFAS-Food/PFAS%20AA%20September%202019%20update.pdf
[31] https://www.ezview.wa.gov/Portals/_1962/Documents/PFAS-Food/PFAS%20AA%20October%202019%20update.pdf
[32] http://listserv.ecology.wa.gov/scripts/wa-ECOLOGY.exe?A2=CHEMICAL-ACTION-PLAN;da689484.1811&S=
[33] https://www.ezview.wa.gov/Portals/_1962/Documents/PFAS-Food/PFAS%20AA%20November%202019%20update.pdf
[34] http://listserv.ecology.wa.gov/scripts/wa-ECOLOGY.exe?A2=CHEMICAL-ACTION-PLAN;34011737.1901&S=
[35] http://listserv.ecology.wa.gov/scripts/wa-ECOLOGY.exe?A2=CHEMICAL-ACTION-PLAN;3b356092.2002&S=
[36] http://listserv.ecology.wa.gov/scripts/wa-ECOLOGY.exe?A2=CHEMICAL-ACTION-PLAN;3bf49975.2002&S=
[37] http://listserv.ecology.wa.gov/scripts/wa-ECOLOGY.exe?A2=CHEMICAL-ACTION-PLAN;953f5a9d.2003&S=
[38] http://listserv.ecology.wa.gov/scripts/wa-ECOLOGY.exe?A2=CHEMICAL-ACTION-PLAN;40fb23ec.2004&S=
[39] http://listserv.ecology.wa.gov/scripts/wa-ECOLOGY.exe?A2=CHEMICAL-ACTION-PLAN;1b3f1119.2005&S=
[40] https://www.ezview.wa.gov/Portals/_1962/Documents/PFAS-Food/PFAS%20AA%20Performance%20Methodology_0601820%20DRAFT%20APPROVED.pdf

monthly beginning in January 2020, aiming to proactively update stakeholders. Find summaries of the webinars in Appendix F.

The April 14, 2020 Webinar focused on the Performance Evaluation Module. While many attended the webinar, some stakeholders may not have been able to participate due to COVID-19 related issues. We shared the recording of the webinar and the presentation slides on the PFAS in Food Packaging AA website.[41] In addition, we conducted an online survey to determine interest in a repeat of the webinar to allow for more input opportunities. Four stakeholders requested a follow-up, so we presented a re-cap during the May 26, 2020 webinar (along with an update of the Performance Evaluation Module methodology). During the webinar, we asked participants to respond to several poll questions related to performance. See the questions and responses in Appendix G.

Phone discussions

During one-on-one phone discussions, we gathered information to help inform the AA. We had numerous phone discussions, both with individual stakeholders and groups of stakeholders, to discuss:

- Information about specific PFAS or PFAS-free alternatives.
- Information on food packaging products.
- Developing the AA scope.
- Developing the exposure, cost and availability, performance, and hazard assessment methodologies.
- Data needs overall and data specific to the cost and availability, performance, exposure, and hazard assessment modules.
- End user engagement.
- CBI protocol for submitting data.
- Timeline updates.
- Social impact concerns.
- Lifecycle issues (biosolids, recyclability, compostability, etc.).

Address or mitigate concerns

We identified concerns and addressed or mitigated them where possible. This report highlights several instances where stakeholder concerns were addressed and mitigated including:

- Communication and transparency.
- Scope.
- End user engagement.
- Development of CBI protocol.

Ecology provided stakeholders many opportunities to communicate concerns and we prioritized addressing them. Some requests—such as incorporating lifecycle factors (like

[41] https://www.ezview.wa.gov/site/alias__1962/37610/pfas_in_food_packaging_alternatives_assessment.aspx

recyclability and compostability) into the assessment methodology—were not addressed because they were not requirements of the law.

Incorporate stakeholder concerns into the decision-making process

It is important to incorporate stakeholder interests during the AA process. Stakeholders contributed to the AA by providing information and feedback throughout the AA process and as we addressed the four assessment modules. Stakeholders had an opportunity to provide pertinent feedback on all aspects of the AA. Some examples of actions to address stakeholder concerns, discussed in more detail above, include:

- Increasing transparency by developing a dedicated project website, and growing the frequency of outreach and webinars to improve information access.
- Handling confidential information by creating a CBI protocol[42] to facilitate the sharing of information considered a trade secret.
- Expanding the scope of products we assessed to incorporate stakeholder concerns about initial scoping being too narrow.

Are the concerns identified serious enough to identify the alternative as unfavorable?

There were no concerns raised by stakeholders that would inhibit identifying safer alternatives for this assessment. We identified and addressed stakeholder concerns throughout the development process for this assessment.

[42] https://www.ezview.wa.gov/Portals/_1962/Documents/PFAS-Food/CBI%20process%20for%20PFAS%20AA%204-8-20.pdf

Section 2. Overview of PFAS Used in Food Packaging

Overview

RCW 70A.222.070[43] prohibits the sale of food packaging to which PFAS has been intentionally added. This prohibition becomes effective for a given food packaging application two years after:

1. Ecology identifies that a safer alternative to that food packaging application is available, and the safer alternative determination is supported by feedback from an external peer review, and
2. Ecology publishes that finding in a report submitted to the Legislature.

This section provides a brief overview of the PFAS currently used in food packaging and the evidence for regulating PFAS as a chemical class. In this section, we also review Ecology's process for identifying which PFAS would act as the comparator to PFAS alternatives in subsequent hazard and exposure evaluations.

Through initial research and consultation with stakeholders, Ecology determined that the majority of PFAS used in food packaging at the time of this AA are C6 side-chain fluorinated polymers (C6 indicates there are six fluorinated carbon atoms in the side chain of a polymer substance). These PFAS compounds are known to contain hazardous impurities and degradation products, such as 6:2 FTOH and PFHxA (Buck, 2015; Rice et al., 2020; Kabadi et al., 2018), which have been detected in food packaging in the U.S. (Schaider et al., 2017; Yuan et al., 2016).

From the list of approved compounds that contain C6 side-chain fluorinated compounds, Ecology chose the copolymer of perfluorohexylethyl methacrylate, 2-N,N-diethylaminoethyl methacrylate, 2-hydroxyethyl methacrylate, and 2,2'-ethylenedioxydiethyl dimethacrylate, acetic acid salt (Chemical Abstracts Service Registry Number [CASRN] 863408-20-2) as a chemical comparator. Future AAs may consider alternative comparators, especially as new regulations and legislation of PFAS in food packaging alter the market.

PFAS approved for use in food packaging

Per RCW 70A.222.010,[44] PFAS are defined within this AA as "a class of fluorinated organic chemicals containing at least one fully fluorinated carbon atom." PFAS are used in food packaging to impart oil, grease, and moisture resistance. They can either be incorporated within the food packaging structure or added to the surface of the packaging as a coating. Food packaging can also be contaminated by PFAS from recycled paper, processing aids such as lubricants, dispersion aids in pigments, or detergents used in the manufacturing process (Trier et al., 2017).

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[43] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.222.070
[44] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.222.010

Currently, there are 28 Food Contact Notifications (FCNs) covering 17 distinct PFAS formulations that the FDA approved for use to provide oil and grease resistance in plant fiber-based food packaging applications (FDA, 2020b). Appendix H contains the name, CASRN, representative chemical structure, and FCN of these compounds. All approved FCNs are for polyfluorinated polymers, with a majority of these being C6 side-chain fluorinated polymers (see Appendix H, Figure 22 for an example structure) and the rest being perfluoropolyethers (see Appendix H, Figure 37 for an example structure).

Side-chain fluorinated polymers consist of a non-fluorinated carbon backbone, typically an acrylate, methacrylate, or urethane polymer, with fluorinated side chains. In fluorinated polymers approved for food packaging, the side-chain is most often made using 6:2 FTOH. Perfluoropolyethers consist of a carbon and oxygen polymer backbone where fluorine is directly bonded to the carbon atoms (Buck et al., 2011). Two additional compounds, a chromium (Cr III) complex of N-ethyl - N -heptadecylfluoro- octane sulfonyl glycine and an undecafluorocyclohexanemethanol ester mixture of dihydrogen phosphate are permitted for use in food packaging—pursuant to the Code of Federal Regulations list of indirect additives (see 21 CFR 176.160 and 21 CFR 176.170).

RCW 70A.222.070 refers to PFAS as a class of compounds. PFAS as a class are concerning because they are highly persistent, both as the original manufactured compounds or as degradation products (Blum et al., 2015; Kwiatkowski et al., 2020; Wang et al., 2017). Some of these compounds are also highly mobile in the environment and are known to be bioaccumulative (Kwiatkowski et al., 2020; Wang et al. 2017). Well-known PFAS show concerning characteristics, such as reproductive and developmental toxicity, endocrine disruption, and immunotoxicity.

Due to human health concerns and persistence associated with PFAS that are C8 or longer, the FDA rescinded its approval of FCMs containing C8 or longer perfluorinated alkyl chains (FDA, 2015). The FDA also rescinded any DiPAP (polyfluoroalkyl phosphoric acid diester) formulations that were approved for FCMs (FDA, 2015). As we learn more about the newer PFAS, we see concerning toxicity evidence, particularly for these persistent chemicals. However, large data gaps remain about the toxicity and fate of some PFAS, such as perfluoropolyethers, and targeted detection of PFAS is still limited to a small subset of compounds (Kwiatkowski et al., 2020; Wang et al., 2017; Wang et al., 2020).

Perfluoropolyethers are characterized as very stable and highly persistent in the environment, while there is evidence to suggest side-chain fluorinated polymers degrade (Li et al., 2017; Washington et al., 2009; Wang et al., 2020). For all PFAS polymer substances, PFAS exposure is more likely to occur through low molecular weight impurities and byproducts than the higher molecular weight fluoropolymers (Wang et al., 2020). 6:2 FTOH is both an impurity in and degradation product of side-chain fluorinated polymers (Buck et al., 2015; Li et al., 2017; Rice et al., 2020; Trier et al., 2017). According to a 2016 study by Yuan et al., 6:2 FTOH was the most common fluorotelomer detected in food packaging material in the U.S. This suggests that short chain (C6) PFAS are prevalent in food packaging and contribute to PFAS exposure (Yuan et al., 2016). PFHxA is a degradation product produced by several PFAS, including 6:2 FTOH (Kabadi et al., 2018; Rice et al., 2020; Washington et al., 2009). Overall, there is relatively limited information about the environmental fate of perfluoropolyethers (Wang et al., 2020).

Selection of a representative PFAS

Using a chemical comparator facilitates a comprehensive AA that is consistent with the IC2 AA Guide and recommendations from the National Academy of Sciences (NAS), particularly for the hazard and exposure modules (NAS, 2014). Although Chapter 70A.222[45] RCW identifies the class of PFAS as the chemical of concern, there is no clear directive as to how to assess PFAS for the purposes of this AA. There is also no clear consensus at this time as to how to group PFAS within the class (Cousins et al., 2020).

Stakeholder opinions were divided over whether Ecology should identify a specific PFAS to act as a chemical comparator in this AA. Some stakeholders questioned whether it was necessary to evaluate any PFAS hazards, given that the Washington State Legislature directed the AA to support a ban on PFAS. Other stakeholders advocated for assessing the hazards associated with PFAS as a chemical class, and felt that focusing on one substance may not wholly capture the human and environmental health concerns associated with PFAS. Still others argued that we over-simplified a complex set of substances, seeing sufficient diversity among PFAS to require individual assessments of all relevant PFAS.

It is important to note that regardless of how this AA uses PFAS, RCW 70A.222.070 bans **all intentionally added PFAS** from food packaging (for applications where a safer alternative is identified). Ultimately, Ecology chose to use a hybrid approach. We identified one specific PFAS as the comparator for the Hazard and Exposure Assessment Modules, and evaluated PFAS as a group used in specific food packaging products for the Performance Evaluation and Cost and Availability Modules. We anticipated that any comparator would have the hazard concerns commonly associated with all PFAS—particularly high persistence in the environment (Cousins et al., 2020; Kwiatkowski et al., 2020).

Given the data needs of the hazard and exposure modules, particularly for conducting a GreenScreen® evaluation, Ecology determined that we needed to collect specific information about the physical, chemical, and toxicological properties of PFAS. This could more easily be done for a single PFAS. Owing to both the limited information available for many PFAS and to our limited resources, we also prioritized compounds that were better characterized to ensure sufficient information would be available for the hazard and exposure evaluations.

To choose the comparator, we focused on evaluating the small subset of PFAS that reflected the current use and exposure risk from PFAS in food packaging. From the list of current PFAS that FDA approved for use, we first identified those PFAS that were widely used in food packaging applications. Stakeholder comments (FluoroCouncil, 2019) suggested that the dominant PFAS substances used in food packaging are C6 polyfluorinated chemistries. A memo from FluoroCouncil to Ecology (dated February 18, 2019) recommended using a “C6 fluoromethacrylate formulation” as the comparator, as it is representative of the majority of

[45] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.222.070

PFAS intentionally added to food packaging. After confirming that C6 fluorinated polymeric chemistries were the dominant PFAS in food contact materials, we removed perfluoropolyethers from consideration as the comparator for this AA.

Next, we considered which chemicals had sufficiently available data to meet the needs of the hazard and exposure modules, including data on physical properties, hazard, exposure, manufacture, use, and migration from food packaging. We also prioritized compounds that are approved for use across a range of food packaging types, base materials, and market segments. To enhance our analysis of the hazard and exposure concerns associated with C6 side-chain fluoropolymers, we looked for well-characterized impurities and breakdown products associated with these compounds. We selected 6:2 FTOH and PFHxA, which were both detected in published food packaging monitoring studies (Schaider et al. 2017; Yuan et al. 2016).

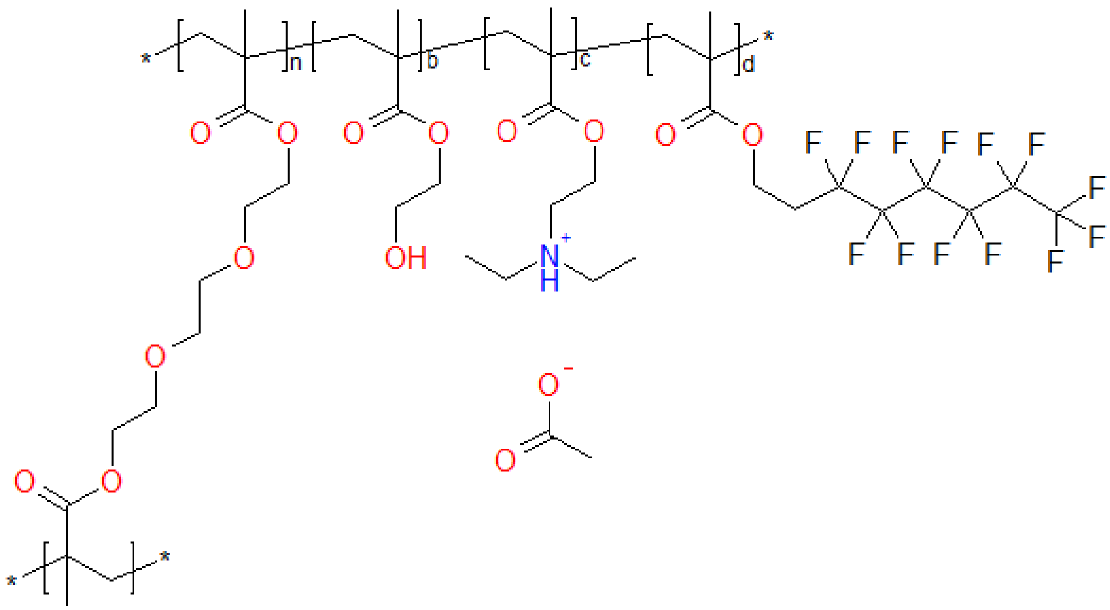
Consultation with chemical manufacturer Chemours confirmed that one candidate C6 side-chain fluoropolymer, FCN 1027 (885) (see Appendix H for name and structure) was in the process of being phased-out of the market, as Chemours was leaving the food packaging business (publicly confirmed in Boudreau, 2019). After we eliminated FCN 1027, the FluoroCouncil provided a list of five commercially relevant PFAS compounds. From this list, we chose the copolymer of perfluorohexylethyl methacrylate, 2-N,N-diethylaminoethyl methacrylate, 2-hydroxyethyl methacrylate, and 2,2’-ethylenedioxydiethyl dimethacrylate, acetic acid salt (CASRN 863408-20-2) produced by AGC, Inc. as the representative PFAS comparator (Figure 2).

We selected this PFAS chemical because existing published data is available for both the substance and its monomers (DEPA, 2015; EDF, 2018). FDA approved it (FCN 604) for use in a wide range of food types and conditions, and it has a relatively high maximum use level compared to other commercially relevant chemistries identified by the FluoroCouncil. We presented the comparator to stakeholders during the July 2019 stakeholder update.[46]

Polyfluoropolyethers meet the definition of PFAS under Chapter 70A.222[47] RCW, so products containing these substances would be subject to any bans promulgated under this law. Not selecting a polyfluoropolyether as a representative PFAS in this assessment is not an endorsement for separating these substances from class-based assessments. Future AAs may consider other PFAS comparators including perfluoropolyethers, to ensure we address the hazard concerns associated with PFAS in food packaging.

[46] https://www.ezview.wa.gov/Portals/_1962/Documents/PFAS-Food/PFAS%20AA%20July%202019%20update.pdf
[47] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.222.070

Figure 2. **Structure of copolymer of perfluorohexylethyl methacrylate, 2-N,N-diethylaminoethyl methacrylate, 2-hydroxyethyl methacrylate, and 2,2'-ethylenedioxydiethyl dimethacrylate, acetic acid salt (CASRN 863408-20-2).**



It is worth noting that as this alternatives assessment was being finalized, the FDA announced that the manufacturers of PFAS containing 6:2 FTOH side chains agreed to a three-year voluntary phase out, beginning January 2021 (FDA, 2020a). This phase out applies to all C6 side-chain fluoropolymers, including the identified comparator. New data concerning the biopersistance of 6:2 FTOH (Rice et al., 2020; Kabadi et al., 2020) drove the decision.

Ecology believes the comparator we chose reflects the state of the PFAS market at the time this AA was conducted. A ban on intentionally added PFAS for any food packaging applications where this AA finds safer alternatives would begin during this phase out period.

Section 3. Identifying Candidate Alternatives to PFAS in Food Packaging

Overview

Chapter 70A.222[48] RCW directs Ecology to evaluate alternatives for "specific food packaging applications." Ecology identified food packaging applications and alternative substances for this first evaluation. Product scoping and prioritization enables us to use state resources efficiently while maximizing the impact of the assessment.

Using the food packaging category approach, Ecology identified viable alternatives for the most prevalent product types. Three food packaging categories were selected: food contact paper, dinnerware, and take-out containers. Within those food packaging categories, we identified ten food packaging applications.

Ecology compiled an initial inventory of alternatives using both existing purchaser guides to PFAS-free packaging and information obtained from engaged stakeholders. We chose candidate alternative substances using Ecology's criteria, starting with:

- Substances used across multiple food packaging categories.
- Substances that were previously identified as of low hazard concern.
- Substances with larger available market share.

We researched the availability of PFAS-free alternatives available under state environmental preferable purchasing programs. We then matched alternative materials and substances with food packaging applications to create a list of candidate alternatives.

Identifying a product scoping strategy

This assessment aimed to provide a science-based methodology to meet the requirements of RCW 70A.222.070. The law does not require an alternatives assessment that includes all existing and emerging alternatives, and to do so would also be beyond both the project budget and timeframe.

As noted in the Stakeholder Involvement Module, we consulted with a variety of stakeholders to determine the AA scope. Some stakeholders had expertise and knowledge of the market, particularly regarding the most common alternatives. During the PFAS AA July 2019 stakeholder update,[49] Ecology surveyed stakeholders to assess their scoping recommendations and to learn what food packaging products could be included. The survey provided three scoping options for stakeholders to comment on:

- **Exclude molded fiber products:** Molded fiber products have consistently tested positive for fluorine (as a marker for PFAS addition) regardless of the plant fiber used to make the base material (Chiang et al., 2018).

[48] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.222
[49] https://www.ezview.wa.gov/Portals/_1962/Documents/PFAS-Food/PFAS%20AA%20July%202019%20update.pdf

- **Identify alternatives by product type:** The food packaging category approach would identify viable alternatives for the most prevalent product types where the use of PFAS for oil, grease, and water repellency is commonplace, thus maximizing reach and impact.
- **Identify alternatives by market sector:** The market sector approach prioritizes the industry sectors with the highest consumption of single-use foodservice products, thus maximizing potential impact.

A complete copy of the Product Scoping Survey is included in Appendix D. Twenty-two stakeholders responded to the survey (Appendix E). Results indicated:

- Limited alternatives to molded fiber products are currently available.
- Significant overlap exists between products used in different market sectors, meaning focusing on only one market sector would not efficiently use resources.

Based on the survey, Ecology concluded that the assessment should focus on end products (e.g., bowls, plates, food pails, etc.), not specific alternative materials or market sectors. Further support for this approach comes from the specific mention of alternatives for "specific food packaging applications" in RCW 70A.222.070.[50]

During a stakeholder call on September 11, 2019, we presented a tentative assessment scope, consisting of assessing alternatives for the food packaging category of food contact paper. We also proposed a tentative list of potential alternatives. Under RCW 70A.222.070(5), Ecology must continue reviewing potential alternatives if safer alternatives are not identified "for some or all categories of food packaging applications." The intention was for paper wraps and liners to serve as a first phase of this assessment. We planned to address other food packaging categories—such as containers, serviceware, pet food bags, etc.—in a future assessment.

While some stakeholders supported this approach, others were concerned that this scope was too narrow and would not result in a significant impact. Based on this feedback and in an effort to maximize the impact of the assessment, Ecology expanded the scope to include more food packaging categories, leveraging the formulation or material alternatives overlap between applications. This scope expansion required continued stakeholder input on the available alternatives for different products. We eventually determined that this AA would include food contact paper, dinnerware, and take-out containers—these categories contained the most overlap in material alternatives.

Following this decision, we subdivided the three food packaging categories into ten food packaging applications based on available data:

- **Food contact paper** (two applications): wraps and liners; bags and sleeves.
- **Dinnerware** (four applications): plates; bowls; trays (including cafeteria trays); food boats.
- **Take-out containers** (four applications): pizza boxes; French fry cartons; clamshells; interlocking folded containers (also called food containers or pails).

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[50] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.222.070

Wraps, liners, bags, and sleeves (food contact paper) will have an estimated $2 billion market demand in 2021 (Freedonia, 2017). In a study on fluorinated compounds in U.S. fast food packaging, 38% of sandwich wraps and 56% of dessert and bread bags tested contained fluorine, suggesting that PFAS-free products are readily available and being used (Schaider et al., 2017). Given the wide range of alternatives already in use in this food packaging category, substitution with PFAS-free products may be the most attainable among this group.

The dinnerware market is expected to have a $2 billion market demand by 2021 (Freedonia, 2017). The Center for Environmental Health (CEH) tested a variety of dinnerware products on the market for fluorine (F) content (CEH, 2020). Of the products tested, 38 of 94 plates, 36 of 72 bowls, and 15 of 43 trays and food boats were confirmed to have “No or Low F” content.

The third food packaging category, containers, is loosely defined as “take-out” containers designed for storage and transport of prepared food. There is an estimated $3.5 billion market demand for these products for 2021 (Freedonia, 2017). Among the most used products in this sector are clamshells, pizza boxes, and French fry cartons.

Identification of alternatives for this assessment

Ecology used the information sources below to identify potential alternatives substances that are used to manufacture the ten food packaging applications:

- **Freedonia Group market research analysis**: Ecology used The Freedonia Group (2017) industry study on foodservice single-use products to identify the major producers and suppliers of PFAS alternative products. We categorized companies by market sector and the product line they offer in each sector. We also identified the alternative material used in each product line.
- **Manufacturers and users**: Ecology collaborated with stakeholders, who voluntarily provide information on their products, to support the alternatives assessment. Stakeholders, including chemical producers, product manufactures, and end users provided alternative products that have been independently verified as likely to be PFAS-free based on the level of fluorine content.
- **U.S. EPA Safer Chemical Ingredients List (SCIL)**: Ecology leveraged the SCIL to identify chemicals that EPA already evaluated and determined are safer for use in products.
- **Databases on PFAS-free products**: Ecology relied on information found in existing databases, including those from CEH[51] and Collaborative Network For Cancer Free Economy.[52]
    - Although meant to serve as a resource for purchasers, these databases are excellent sources of information. They represented a good starting point to identify and prioritize alternatives for this assessment (Blake et al., 2018; CEH, 2020; Chiang et al., 2018; Freedonia, 2017; OECD, 2020; SPLC, 2020).

[51] https://www.ceh.org/ceh-report-avoiding-hidden-hazards-purchasers-guide-safer-foodware/

[52] https://sustainablepackaging.org/wp-content/uploads/2018/07/Purchasing-Safer-Compostable-Food-Service-Ware.pdf

- **Standards setting and certifying programs**: Ecology considered existing and emerging efforts to establish standards for materials, products, and services that meet high technical quality and market relevancy. Standards and certification programs help promote the use of transparency in the market through a rigorous process to address both U.S. and global standards.
- **Literature search**: Ecology reviewed scientific literature to supplement our understanding of chemicals used in food packaging.

Alternatives to PFAS in plant-based food packaging can be roughly categorized into three groups: process treatments, base materials, and system alternatives (we discussed these at the May 2019 Stakeholder Webinar[53]). For the purposes of this project, they are defined as:

- **Process treatments**: dry-end coatings or wet-end additives that are applied to the base material to provide oil and grease resistant (OGR) properties to the product.
- **Base materials**: the primary substrate (paper, paperboard, fiber pulp, plastics, and aluminum), treated (including mechanical densification) or untreated.
- **System alternatives**: alternatives that provide the desired function but are not process treatments or base material alternatives. The primary system alternative for this assessment is reusable packaging and serviceware.

We gathered a list from various sources on the different types of coating alternatives, base material alternatives, and system alternatives (Chiang et al., 2018; Nestler et al., 2019; Trier et al., 2017). The initial alternative materials are summarized below (Chiang et al., 2018; Nestler et al., 2019; Trier et al., 2017).

Alternative type: Coating/process treatment (also called "barrier" treatments)

- Bio-based
  - Waxes
  - Lignin and glycerol based coatings
  - Polylactic acid (PLA)
- Plastics
  - Acrylics
  - Polyvinyl alcohol (PVOH) and ethylene vinyl alcohol (EVOH) copolymer
  - Polyethylene (PE) and polyethylene terephthalate (PET)
- Other
  - Paraffin wax
  - Clay
  - Proprietary

[53] https://www.ezview.wa.gov/Portals/_1962/Documents/PFAS/PFAS%20AA%20Webinar_05152019.pdf

Alternative type: Base material

- Bio-based
  - Plant fiber (e.g., bamboo, sugarcane)
  - PLA
- Plastics
  - Polystyrene
  - High-density PE and PET
  - Polypropylene
- Metals: Aluminum

Alternative type: System

- Reusable plastics
- Washable food wraps
- Reusable china

Other process alternatives such as machine-finished paper (including vegetable parchment), mechanical densification, and mechanical glazing were categorized as "uncoated" alternatives in this assessment.

Other PFAS-free alternatives such as palm leaf, talc, coated cloth, lignin, and nanotech were identified (Nestler et al., 2019), but were not included in this assessment because of their limited availability compared to other alternatives.

In 2020, California's Safer Consumer Products Program identified other potential barrier alternatives including starch, carboxymethyl cellulose, aqueous dispersions of copolymers such as styrene and butadiene, aqueous dispersions of waxes, water-soluble hydroxyethylcellulose, chitosan, alkyl ketene dimer, and alkenyl succinic anhydride (DTSC, 2020a). Ecology may address these substances in future assessments.

Ecology selected materials from the initial list based on the following principles:

- **Market share:** Ecology will prioritize product categories that are widely available in the food packaging market.
- **Available alternatives:** Ecology will prioritize product categories where we know PFAS-free food packaging products are available and used.
- **Safer alternatives:** Ecology will prioritize alternatives found on the SCIL or comprised of materials known to be of low concern (e.g., paper, aluminum). See Section 4 for details.

We also considered state efficiency and environmental performance standards regarding recyclability and compostability (Nestler et al., 2019). Washington state has preferable purchasing programs for recyclable and compostable products, and some local mandates ban non-recyclable polystyrene products. However, these standards are not required to identify a safer alternative under RCW 70A.222.070.[54]

[54] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.222.070

As a result of this scoping exercise, we prioritized an initial set of eight substances and uncoated paper for hazard and exposure evaluations. Each substance would be evaluated for each product in the separate food packaging categories:

- **Uncoated paper:** Paper-based packaging can be manufactured with OGR properties without the addition of a chemical barrier via the process of mechanical densification, glazing, or machine finishing (Trier et al., 2017; DTSC, 2020a). This alternative was assumed to be of low hazard concern and amenable to recycling and composting.
- **Wax-coated paper:** Petroleum and bio-based waxes are lipid compounds composed of esters of a long-chain fatty acid and alcohol (Robertson, 2012). Aqueous dispersion of wax can be used as a coating on paper or paperboard as a chemical barrier (Trier et al., 2017). Both petroleum-based and bio-based waxes have been designated a low hazard concern based on their listing on EPA's SCIL (U.S. EPA, 2020a). They are compostable (Eco-Cycle, 2016).
- **Clay-coated paper:** Kaolin clay is a naturally occurring mineral that can be added as a coating to paper and paperboard to provide a barrier (Chiang et al., 2018; Imerys, 2020). This alternative was designated a low hazard concern based on its listing on EPA's SCIL (U.S. EPA, 2020a). Clay-coated paper products are compostable (Chiang et al., 2018).
- **Siloxane-coated paper:** Siloxane compounds consist of a silicon-oxygen backbone with organic groups attached to the silicon atoms. Paper and paperboard can be coated in siloxane-based polymers to provide a chemical barrier (Trier et al., 2017). Siloxane-coated paper is commonly used in paper wraps and liners, particularly baking papers (Verschueren & Parein, 2018). These products are not recyclable or compostable.
- **PVOH- or EVOH-coated paper:** PVOH is a polymer made from vinyl acetate. The acetate groups undergo transesterification after polymerization to produce alcohol functional groups. In EVOH, ethylene is polymerized with vinyl acetate (Robertson, 2012). PVOH and EVOH copolymers can be added as coatings to paper and paperboard to provide a chemical barrier (Kuraray, 2020; Trier et al., 2017). PVOH and EVOH coated paper products are recyclable (Kuraray, 2020).
- **PLA and PLA-coated paper:** Polylactic acid is a bio-based plastic made from lactic acid monomers, which can be produced through biomass fermentation (Robertson, 2012). PLA alternatives can be base materials, such as PLA bioplastic or foam, or chemical barriers such as PLA-coated paper and paperboard (Chiang et al., 2018). PLA plastics and foams are compostable. PLA-lined paper products are compostable and may also be recyclable if not contaminated with food (Chiang et al., 2018).
- **PE- or PET-coated paper:** PE and PET are plastics formed from the polymerization of ethylene (PE) or bis(2-hydroxyethyl) terephthalate (PET) compounds (Robertson, 2012). In this AA, these polymer alternatives were only evaluated as coatings on paper or paperboard, not as base materials (Chiang et al., 2018). Very few recycling collection services are capable of recycling PE- and PET-lined paperboard and these products are also not compostable (Chiang et al., 2018).

We used the data collected for each alternative substance to confirm that the alternative substance was available on the market and used in food packaging products (Chiang et al., 2018; Nestler et al., 2019; Trier et al., 2017). Collected data were also used to group alternative substances within the relevant food packaging categories.

We summarize these substances, along with relevant CASRNs and FDA approvals, in Table 4. The CASRNs listed for each alternative substance are not an exhaustive list. Others not listed here may also be relevant and allowed for use by the FDA.

Table 4. Alternative substances prioritized for evaluation in this AA.

Alternative substance	Alternative type	Relevant CASRNs	Approved for use in food packaging?[1]	Food packaging categories used in
Uncoated paper	Non-chemical alternative	65996-61-4	Yes	Food contact paper; dinnerware
Wax	Coating	64742-43-4; 64742-51-4; 8001-22-7; 67784-80-9; 8012-89-3; 8015-86-9	21 CFR 176.170, 21 CFR 176.180	Food contact paper
Clay	Coating	1332-58-7	21 CFR 176.170	Dinnerware; take-out containers
Siloxane	Coating	68083-19-2; 68083-18-1; 68037-59-2; 977161-67-3; 63148-57-2; 63148-53-8; 144635-08-5; 977183-95-1	FCN 1907; 21 CFR 176.170	Food contact paper
PVOH	Coating	9002-89-5; 25213-24-5	FCNs 1349, 333; 21 CFR 176.170, 21 CFR 176.180	Food contact paper; dinnerware; take-out containers
EVOH copolymers	Coating	26221-27-2; 1485481-35-3	FCNs 1763, 1179	Food contact paper; dinnerware; take-out containers
PLA	Coating; base material	9051-89-2; 4511-42-6; 615-95-2[2]	FCNs 475, 178	Dinnerware; take-out containers
PE	Coating	9002-88-4	21 CFR 177.1520	Dinnerware; take-out containers
PET	Coating	25038-59-9	21 CFR 177.1630	Dinnerware

Table notes:

1. FCNs were identified using the FCN inventory (FDA, 2020b).
2. CASRNs 4511-42-6 and 615-95-2 refers to the dilactide precursors for polylactic acid.

Combining a specific alternative substance (such as PLA foam) from the list above with a specific food packaging application (such as plates from the dinnerware category) creates a product-level alternative (such as PLA foam plates). Whether we evaluated an alternative at the material/chemical level or the product level depended on the assessment module.

The alternatives we prioritized in this assessment do not represent a comprehensive list of all available products on the market. Focusing on widely available products increased the likelihood that products would have sufficient availability and maximized the impact of the assessment.

We recognize that we could streamline the assessment by only evaluating substances known to be low hazard concerns. However, we felt it was necessary to include substances that needed hazard evaluation, because they represent a large share of the market.

Alternatives outside the scope of this assessment

The alternatives in this assessment are not a comprehensive representation of all possible PFAS-free alternatives available on the U.S. market. We did not consider single-use, petroleum-based plastics in this assessment. We based this exclusion on Executive Order 20-01 issued by Governor Jay Inslee, which requires state agencies to consider reducing solid waste and toxics in products in state purchasing (EO 20-01, 2020). We also did not include polystyrene products in this assessment, as they would be considered a regrettable substitution based on polystyrene's environmental impact. Further, some jurisdictions in Washington state, notably the City of Seattle, banned the use of polystyrene food packaging (City of Seattle, 2020).

Reusable foodservice options are an increasingly available alternative, especially in institutional and cafeteria-style settings. Certain market sectors and product lines have alternative reusable options as opposed to single-use products. We identified several case studies showing cost savings and feasibility when these food service areas are partially or fully converted to reusable products (Clean Water Action, 2019; Wie et al., 2003). Find more detail on reusable food serviceware in the Cost and Availability Module (see Section 7). We did not conduct hazard, exposure, or performance assessments for these products, as they would be assessed differently than other alternatives, but we may in the future.

Finally, in this AA, we did not explore substituting or augmenting one food packaging application with another as an available system alternative. For example, a disposable paper liner and a reusable plastic food boat could replace a disposable food boat. In this way, end users could potentially substitute a known safer alternative we identified in this AA for a PFAS-containing version of a different food packaging application where we did not identify safer alternatives.

Section 4. Hazard Module

Overview

Ecology conducted an IC2 Level 2 Hazard Module for the candidate alternatives to determine if their potential hazards to human health and the environment are lower than PFAS. The IC2 Level 2 Hazard Module recommends the use of GreenScreen® for Safer Chemicals. In this section, we evaluated PFAS and alternatives to PFAS on the chemical level (see the Introduction for a brief definition).

Find the list of candidate alternative substances in Table 4. For this hazard assessment, we evaluated the chemicals or materials that provided oil and grease resistance or leak-proofing (the active ingredient), not the formulations of entire food packaging products.

The candidate alternatives we considered represent a large group of substances covering multiple types of functional alternatives, including alternative materials and chemical barriers. Therefore, we developed a tiered approach to implementing the IC2 AA Guide. Prior to conducting GreenScreen® evaluations, we screened each candidate substance using the GreenScreen List Translator™ methodology and the EPA SCIL to determine whether that chemical was already known to be of either high or low concern. We then evaluated all remaining alternatives using the GreenScreen® method. We provided a consistent hazard approach to each alternative by only comparing hazards that had been evaluated using the GreenScreen® method.

Due to a lack of information about specific proprietary versions of the candidate chemicals, we evaluated some substances using representative chemicals. Table 9 lists the outcome of the hazard assessment for each candidate alternative. **Several alternatives were identified with lower hazard concerns than the evaluated PFAS.**

Choice of IC2 AA Guide level

The IC2 AA Guide describes three levels for the Hazard Module:

- **Level 1 Basic Evaluation**: Utilizes the Quick Chemical Assessment Tool to determine if hazards exist for specific hazard criteria using well-defined, readily available data sources.
- **Level 2 GreenScreen Evaluation**: Uses the GreenScreen for Hazard Assessment tool (GreenScreen®) to conduct a thorough hazard evaluation. GreenScreen® is a free, publicly available hazard assessment tool.
- **Level 3 Expanded GreenScreen Evaluation**: Expands on Level 2 by eliminating data gaps and requiring an independent, third-party verification.

Ecology chose to perform a Level 2 hazard evaluation because it provides a thorough and transparent method to evaluate hazard concerns without generating new data (which is required in a Level 3 assessment). The IC2 Level 2 hazard evaluation recommends using GreenScreen®, which evaluates each substance for 18 hazard endpoints. These endpoints are then used to compare alternatives to the comparator. We believe the consistent and transparent hazard evaluation approach provided by the GreenScreen® method strengthens our ability to compare hazards and supports our conclusions.

Hazard assessment methodology

Data needs for hazard assessment

Whenever possible, Ecology used publicly available information to conduct our evaluation. In order to fill gaps in the public dataset, we requested alternative chemical product formulation information from manufacturers.

We first outlined these data needs for stakeholders in May 2019. We published a hazard assessment methodology on the EZ view website[55] on March 20, 2020. It included the following information request for PFAS and candidate alternative substances:

1. Product formulation disclosure, including:
   - Active ingredient (substance providing oil/grease-proofing function)
   - Functional additives
   - Known residual monomers or oligomers (>100 ppm [greater than 100 ppm] or 0.01%)
   - Known byproducts or impurities (>100 ppm [greater than 100 ppm] or 0.01%)
2. Should include at a minimum a CASRN and systematic chemical name for each formulation component.
3. Chemical structure (simplified molecular-input line-entry system [SMILES], image). At the very least, one that could be easily derived from a CASRN and chemical name.
4. For polymeric substances, the following additional information are also required:
   - Representative structure
   - Mole ratios of monomers
   - Indication as to whether the monomers are blocked
   - MW_n (molecular weight average)
   - Oligomer characterization:
     - %MW less than 1000
     - %MW less than 500

Stakeholders were able to use a CBI disclosure process to submit this information. Stakeholders could also include experimental studies that address the endpoints for the hazard assessment and Safety Data Sheets (SDS), although these documents alone could not fulfill the data requirements for a GreenScreen® evaluation. Our process required stakeholders to voluntarily disclose their formulations—the statute does not make disclosure mandatory.

[55] https://www.ezview.wa.gov/site/alias__1962/37610/DesktopDefault.aspx?alias=1962&PageID=37610

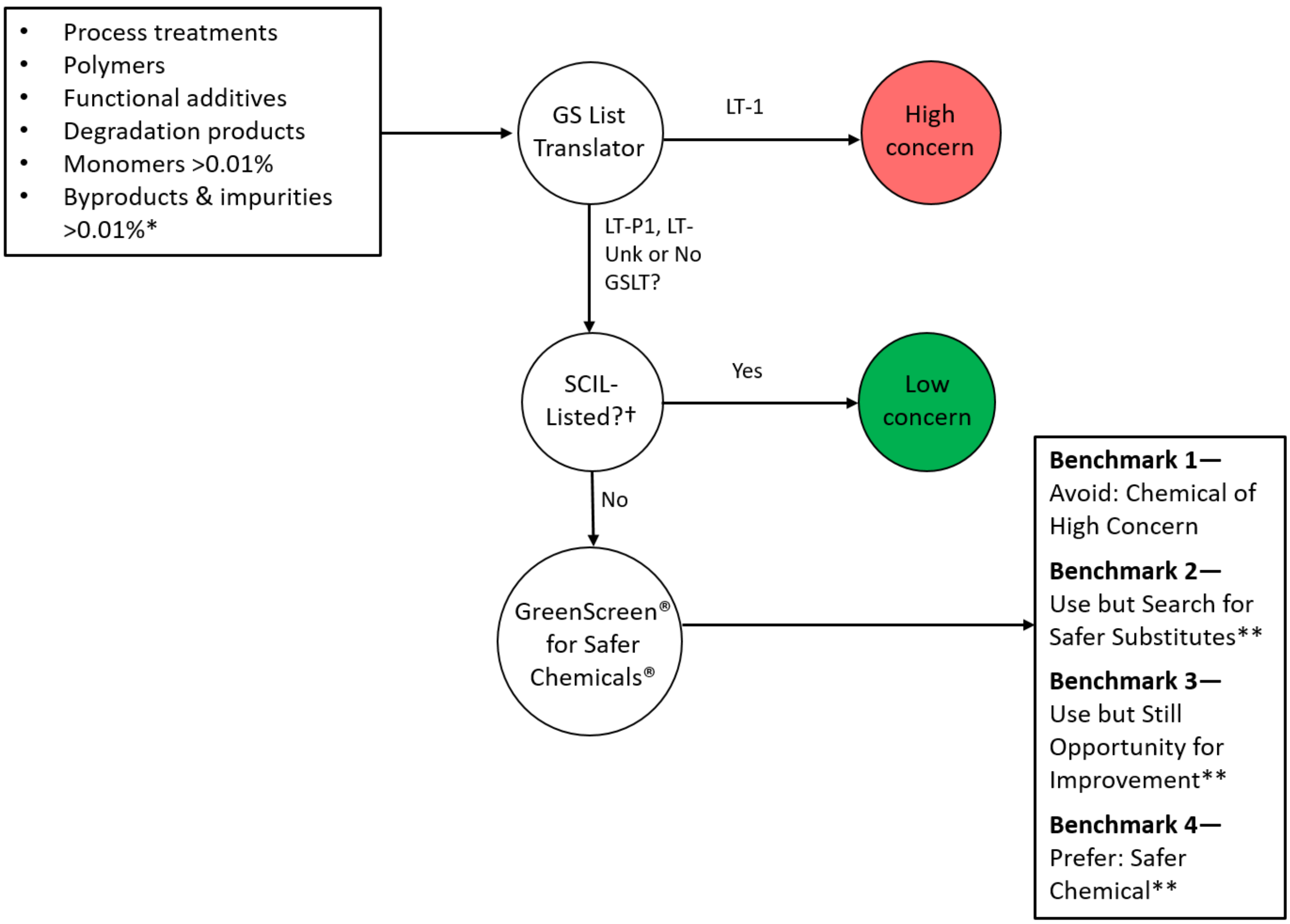
Tiered approach to hazard assessment

Ecology used a tiered approach to assess substances in a way that ensured project efficiency while maintaining consistency with IC2 AA Guide. This tiered assessment approach is outlined in Figure 3.

First, we used the GreenScreen List Translator™[56] to screen chemicals (CPA, 2018c). This rapid screening tool identifies chemicals of high concern based on their status on authoritative lists—such as the U.S. EPA Priority PBTs chemical list (Annex 11, CPA, 2018b)—which identify chemicals known to have human and ecological hazard concerns.

A List Translator score of "LT-1" means the hazard classifications for this chemical meet one or more of the GreenScreen® Benchmark-1 criteria. For the purposes of this assessment, we will designate any substance with a List Translator score of "LT-1" as high concern, and will not evaluate it further.

Figure 3. Tiered approach for substances undergoing hazard evaluation.



[56] https://www.greenscreenchemicals.org/images/ee_images/uploads/resources/GS_ListTranslator_Factsheet.pdf

Figure notes:

- * Base materials consisting paper, paperboard, and plant-based pulp are assumed to be of low concern and will not be assessed under this approach.
- † Green circle designations only.
- ** Benchmarks 2 – 4 are not automatically assumed to be safer alternatives. Ecology may further clarify safer alternatives based on the hazard information and how it compares to the PFAS comparator (Ecology & Health, 2008).
- Access an accessible text description of this graphic.[57]

The Safer Chemical Ingredients List (SCIL)[58] contains chemicals that meet the Safer Choice Criteria for Safer Chemical Ingredients, which is a hazard-based assessment similar to GreenScreen®. These designations are based on data-driven assessments conducted by third-party assessors that are verified by the U.S. EPA. In order to meet the SCIL criteria, a chemical cannot be a known or suspected carcinogen, mutagen or reproductive or developmental toxicant. It cannot have endocrine disrupting properties associated with adverse health outcomes. Toxicity data from the other endpoints, such as systemic toxicity, acute toxicity, and skin and eye sensitization, are compared to thresholds established by the Globally Harmonized System of Classification and Labeling of Chemicals (GHS) and other authoritative bodies.

To be conservative, we only considered SCIL designations of "green circle" as low concern. These substances did not proceed to a GreenScreen® hazard assessment. SCIL chemicals designated as "half-green circle" or "yellow triangle" (which have specified use-restrictions), or those listed under Specialized Industrial Products (SIP) were not considered supportive of low concern designation.

[57] https://www.ezview.wa.gov/Portals/_1962/Documents/PFAS-Food/TextDescriptions_Figures_PFAS_FoodPackaging_AA.pdf
[58] https://www.epa.gov/saferchoice/safer-ingredients

GreenScreen® for Safer Chemicals

We evaluated all target substances not designated as a high or low concern, including the comparator and candidate alternatives, using GreenScreen®.[59] A GreenScreen® assessment evaluates the following 18 hazard endpoints:

Group I Human

- Carcinogenicity
- Genotoxicity/ Mutagenicity
- Reproductive Toxicity
- Developmental Toxicity
- Endocrine Activity

Group II and II* Human

- Acute Toxicity
- Systemic Toxicity (single)
- Systemic Toxicity (repeat*)
- Neurotoxicity (single)
- Neurotoxicity (repeat*)
- Skin Sensitization*
- Respiratory Sensitization*
- Skin Irritation
- Eye Irritation

Ecotoxicity

- Acute Aquatic Toxicity
- Chronic Aquatic Toxicity

Fate

- Persistence
- Bioaccumulation

Physical

- Reactivity
- Flammability

GreenScreen® builds on existing frameworks for comparing chemical hazards, such as GHS and EPA's Design for the Environment program, now called Safer Choice. In a GreenScreen® assessment, data from peer-reviewed science, authoritative bodies, and regulatory studies (e.g., studies following Organisation for Economic Cooperation and Development protocols) are used to assess toxicity. Toxicity data for chemical analogs (which are chemically or biologically suitable substitutes for the chemical under assessment) or modeling data (e.g., the Ecological Structure Activity Relationships Program (ECOSAR) tool) may also be used to fill in data gaps.

The certified GreenScreen® assessor compiles data and assigns a score for each endpoint based on criteria developed from the GHS and other health and environmental protection agencies (such as EPA). If there are conflicting reports, the assessor uses a weight of evidence approach based on guidance from the European Chemicals Agency to assign a score (ECHA, 2020a). The compile data used to assign scores are included in the complete GreenScreen® report.

The scores for each hazard endpoint are then used to assign a benchmark (BM) score of 1 to 4 for the chemical. A BM-1 stands for "Avoid: Chemical of High Concern" while a BM-4 means "Prefer: Safer Chemical." A chemical may be assigned Benchmark-U (unknown) if there are inadequate data to characterize the chemical under the benchmark criteria (CPA, 2018b). GreenScreen® assessments that result in scores of BM-U, BM-2, BM-3, or BM-4 expire five years after the assessment date, and the substance must be re-evaluated (CPA, 2019).

For a complete GreenScreen® evaluation of a polymer substance, the molecular weight (MW) and structural details of the substance are required (CPA, 2018b). This evaluation also assesses hazard concerns for the breakdown products, impurities, functional additives, and residual monomers (if applicable) present above 100 ppm. The hazard characteristics of a polymer may be different from a monomer, as the polymerization reaction changes the physical

[59] https://www.greenscreenchemicals.org/learn/guidance-and-method-documents-downloads

characteristics. However, the hazards of the impurities, such as breakdown products and residual monomers, influence the benchmark score or the polymer substance.

Evaluating impurities and breakdown products is particularly relevant to this alternatives assessment because these are often the chemicals found in food (Bhunia et al., 2013; Muncke at al., 2020; Till et al., 1987; 21CFR 176.17). For example, food packaging uses PFAS polymers that may have residual chemicals such as 6:2 FTOH or degrade into products such as PFHxA (Buck, 2015), both of which have been detected in food packaging and may migrate into food (Yuan et al., 2016).

We compared both the final benchmark score and individual hazard endpoint scores to evaluate alternatives. As relevant, Ecology considered whether the hazard profile for the candidate alternatives demonstrates that the endpoints of concern for PFAS were adequately reduced or alleviated.

In the absence of detailed substance information, we determined whether there was sufficient information to perform a GreenScreen® evaluation on polymer impurities or breakdown products. Monomers in particular have been used to compare the relative polymer hazards (Lithner et al., 2011; Rossi & Blake, 2014). If we could not evaluate an alternative using GreenScreen® (for either the alternative substance or its key impurities and breakdown products), then we could not determine whether it is less hazardous than PFAS.

Hazard assessment results

GreenScreen List Translator™ results

No candidate alternative substances were identified as LT-1 using the GreenScreen List Translator™ (Pharos, 2020). This initial screening exercise indicated that all substances were eligible for further hazard evaluation.

Substances of low concern

SCIL contains chemicals that meet the Safer Choice criteria (EPA, 2020b), which is a hazard-based standard that is foundational to the criteria used in GreenScreen®. Similar to GreenScreen®, the SCIL criteria relies on toxicological thresholds identified by authoritative health and environmental protection agencies and reviews all available data (including the peer-reviewed science) to determine whether a chemical meets the criteria.

Several alternative substances were previously identified as low concern and were not evaluated with GreenScreen® (Table 9). Uncoated paper, which is a non-chemical alternative to PFAS, was determined to be of low concern because it consists of the paper pulp that is mechanically densified to impart oil, grease, and leak resistance. Further, it does not contain additives intended to repel oil or water. Additionally, paper pulp (CASRN 65996-61-4) is listed on SCIL as a green circle substance.

Three other alternative substances, waxes, kaolin clay, and PVOH, were determined to be of low concern due to their designation on the U.S. EPA SCIL as a "green circle" (EPA, 2020a). Several petroleum and bio-based waxes are designated as green circle substances, including paraffin waxes, petroleum, clay-treated (CARN 64742-43-4) and hydrotreated (CASRN 64742-

51-4), beeswax (CASRN 8012-89-3), and soybean oil (CASRN 8001-22-7) (which can be hydrogenated to produce soy-based wax). Additional relevant CASRNs are provided in Table 9.

Stakeholders identified PVOH as an alternative that would require a GreenScreen® evaluation. However, both fully hydrolyzed (CASRN 9002-89-5) and partially hydrolyzed PVOH made from polyvinyl acetate (CASRN 25213-24-5) are listed on SCIL as green circle, and stakeholder-provided data confirmed that both the fully and partially hydrolyzed PVOH are used in food packaging materials. Therefore, PVOH was determined to be of low concern and did not undergo a GreenScreen® assessment. Results from this section are summarized in Table 9.

Evaluations using GreenScreen®

We evaluated alternative substances that were not positively identified as low concern using the EPA SCIL or high concern using GreenScreen® List Translator™ using a GreenScreen® assessment. To provide a consistent approach to evaluating hazards, only the GreenScreen® method was used. All GreenScreen® evaluations used in this AA are publicly available. Many can be found in the IC2 Chemical Hazard Assessment Database,[60] including any GreenScreen® assessment paid for by Ecology.

Although we established protocols to confidentially collect and evaluate product formulation information, and several stakeholders expressed interest in submitting this information, we did not receive any formulations in time to complete this assessment.

In the absence of either complete or partial product formulation information, for each alternative, we determined whether there was sufficient information to perform a GreenScreen® evaluation on polymer impurities or breakdown products. These compounds are more likely to migrate from food packaging into food and therefore represent an important exposure risk (Bhunia et al., 2013; Till et al., 1987; 21 CFR 176.17).

PFAS and related substances

RCW 70A.222.070[61] applies to all intentionally added PFAS. As a chemical class, PFAS are concerning because they are highly persistent—both as the original manufactured compound and as PFAS products produced through degradation (Blum et al., 2015; Kwiatkowski et al., 2020; Wang et al. 2017). Some PFAS are highly mobile in the environment and are known to be bioaccumulative (Kwiatkowski et al., 2020; Wang et al. 2017). Well-known PFAS have other concerning toxicities, such as reproductive and developmental toxicity, but large data gaps remain regarding the toxicity and fate of some PFAS (Kwiatkowski et al., 2020; Wang et al. 2017; Wang et al. 2020).

Since hazard data specific to the comparator are considered CBI and were not made available for this AA, we based the hazard evaluation on analyzing the impurity 6:2 FTOH and the degradation product PFHxA. As discussed in Section 2, polymeric PFAS compounds are often considered chemicals of concern due to the migration of lower-weight, hazardous impurities and degradation products (Kabadi et al., 2018; Rice et al. 2020; Wang et al. 2020). Although the

[60] http://theic2.org/hazard-assessment#gsc.tab=0
[61] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.222.070

polymeric resins containing PFAS are the substances applied directly to the paper food packaging, 6:2 FTOH and PFHxA were commonly identified in studies monitoring the presence and migration of PFAS in food packaging (Fengler et al., 2011; Müller et al., 2012; Trier et al., 2017).

According to a 2016 study, 6:2 FTOH was the highest concentration fluorotelomer detected in food packaging material in the U.S., suggesting that short chain (C6) fluoropolymers contribute to exposures related to PFAS food migration (Yuan et al., 2016). Some reports suggest that heat increases the volatility of fluorotelomer alcohols, and this may increase exposure when PFAS are used in packaging for hot foods (Sinclair et al., 2007). Furthermore, studies note that migration efficiencies of 6:2 FTOH into food increase when the food is higher in fat or alcohols (Trier et al., 2017; Yuan et al., 2016).

Existing GreenScreen® assessments for 6:2 FTOH (ToxServices, 2019) and PFHxA (ToxServices, 2016) are available online. Both substances are reported as Benchmark-1 chemicals due to high human health and very high persistence concerns. The results of these GreenScreen® assessments for all 18 hazard endpoints are summarized in Table 5.

Table 5. GreenScreens® for PFAS comparators.

Chemical (CASRN)	Carcinogenicity	Genotoxicity/Mutagenicity	Reproductive Toxicity	Developmental Toxicity	Endocrine Activity	Acute Toxicity	Systemic Toxicity (single)	Systemic Toxicity (repeat*)	Neurotoxicity (single)	Neurotoxicity (repeat*)	Skin Sensitization*	Respiratory Sensitization*	Skin Irritation	Eye Irritation	Acute Aquatic Toxicity	Chronic Aquatic Toxicity	Persistence	Bioaccumulation	Reactivity	Flammability	Benchmark Score
6:2 FTOH (CASRN 647-42-7)	M*	L	L	M*	M*	H	VH	H*	DG	DG	L	L*	L	L	H	H*	*VH*	VL	L*	M	BM-1
PFHxA (CASRN 307-24-4)	L	L*	L*	M*	DG	M	H	M*	DG	L	L*	DG	VH*	VH*	M	L	VH	L	M*	M*	BM-1

Table 6. GreenScreens® for alternatives and related substances.

Chemical (CASRN)	Carcinogenicity	Genotoxicity/Mutagenicity	Reproductive Toxicity	Developmental Toxicity	Endocrine Activity	Acute Toxicity	Systemic Toxicity (single)	Systemic Toxicity (repeat*)	Neurotoxicity (single)	Neurotoxicity (repeat*)	Skin Sensitization*	Respiratory Sensitization*	Skin Irritation	Eye Irritation	Acute Aquatic Toxicity	Chronic Aquatic Toxicity	Persistence	Bioaccumulation	Reactivity	Flammability	Benchmark Score
Vinyl dimethylsiloxy-terminated polydimethylsiloxane (CASRN 68083-19-2)	*L*	L	L	M	DG	L	L	L*	DG	L*	L	DG	L	L	L	L	VH	VH	L*	L	BM-1
Lactide (CASRNs 4511-42-6; 615-95-2) as a surrogate for PLA	L	L	L*	L*	L*	L	L	L	M*	L*	L	L*	L	H*	L	L*	L	vL	L*	L	BM-3
Ethylene glycol (CASRN 107-21-1), monomer of PET	L	L	M	H	L*	M	vH	H	H	L	L	DG	M	M	L	L	vL	L	L	L	BM-1

Table notes:

- *Italics* = estimated values and low confidence (these scores are marked with an asterisk)

- DG = data gap
- VL = very low concern
- L = low concern
- M = moderate concern
- H = high concern
- VH = very high concern

Siloxanes

We identified siloxanes as a possible alternative substance for this AA. This assessment used vinyl dimethylsiloxy-terminated polydimethylsiloxane (CASRN 68083-19-2) to evaluate siloxanes used in alternative food packaging products. It is unclear how often different siloxane substances are used in food packaging products, or if any other additional additives are used.

The List Translator evaluation of hydrogen dimethicone (CASRN 68037-59-2) showed this compound on environmental screening lists due to concerns about high persistence and high bioaccumulation potential (Pharos, 2020). Although these hazard designations may not be representative of all siloxane substances used in food packaging, they do raise concerns about food packaging products that use this group of chemicals.

A publicly available GreenScreen® for vinyl dimethylsiloxy-terminated polydimethylsiloxane (CASRN 68083-19-2) concluded that this substance is Benchmark-1 (Toxservices, 2014b). The hazard endpoints of this GreenScreen® are summarized in Table 6. This substance was identified as having very high persistence and very high bioaccumulation—two hazard concerns that are also associated with PFAS as a class. This indicates that siloxanes should be removed from consideration as safer alternatives.

Plastics and bioplastics

A number of candidate alternative substances in this AA are plastics or plastic-coated paper. Plastics are a group of polymers that can be shaped by flow into a variety of forms (Robertson, 2012). Like other polymers, plastics are a mixture of polymer chains, impurities such as unreacted monomers and oligomers, functional additives, and degradation products (Lithner et al., 2011). The identity and concentration of these chemicals varies between plastics, and sometimes between product formulations of the same plastic. Although most plastic polymers are characterized by high persistence, bioplastics such as PLA are designed to degrade, particularly in certain environments (Hahladakis et al., 2018).

For manufacturers, the product formulations used to make plastics for food packaging applications are trade secrets. Chemical information specific to the polymer, such as molecular weight, is also proprietary. Like all polymer substances used in food contact materials, the lower molecular weight impurities, additives, and degradation products are concerning because they can more easily migrate into food (Bhunia et al., 2013; Groh et al. 2019; Lithner et al., 2011; Till et al., 1987). Previous studies show migration of monomers, oligomers, antioxidants (which reduce oxidative damage), plasticizers (which improve the workability of a plastic), and light stabilizers (which reduce UV damage to the plastic) from food contact plastic to food or food simulants (Bhunia et al., 2013; Muncke et al., 2020).

Without specific product information for the alternative substance, it is difficult to identify which polymer impurities, additives, or breakdown products are likely to be present in concentrations greater than or equal to the 100 ppm threshold used in GreenScreen® evaluations. Many impurities that migrate from a specific food packaging material into food have not been characterized or the information is not publicly available (Groh et al., 2019; Muncke et al., 2020).

A recent effort to aggregate the hazards associated with chemicals used in plastic packaging identified 906 chemicals that are likely associated with plastic packaging, and 3,377 substances potentially associated (Groh et al., 2019). We searched this list and identified 54 chemicals that are likely associated with PET and 87 chemicals that are likely associated with PE. Only one chemical, polypropylene, was associated with EVOH (as a co-laminate for EVOH plastic films), but that likely indicates a dearth of information for EVOH, rather than a consistent polymer substance composition (Groh et al., 2019). The study authors acknowledged many data gaps that hindered a comprehensive hazard assessment of specific plastics.

Recognizing that we had limited resources to perform our hazard assessment without specific product information from manufacturers, we compared our plastic alternatives and prioritized PLA for a GreenScreen® evaluation of impurities, functional additives, and breakdown products. First, several PLA impurities and functional additives were already assessed using the GreenScreen® method, which limited the amount of new information we needed (Rossi & Blake, 2014; ToxServices, 2014b). Second, at least two comparative studies of the hazards associated with the candidate plastic substances suggested that PLA was likely to have the lowest hazard concerns.

Lithner et al. (2011) used hazard classification data for the monomers of PE, PET, EVOH, and PLA to assess and compare the polymers. PLA was classified as likely a very low hazard, although limited hazard classification data were available for its monomer lactic acid. SCIL currently lists two stereoisomers of lactic acid as green circle substances (CASRN 50-21-5 and 79-33-4). PE, which is made from ethylene, and EVOH, which is a copolymer made from ethylene and vinyl acetate, were both classified as low hazards. PET, which is made from ethylene glycol and either terephthalic acid or dimethyl terephthalate, was assessed as a low hazard. However, this was a lower confidence assignment because there is limited information about terephthalic acid and dimethyl terephthalate (Lithner et al., 2011).

Similarly, Clean Production Action's analysis of several plastics (including PLA, PE, and PET) identified PLA as having the lowest hazard concerns, based on an evaluation of the primary chemical inputs, monomers, and intermediates (Rossi & Blake, 2014). Because PLA appeared to have low hazard concerns, and hazard information was publicly available for several of its impurities, we prioritized gathering data to assess PLA.

PLA and related substances

Although we requested the relevant information from manufacturers, we were unable to obtain sufficient data to evaluate the PLA polymer or product formulation under the GreenScreen® methodology. However, since PLA is a high MW polymer (typically greater than 100,000 Daltons) with low bioavailability, chemical exposure from plastic food packaging is likely to be in the form of impurities, additives, and degradation products (Masutani & Kimura, 2014; Bhunia et al. 2013; Till et al. 1987). PLA is created by the ring-opening polymerization of L-lactide and D-lactide, with control of the stereoisomer ratio and sequence used to alter the mechanical properties of the polymer (Masutani & Kimura, 2014).

According to Conn et al (1995), lactic acid is the substance that is likely to migrate from food packaging containing PLA based on "reasonable worst case" migration and extraction experiments. On SCIL, lactic acid is designated as a green circle—it is therefore considered a chemical of low concern. Ecology also paid to have lactide re-evaluated; the GreenScreen® on lactide reported this substance as a Benchmark-3 ("Use but still opportunity for improvement"). This score was based on the combination of a moderate hazard score for single dose neurotoxicity and a high hazard score for eye irritation (Toxservices, 2020; find the full assessment under GreenScreens® in the IC2 Chemical Hazard Assessment database[62]). Although lactide does function as a degradation product of PLA, it and other small PLA oligomers quickly hydrolyze to lactic acid in aqueous solution (ECHA, 2020b).

The production of PLA from lactide for food packaging is commonly catalyzed by tin octoate, which is FDA approved for use in producing polymers for food packaging (Henton et al., 2005; Masutani & Kimura, 2014; FDA, 2019). Tin octoate was previously evaluated using GreenScreen® methodology and was determined to be a Benchmark-1 for very high persistence, high bioaccumulation, high ecotoxicity endpoints, and very high Group II human health endpoints (eye irritation) (Toxservices, 2014a). Catalyst amounts used in PLA synthesis typically range from 100 – 1,000 ppm (Henton et al., 2005). However, it's unclear how much residual catalyst may be present in the final product.

Since the catalyst is neutralized or removed to prevent depolymerization of PLA (Masutani & Kimura, 2014), the residual amounts are likely to be less than the 100 ppm limit used in GreenScreen® hazard assessment. Furthermore, 1-dodecanol, which is as a green circle on the EPA SCIL, is added as an initiator to PLA reactions, and can be used to decrease the amount of tin octoate added to below 1 ppm (Masutani & Kimura, 2014).

The PLA components discussed here do not represent the only possible components of PLA. For example, there is some evidence that plasticizers, such as tributyl citrate or polyethylene glycol, may be added to PLA (Groh et al., 2019; Henton et al., 2005). Both of these compounds are listed as LT-UNK (Pharos, 2020). However, leftover lactide monomer can also act as a plasticizer (Henton et al., 2005; Masutani & Kimura, 2014).

We summarize hazard concerns for PLA components in Table 7. With the exception of the tin octoate catalyst, all other components are of low concern. When using the GreenScreen® methodology to assess a polymer, only Group I human health hazard endpoints are considered for impurities with concentrations between 100 and 1,000 ppm. Since typical catalyst amounts fall within this range prior to PLA purification and are likely below this in the final product, the hazards of tin octoate likely do not impact the Benchmark score.

[62] http://theic2.org/hazard-assessment#gsc.tab=0

Based on the hazard concerns of the components, PLA is consistent with a Benchmark-3 score ("Use but still opportunity for improvement") and meets our criteria for a lower hazard concern.

As we were finalizing this AA following peer review, Natureworks shared that they had recently contracted a GreenScreen® evaluation through a licensed assessor for several product grades of Ingeo® PLA. These formulations received a BM-3 score. We were unable to review this evaluation for inclusion in this assessment. While we believe the information included here is adequate to characterize the hazard concerns associated with PLA used in food packaging, future assessments may continue to seek out specific product formulation information to increase certainty.

Table 7. Components of PLA.

Chemical (CASRN)	Relation to PLA	Hazard Concern
Lactide (4511-42-6; 615-95-2)	Monomer	BM-3: Use but Still Opportunity for Improvement
Tin octoate (301-10-0)	Catalyst	BM-1: Avoid Chemical of High Concern
Lactic acid (50-21-5; 79-33-4)	Degradation product	EPA SCIL: Green Circle
1-dodecanol (112-53-8)	Initiator	EPA SCIL: Green Circle

PET

For PET (CASRN 25038-59-9), GreenScreen® evaluations were conducted previously for ethylene glycol and terephthalic acid, the monomers used in one PET formulation method (Lithner et al., 2011; Nistico, 2020). These monomers combine to form bis(2-hydroxyethyl) terephthalate, which then forms PET (Rossi and Blake, 2014).

GreenScreen® hazard evaluations conducted in 2013 scored terephthalic acid as a BM-2 (ToxServices, 2013c) and bis(2-hydroxyethyl) terephthalate as a BM-U (ToxServices, 2013a), although those GreenScreen® evaluations have since expired. A GreenScreen® evaluation conducted at the same time for ethylene glycol categorized the chemical as having a high developmental toxicity hazard endpoint, resulting in a score of BM-1 (ToxServices, 2013b; see Table 6). BM-1 scores do not expire (CPA, 2019).

In the absence of detailed product formulation information about PET coatings or general information about PET coatings used for food packaging, it is difficult to interpret the impact these assessments might have on a GreenScreen® evaluation of PET. For example, a known impurity of PET are small cyclic oligomers of PET, which make up 0.06 – 1% of the PET polymer substance, but it is unclear if those oligomers further degrade (Hahladakis et al., 2018).

It was also difficult to identify any functional additives or other impurities that are likely to be present in PET used in food packaging (Groh et al., 2019). As a result, we found that the hazard evaluation for PET had "insufficient data." This label is intended to emphasize that we need more specific information about PET polymer substances used in food packaging to compare PET to the comparator PFAS.

PE and EVOH

For PE (CASRN 9002-88-4) and EVOH copolymers (CASRN 26221-27-2), no GreenScreen® evaluations were publicly available, and we were unable to acquire the needed information to conduct GreenScreen® evaluations for either these alternatives or for their impurities or breakdown products. While some studies assess some of the hazard concerns of PE and EVOH, most do not appear to be applicable to food packaging applications. For studies that could be applied, we do not believe there is enough information at this time to compare these alternative substances with the PFAS comparator chemicals across all 18 hazard endpoints identified by the GreenScreen® methodology (Bhunia et al., 2013; Groh et al. 2019; Lithner et al., 2011).

Since Ecology decided to use GreenScreen® as the only hazard evaluation tool, the absence of a GreenScreen® evaluation meant we had insufficient data to evaluate the alternative in this assessment. The label "insufficient data" is not intended as a comment on the hazard concerns associated with the alternative, and does not preclude us from conducting a hazard evaluation in future alternatives assessments.

Summary of hazard evaluation results

A summary of hazard evaluations we performed in this AA are listed in Table 8 and Table 9. When GreenScreen® evaluations were neither available nor able to be conducted in time, the alternative is given the label "insufficient data." In the absence of polymer information, both the PFAS comparator and PLA were evaluated using impurities and degradation products. Unfortunately, this approach introduces uncertainty into the hazard assessment. It considers residual monomers and degradation products without quantifying their concentrations within the polymer substance or considering the hazard concerns of the polymer. However, it uses the best available science at this time.

Table 8. Hazard assessment summary for the comparator and related substances.

Substance name	CASRN	Approach	Result
Copolymer of perfluorohexylethyl methacrylate, 2-N,N-diethylaminoethyl methacrylate, 2-hydroxyethyl methacrylate, and 2,2'-ethylenedioxydiethyl dimethacrylate, acetic acid salt	863408-20-2	Insufficient information was available to evaluate these substances using GreenScreen® for Safer Chemicals	Insufficient data
6:2 FTOH (impurity)	647-42-7	Evaluated using GreenScreen® for Safer Chemicals	Benchmark-1: Avoid – Chemical of High Concern
PFHxA (degradation product)	307-24-4	Evaluated using GreenScreen® for Safer Chemicals	Benchmark-1: Avoid – Chemical of High Concern

Table 9. Hazard assessment summary for alternative substances.

Substance name	CASRN	Approach	Result
Uncoated paper	65996-61-4	Non-chemical alternative	Low concern
Waxes (petroleum- or bio-based)	(Petroleum-based) 64742-43-4; 64742-51-4 (Bio-based) 8001-22-7; 67784-80-9; 8012-89-3; 8015-86-9	U.S. EPA Safer Chemical	Low concern
Kaolin Clay	1332-58-7	U.S. EPA Safer Chemical	Low concern
PVOH	9002-89-5 (fully hydrolyzed), 25213-24-5 (partially hydrolyzed)	U.S. EPA Safer Chemical	Low concern
Siloxanes (by analogy to Vinyl dimethylsiloxy-terminated polydimethylsiloxane)	68083-19-2	Evaluated using GreenScreen®	Benchmark-1: Avoid – Chemical of High Concern
PLA (by analogy to the monomer lactide [CASRNs 4511-42-6; 615-95-2])	9051-89-2		Consistent with Benchmark-3: Use but Still Opportunity for Improvement
PE	9002-88-4	Insufficient information was available to evaluate this substance using GreenScreen®	Insufficient data
PET	25038-59-9	Insufficient information was available to evaluate this substance using GreenScreen®	Insufficient data
EVOH copolymers	26221-27-2[1]	Insufficient information was available to evaluate this substance using GreenScreen®	Insufficient data

Table notes:

1. Based on FDA FCN 1179.

Section 5. Exposure Assessment Module

Overview

The IC2 AA Guide Level 1 Comparative Exposure Assessment Module is a qualitative assessment based on readily available data "to identify whether material differences exist between the chemical of concern and potential alternatives." In this section, we evaluated the PFAS comparator (see Section 2) and alternatives to PFAS on the chemical level (see the Introduction for a brief definition).

Similar to the Hazard Assessment Module (Section 4), we developed a tiered approach to comply with the IC2 AA Guide. This approach applies questions from the IC2 AA Guide to determine which substances must undergo a comparative exposure assessment. Preliminary questions are used to determine, based on the hazard concerns identified in the hazard assessment, if an alternative should be considered in the exposure module.

1. Has the alternative been evaluated for hazard and determined to be of low concern (e.g., EPA SCIL Green Circle, GreenScreen® Benchmark-3 or 4)?
2. Does the alternative have persistence, bioaccumulative, and/or toxic properties of concern?

Subsequent questions compare chemicals by evaluating differences in chemical properties, exposure pathways, and exposure concerns between a potential alternative and the PFAS comparator. If there are no material differences between the comparator and the potential alternatives, a full exposure evaluation is not required.

3. Are the chemical properties for the comparator and alternative materially similar? Or do material differences exist?
4. Are there material differences when the exposure pathways between the comparator and the alternative(s) are compared?
5. Are there substantive differences between the comparator and the possible alternatives that are likely to increase exposure concerns for the any of the alternatives?

If we identify material differences indicating that the potential exposure of the alternative is likely to be higher than the chemical of concern, four additional questions are asked.

All alternatives successfully evaluated in the hazard module were determined to meet the criteria identified in questions 1 and 2 based on their hazard concerns, and so no exposure assessments were performed. Table 13 and Table 14 include summaries of the exposure assessment determination for the comparator and alternative substances.

Choice of IC2 AA Guide level

The IC2 AA Guide describes three levels for the Exposure Assessment Module:

- **Level 1 Basic Comparative Exposure Evaluation**: This level utilizes a qualitative assessment of readily available data to identify whether material differences exist between the chemical of concern and potential alternative(s). If material differences in exposure potential do exist, a separate exposure assessment is necessary for the alternative. Decisions in this level are based upon a qualitative assessment using readily available data.
- **Level 2 Expanded Comparative Exposure Evaluation**: Builds on the previous level by increasing the quality and quantity of information. More detailed quantitative data is required to evaluate the importance of exposure in the AA process.
- **Level 3 Detailed Exposure Evaluation**: This level builds on previous levels and requires detailed scientific studies as the basis for decisions. If these studies are not available, they are conducted and the data used to determine the importance of exposure in the AA process.

In our hazard assessment, we prioritized identifying alternatives that not only address the specific hazard concerns of the PFAS comparator, but also that did not have any additional hazard concerns indicating the alternative was a regrettable substitution. Ecology determined that a Level 1 Exposure Assessment Module, when combined with the Level 2 Hazard Module, would provide sufficient information to identify safer alternatives and meet the requirements of RCW 70A.222.070.[63]

Exposure considerations for PFAS

Stakeholders asked that we consider PFAS exposures from non-food packaging products in this module. It is outside the scope of this AA to address the impact of cumulative PFAS exposure. However, the Draft PFAS Chemical Action Plan[64] (CAP), which is publicly available as of this assessment, provides detailed information on PFAS exposure sources and their impacts in Washington state.

There is evidence that PFAS in food packaging materials can migrate into the food products they contain (Trier et al., 2017; Schaider et al., 2017; Yuan et al., 2016; Fengler et al., 2011; Müller et al., 2012). The potential of PFAS migration to food depends on the food composition, temperature, the presence of salts and emulsifiers, the concentration of PFAS, total surface area, and surface energy (Trier et al., 2017). PFAS tend to migrate more easily to proteins, starches, and ethanol (Trier et al., 2017).

Shorter-chain FTOHs showed higher migration efficiencies than their longer-chain counterparts (Trier et al., 2017). PFAS used in food packaging contain C6 side chains and may break down to PFHxA (Kabadi et al., 2018; Rice et al., 2020; Schreder & Dickman, 2018). In addition, 6:2 FTOH

[63] https://app.leg.wa.gov/rcw/default.aspx?cite=70A.222.070
[64] https://apps.ecology.wa.gov/publications/summarypages/2004035.html

is often used as a precursor to PFAS polymers used in food packaging products and can be present as an impurity (Boucher, 2020).

PFAS-containing food packaging contaminates waste streams, which can lead to environmental exposures. Choi et al. (2019) detected shorter-chain (C6 or less) PFAAs in commercial compost. The PFAA load in streams containing food packaging was notably higher (28.7 to 75.9 µg/kg) than the load from organic waste that did not contain food packaging (2.38 to 7.60 µg/kg). The PFAA was leachable to pore water (25 – 49%) and was strongly correlated with the PFAA load (Choi et al., 2019).

Although we cannot predict the magnitude, a decrease in exposure to certain PFAS via food packaging is expected with increased use of safer alternatives. However, many routes of PFAS exposure exist, so this would not completely eliminate exposure to these chemicals.

Environmental justice considerations of PFAS in food packaging

Environmental justice is defined as "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation and enforcement of environmental laws, regulations and policies. Fair treatment means that no group of people should bear a disproportionate burden of environmental harms and risks, including those resulting from the negative environmental consequences of industrial, governmental, and commercial operations or programs and policies" (EPA, 2018). Per the IC2 AA Guide, a full Social Impact Assessment is outside the scope of this assessment. However, we used aspects of this module to identify overburdened communities and those at highest risk of exposure to PFAS in food packaging.

Overburdened communities may be more vulnerable to environmental hazards and experience a disproportionate risk for exposure (EPA, 2019). In Washington, certain communities have higher PFAS concentrations in the environment or in their drinking water, and some use fast food, take-out, or packaged food products more often than others (Health, n.d.).

Additionally, landfills, incinerators, composting, and illegal dumping or littering can release PFAS from food packaging into the environment. Communities who live near landfills, incinerators, and composting areas may experience exposure to certain pollutants that might not affect other communities. Unequal burdens regarding waste disposal facilities tend to be placed on low-income and minority communities (Dovey, 2015).

Certain populations may have higher concentrations of PFAS in their bodies from various exposures. Higher PFAS concentrations in the body have been associated with consuming more microwavable popcorn and having the Gilbert syndrome phenotype (Susmann et al., 2019; Fan, Ducatman, & Zhang, 2014). Gilbert syndrome is an inherited bilirubin conjugation defect that can affect the metabolism and excretion of drugs and xenobiotics, and an increase in PFAS accumulation in individuals with the syndrome has been reported (Fan, Ducatman, & Zhang, 2014). Gilbert syndrome is prevalent in approximately 3 – 7% of the U.S. population, and is found more often in males than females, across all races (Susmann et al., 2019).

There are also certain populations who tend to consume fast food at higher rates and may be more impacted by the ban due to their food habits, proximity to fast food outlets, or other socioeconomic factors that can influence food choice and behavior. These populations could benefit from a decrease in PFAS exposure, although the magnitude of that benefit is unknown at this time. We identified increased rates of fast food consumption for the following sub-populations:

- Food insecure children and youth (Chi et al., 2015; Widome et al., 2009).
- Obese adults, both generally and specifically among Hispanic/Latino adults (Anderson et al., 2011; Burgoine, et al., 2016; Fraser et al., 2012; Garcia, Sunil, & Hinojosa, 2012; McClain et al., 2018).
- Individuals working non-standard hours/schedules (Devine et al., 2009; Zagorsky & Smith, 2017).
- Individuals with increased levels of education (Hidaka et al., 2018; Paeratakul et al., 2003; Rydell et al., 2008).
- Racial and ethnic groups, including African American adolescents and pregnant or post-partum women, English-speaking Mexican Americans of higher socioeconomic status and educational levels, and young and employed Latino women (Arcan et al., 2009; Ayala et al., 2005; Harris et al., 2016; Langellier et al., 2015).
- Children and those of childbearing age (Fanning, Marsh, & Stiegert, 2010; Paeratakul et al., 2003).
- Individuals living, working, or attending a school in proximity to fast food outlets (Bernsdorf et al., 2017; Forsyth et al., 2012; Longacre et al., 2012; Simon et al., 2008).
- Neighborhoods that lack alternative options to fast food (predominantly impacting primarily African-American neighborhoods) (Hilmers, Hilmers, & Dave, 2012).

Direct research on food packaging chemical exposure and environmental justice issues is limited. This lack of data may not necessarily mean there is no issue, but instead could be indicative of groups who have been historically overlooked (Nelson & Brooks, 2016).

Exposure assessment methodology

Data needs for exposure assessment

We worked with stakeholders interested in sharing relevant exposure data for this assessment. In general, our data needs for characterizing exposure included:

1. Ingredient physical chemistry properties, substance identification, or details that support adequate estimation of physical-chemical properties using QSAR’s models.
2. Unpublished studies on disposal considerations or environmental fate pathways.
3. If additional evaluations are needed to address the remaining questions, information related to:
    a) Bio- or environmental monitoring.
    b) Manufacturing criteria.
    c) Lifecycle.

We also sought other available or relevant data that could inform the potential for exposure.

Tiered approach to comparative exposure assessment

The exposure assessment approach for this AA follows the IC2 AA Guide for a Level 1 Basic Comparative Exposure Assessment. This approach meets the U.S. National Academy of Sciences (NAS) "Path B" recommendations for comparative exposure assessment (NAS, 2014). Our approach also incorporates elements of both the EPA's The Sustainable Futures Interpretative Assistance Document for Assessment of Polymers (2013) (EPA, 2013; herein: SF Polymer Criteria) and the Health and Environmental Sciences Institute's (HESI) Sustainable Chemical Alternatives Technical Committee's qualitative comparative approach (herein: HESI Exposure Guidance) (Greggs W et al., 2019).

The IC2 AA Guide organizes the Basic Comparative Exposure Assessment into a series of questions to address and document. The questions assess readily available data to identify whether material differences exist between the comparator and potential alternatives.

If the properties and potential pathways are similar, additional evaluation is not necessary, and decision rules are applied. If there are material differences, then an additional evaluation will address questions related to biomonitoring data, manufacturing criteria, or lifecycle information. Figure 4 provides an illustration of this approach and how the decision rules are incorporated.

Figure 4. IC2 Basic Comparative Exposure Approach.

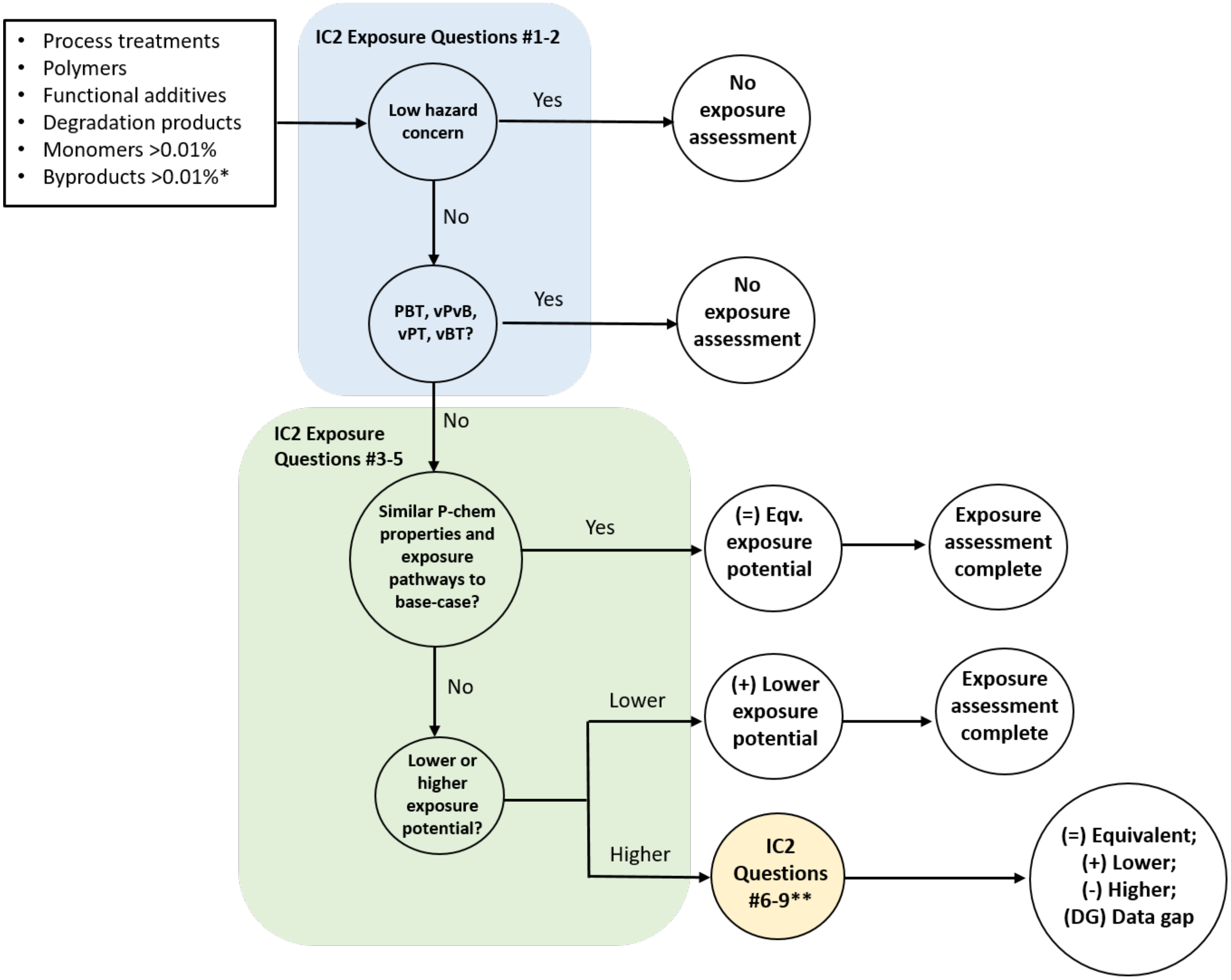


Figure notes:

- * Base materials consisting of paper, paperboard, and plant-based pulp are assumed to be of low concern and will not assessed under this approach.
- ** IC2 questions #6 – 9 incorporate biomonitoring studies, manufacturing criteria, and qualitative lifecycle information to determine if material differences between the comparator and alternative exist.
- Access an accessible text description of this graphic.[65]

[65] https://www.ezview.wa.gov/Portals/_1962/Documents/PFAS-Food/TextDescriptions_Figures_PFAS_FoodPackaging_AA.pdf

Evaluation of exposure concerns

Initial screening questions

Question 1: Has the alternative been evaluated for hazard and determined to be of low concern (e.g., GreenScreen® Benchmark-3 or -4)?

- The exposure assessment was applied to the candidate alternatives (process treatments only), polymers, functional additives, degradation products, and monomers and byproducts present at greater than 0.01% that were screened by the Level 2 Hazard Module and deemed to be of moderate concern.
- Substances that were concluded to be of low concern under the Tiered Approach to Hazard Assessment did not undergo a comparative exposure assessment.
- Base materials consisting of paper, paperboard, and plant-based pulp were assumed to be of low concern and were not assessed under this approach.

Question 2: Does the alternative have persistence, bioaccumulative, and/or toxic properties of concern?

- Highly persistent and/or highly bioaccumulative and/or toxic alternatives (vPvB, vPT, vBT, PBT) were removed from consideration and did not undergo exposure assessment.

Note: We did not need to evaluate any candidate alternative substances beyond Question 2. The remaining method was previously presented to stakeholders and is included here for context. Find the exposure assessment outcome in the determination of exposure assessment need based on identified hazard endpoints section.

Qualitative exposure assessment

Questions 3 – 5 represent a qualitative exposure assessment. Answers are recorded in an assessment template (IC2 AA Guide page 112). Generally, there are five parts in the template:

1. Compare physicochemical properties between the chemical of concern and alternative.
2. Consider other inherent chemical properties of the alternative relevant to exposure.
3. Compare human exposure pathways between the chemical of concern and alternative.
4. Compare ecological exposure pathways between the chemical of concern and alternative.
5. Has the alternative been found in bio or environmental monitoring studies? [If required]

Question 3: Are the chemical properties for the chemical of concern and alternative materially similar? Or do material differences exist?

- Pertinent properties will be assessed and evaluated using the endpoint criteria in the IC2 AA Guide, with some additional endpoints supplemented by the HESI Exposure Guidance,[66] summarized in Table 10 and Table 11 (Greggs W et al., 2019).

[66] https://setac.onlinelibrary.wiley.com/doi/full/10.1002/ieam.4070

Table 10. IC2 Level 1 related properties.

Property	Reason	Guidelines (NAS, 2014)
Volatility/ vapor pressure	Volatility/vapor pressure influence how likely the chemical is to be found in the air or how likely it is to enter the body.	$>10^{-8}$ mmHg (greater than 10^{-8} mmHg); considered likely to found in the air. $> 10^{-4}$ mmHg (greater than 10^{-4} mmHg); considered to be more likely to enter the body.
Molecular weight	Generally, as molecular weight and size increase, bioavailability decreases (leading to a lower toxicity potential).	>1000 amu (greater than 1000 amu) is less likely to be bioavailable
Solubility in water	Generally, a chemical that is highly soluble in water will have more bioavailability and toxicity. In addition, water soluble chemicals are more likely to be found in water bodies and precipitation.	<1 ppb (less than 1 ppb) generally have lower water solubility
Log K_{ow}	The log of the water-octanol coefficient (Log K_{ow}), is an indicator of potential for bioaccumulation, as well as bioavailability.	Less than 5 for mammals Less than 4 for aquatic species
Boiling point	The boiling point helps to determine if the chemical will be a liquid or gas at a certain temperature.	<25 C (less than 25 C) will be a gas at room temperature
Melting point	The melting point will determine if the chemical will be a solid or liquid at a certain temperature.	<25 C (less than 25 C) will be a liquid at room temperature
Density/ specific gravity	Has implications for where the chemical might partition when with other liquids or gases.	
pH	A measure of free hydrogen. Has implication for water solubility and potential damage to cells.	For certain products, a pH of greater than 2 and less than 11.5 is safest for eyes and skin (Safer Choice, 2015)
Corrosivity	Associated with the ability to gradually destroy materials by chemical reaction.	GHS criteria used to determine level of concern. Typically, the more extreme the pH (either high or low), the more likelihood of corrosivity issues whether it be to the eye, skin, respiratory system, etc. Typical pH values used are approximately below 3 and above 10. Review GHS criteria for more details.
Environmental partitioning	A measure of how easily molecules or salts will break apart in under certain conditions (primarily in solution).	The higher the constant (K_d), the more likely the molecules or salts will break apart.

Property	Reason	Guidelines (NAS, 2014)
Use characteristics (binding properties) or synergistic effects	Other properties that can help determine the state of the chemical in the environment and biological compartments or interactions with other chemicals found in the environment.	The acid dissociation constant (pKa) is used to help identify availability of chemicals to bind to one another. pKas of concern typically range between less than 3 (acid) and greater than 11 (bases). Synergistic effects identify how other chemicals may impact availability of the chemical of concern. For example, dimethyl sulfoxide (DMSO) easily enters skin. Chemicals dissolved in DMSO can be more biologically available than chemicals dissolved in other solvents.

Table 11. HESI Exposure related properties (Greggs et al., 2019).

Property	Reason	HESI Exposure Guidance
Particle size	Addresses inhalation exposure related to particulates.	Likely to penetrate the alveolar region <10 µm (less than 10 µm); Likely to enter the nose or mouth and penetrate the tracheo-alveolar region ≥10 and ≤100 µm (greater than or equal to 10 and less than or equal to 100 µm); Not likely to be inhaled >100 µm (greater than 100 µm) Inhalable fraction (in mg/kg) - Firm granules, flakes, or pellets: ≤100 (less than or equal to 100); Granules, flakes, or pellets: 100–500; Course dust: 501–2000; Fine dust: 2000–5000; Extremely fine and light powder: >5000 (greater than 5000)
Volatility (Henry's Law Constant)	Henry's Law Constant is used to estimate the potential to volatilize from water surfaces.	Very volatile from water: $>10^{-1}$ (greater than 10^{-1}); Volatile from water: 10^{-1} to 10^{-3}; Moderately volatile: 10^{-3} to 10^{-5}; Slightly volatile: 10^{-5} to 10^{-7}; Nonvolatile: $<10^{-7}$ (less than 10^{-7})
$LogK_{oc}$	Addresses the potential to migrate in soil which could lead to groundwater contamination.	Very strong sorption, negligible migration: greater than 4.5; Strong sorption, negligible to slow migration: 3.5 – 4.4; Moderate sorption, slow migration: 2.5 – 3.4; Low sorption, moderate migration: 1.5 – 2.4; Negligible sorption, rapid migration: less than 1.5
Bioaccumulation	Considers the potential for the target chemical to accumulate in organisms.	BCF/LogBCF or BAF/LogBAF: Very high: greater than 5000 (3.7); High: 5000 to 1000 (3.7 to 3); Moderate: 1000 to 100 (3 to 2); Low: less than 100 (2)
Persistence	Addresses the potential for the target chemical to persist in environmental media.	Half-life in days: Very high: greater than 180 (air: 2); High: 60 – 180; Moderate: 60 to 16; Low: less than 16 or pass ready biodegradability test not including the 10-d window; Very low: pass biodegradability test with 10-d window

Polymers with low molecular weight (MW less than 1000; SF Category 1) are expected to be bioavailable, and will be evaluated using the same methods and approaches as for discrete substances—including evaluating any experimental physical property data or reliable estimation methods (such as read across, QSAR models, etc.). The SF Polymer Criteria will be used to address the special considerations associated with evaluating polymers with high MW (MW greater than 1000; SF Category 2 & 3). Many of these substances are of variable composition and lack adequate data sets, making it difficult to evaluate their physicochemical properties. The SF Polymer Criteria summarizes various approaches for assessing physical/chemical properties.

In cases where the data set for an endpoint contains limited or conflicting data, a weight of evidence approach may be used. Endpoint characterizations based on weight of evidence will be supported by adequate justification.

Question 4: Compare exposure pathways between the chemical of concern and the alternative(s). (Are there material differences?)

- This question addresses the potential for ingestion, inhalation, and dermal exposures related to the use and disposal of the chemical of concern and the candidate alternatives.
- The comparison will encompass any relevant media and biota related to human and environmental exposures.

Comparative exposure decision rules

Question 5: Are there substantive differences between the chemical of concern and the possible alternatives that are likely to increase exposure concerns for the any of the alternatives?

- After populating the assessment template (IC2 AA Guide, page 112), the overall comparison of the proposed alternative to the chemical of concern will be conducted, and the decision rules in Table 12 will be applied.
- Rationale for the relevance parameters, the key parameters driving the conclusion, uncertainties, and data gaps will be written in a brief discussion.

Table 12. Decision Rules for IC2 comparative exposure assessment.

Exposure determination	Score*	Assessment complete?
The potential exposure is likely to be equivalent to the chemical of concern	= (equal)	Yes
The potential exposure of the alternative is likely to be lower than the chemical of concern	+ (plus)	Yes
The potential exposure of the alternative is likely to be higher than the chemical of concern	- (minus)	No, proceed to Question 6
Data Gap**	DG	Yes

Table notes:

- * = Based on the example template IC2 AA Guide page 112.

- ** = Only applied if initial comparison suggests higher exposure potential and there are insufficient data to address questions 6 – 9.

Questions 6 – 9 of the IC2 AA Guide will be addressed if initial comparison suggests the alternative has higher exposure potential. These questions aim to clarify and confirm whether a higher exposure concern is justified. Should the assessment proceed to this level, the IC2 Guidance will be followed exactly. All conclusions will be justified with adequate documentation.

- Question 6 requires the identification of any available bio- or environmental monitoring studies.
- Question 7 considers manufacturing criteria to evaluate exposure concern.
- Question 8 considers qualitative lifecycle aspects to evaluate exposure concern.
- Question 9 considers whether there are sufficient data to evaluate exposure or if exposure should be considered a critical data gap.

Comparative exposure outcomes will be generated for the process treatment or polymer (i.e., an active ingredient that is contributing oil and grease repellency to the product) as well as functional additives, degradation products, residual monomers >0.01%(greater than 0.01%), and byproducts >0.01% (greater than 0.01%).

- = (equals) represents equivalent exposure potential
- + (plus) represents lower exposure potential
- – (minus) represents higher exposure potential

Determination of exposure assessment need based on identified hazard endpoints

1. Has the alternative been evaluated for hazard and determined to be of low concern (e.g., EPA SCIL Green Circle, GreenScreen® Benchmark-3 or -4)?

Uncoated (mechanically treated paper), petroleum-based wax, bio-based wax, kaolin clay, PVOH, PLA (through analysis of the lactide monomer), and siloxanes (represented by Vinyl dimethylsiloxy-terminated polydimethylsiloxane) were evaluated for hazard (see Section 4). All substances, except for Vinyl dimethylsiloxy-terminated polydimethylsiloxane, were determined to be of low concern. According to the IC2 AA Guide, further exposure assessment for these substances is not required.

For the unevaluated alternative candidates that we determined there was insufficient data to analyze potential hazards, we did not apply the exposure methodology (specifically PE, PET, and EVOH copolymers). This is for two reasons. First, the same data limitations that prevent a complete hazard evaluation also complicate an exposure assessment. Second, even if one of these alternative substances had a lower exposure concern than the comparator, we would not find it to be a safer alternative because we could not assess it in the Hazard Module. See Section 8 for more details on the simultaneous analysis of alternatives.

2. Does the alternative have persistence, bioaccumulative, and/or toxic properties of concern?

Vinyl dimethylsiloxy-terminated polydimethylsiloxane was determined to be a Benchmark-1 ("Avoid chemical of high concern") due to very high persistence and very high bioaccumulation potential (see Section 4). According to the IC2 AA Guide, this substance should be removed from consideration and does not require an exposure assessment.

Table 13. Summary of the exposure assessment determinations for comparator and related substances based on hazard concern.

Substance name	CASRN	Hazard concern	Exposure assessment
Copolymer of perfluorohexylethyl methacrylate, 2-N,N-diethylaminoethyl methacrylate, 2-hydroxyethyl methacrylate, and 2,2'-ethylenedioxydiethyl dimethacrylate, acetic acid salt	863408-20-2	Insufficient information was available to evaluate these substances using GreenScreen®	Insufficient data
6:2 FTOH [1]	647-42-7	Benchmark-1: Avoid – Chemical of High Concern	Very high persistence, very high systemic toxicity
PFHxA [2]	307-24-4	Benchmark-1: Avoid – Chemical of High Concern	Very high persistence, very high skin/eye irritation

Table notes:

1. Impurity associated with the chemical of concern.
2. Degradation product of the chemical of concern.

Table 14. Summary of the exposure assessment determinations for alternative substances based on hazard concern.

Substance name	CASRN	Hazard concern	Exposure assessment
Uncoated paper	65996-61-4	Non-chemical alternative and U.S. EPA Safer Chemical – low concern	Low hazard concern—no exposure assessment required
Waxes (petroleum- or bio-based)	(Petroleum-based) 64742-43-4; 64742-51-4 (Bio-based) 8001-22-7; 67784-80-9; 8012-89-3; 8015-86-9	U.S. EPA Safer Chemical – low concern	Low hazard concern—no exposure assessment required
Kaolin clay	1332-58-7	U.S. EPA Safer Chemical – low concern	Low hazard concern—no exposure assessment required
PVOH	9002-89-5 (fully hydrolyzed), 25213-24-5 (partially hydrolyzed)	U.S. EPA Safer Chemical – low concern	Low hazard concern—no exposure assessment required
Siloxanes*	68083-19-2	Benchmark-1: Avoid – Chemical of High Concern	Very high persistence, very high bioaccumulation—not considered for exposure differences
PLA**	9051-89-2	Likely consistent with Benchmark-3: Use but Still Opportunity for Improvement	Low hazard concern (based on degradation products)—no exposure assessment required
PE	9002-88-4	Insufficient information was available to evaluate this substance using GreenScreen®	Insufficient data
PET	25038-59-9	Insufficient information was available to evaluate this substance using GreenScreen®	Insufficient data
EVOH copolymers	26221-27-2***	Insufficient information was available to evaluate this substance using GreenScreen®	Insufficient data

Table notes:

- * Based on representative siloxane substance vinyl dimethylsiloxy-terminated polydimethylsiloxane (CASRN 68083-19-2).
- ** Based on GreenScreen® for the precursor lactide (CASRN 4511-42-6; 615-95-2).
- *** Based FDA FCN 1179.

Section 6. Performance Evaluation Module

Overview

We conducted an IC2 Level 1 Performance Evaluation Module to determine whether the prioritized alternatives "perform as well as or better than PFAS chemicals in a specific food packaging application" according to RCW 70A.222.070.[67] In this section, we evaluated PFAS and alternatives to PFAS on both the product and on the chemical/material level (see the Introduction for brief definitions).

For the purposes of this assessment, assessing performance primarily at the product level means we will evaluate an alternative chemical multiple times—once for each food packaging application it is used in. A list of products was compiled for each food packaging category and associated candidate alternative substance to support the assessment (see Appendix I to Appendix K). We then evaluated promotional material for each product to determine whether it met the performance requirements of oil and grease resistance (OGR) and leak resistance, defined as:

- **OGR:** Ability of a product to resist the permeation of grease through a substrate as evidenced by a reduction or lack of spotting, staining, or spreading.
- **Leak resistance:** Ability of a product to resist grease or other fluid by either reduced permeation **and** transfer through the substrate, or the ability to resist leaks through folds or seals (e.g., in folded paperboard products).

Some alternative products could not be assessed because promotional materials were inconclusive. Although not all products identified OGR or leak resistance in their promotional materials, many products did. For each candidate alternative substance, we found either promotional data or expert input identifying the alternative as having OGR and leak resistance.

Choice of IC2 AA Guide level

The IC2 AA Guide describes three levels for the Performance Evaluation Module:

- **Level 1 Basic Performance Evaluation**: Identifies a few basic questions about whether the alternative performs the required function in the product. This level uses qualitative information readily available from manufacturers and other sources to evaluate alternatives.
- **Level 2 Extended Performance Evaluation**: Builds upon the information obtained in Level 1 to determine whether the alternative performs the required function in the product. It uses quantitative information from existing data reviewed by technical experts in the field to evaluate alternatives.

[67] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.222.070

- **Level 3 Detailed Performance Evaluation:** Expands upon the previous levels. It uses quantitative information to evaluate alternatives based upon results of specified tests reviewed and validated by technical experts.

Ecology chose a Level 1 performance evaluation. We determined that a qualitative assessment of product performance would be sufficient to meet the additional criteria from RCW 70A.222.070[68] requiring that the alternatives "perform as well as or better than PFAS chemicals in a specific food packaging application." Level 2 requires performance verification via third-party laboratory testing, which we determined was beyond the scope of this AA.

Performance assessment methodology

Identifying performance requirements

Based on the IC2 AA Guide, we assessed product performance requirements by answering several questions regarding performance requirements. The Level 1 performance assessment asks **"**What are the performance requirements at the chemical level? At the material level? At the product level? At the process level?"

PFAS are added to paper- and fiber-based food packaging to add oil, grease, and moisture resistance properties to the paper substrate. Therefore, at the chemical- or material-level, the chemical alternatives must also perform this function. All of the ten food packaging applications can be made using multiple alternative substances (see Table 4 for details). The alternative products rely on alternative substances to meet chemical/material-level performance requirements.

Based on the available technical information and our discussions with stakeholders, alternative substances need to perform at least one of three functions:

1. Create a surface barrier on the substrate (i.e., fiber) that can resist oil, grease, and moisture.
    - Applied as a coating or extruded layer to the surface of the substrate (Trier et al., 2017).
2. Act as an internal sizing agent to decrease the spaces between the substrate fibers and decrease permeability.
    - This is often achieved via wet-end processes where the chemical is added directly to the pulp before molding and drying (Trier et al., 2017).
3. Create a foam, plastic, or metal solid substrate or material that is impermeable to oil, grease, and moisture.

Alternatives such as uncoated, mechanically treated paper or reusable plastic-, ceramic- or metal-ware are expected to meet these material performance requirements without the addition of chemicals. The table below summarizes which of the three functions each alternative is capable of performing.

[68] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.222.070

Table 15. Summary of functions that can be performed by each chemical alternative to PFAS.

Chemical alternative	Creates surface barrier (Trier et al., 2017)	Acts as a sizing agent (Trier et al., 2017)	Creates foam, plastic, metal solid
Silicone/siloxane	Yes	Yes	No
Polyvinyl alcohol (PVOH)	Yes	Yes	Yes*
Polylactide (PLA)	Yes	Yes	Yes
Polyethylene (PE)	Yes	Yes	Yes*
Polyethylene terephthalate (PET)	Yes	Yes	Yes*
Petroleum wax	Yes	No	No
Bio-based wax	Yes	No	No
Kaolin clay	Yes	No	No

Table notes:

- * Single-use plastics made of PVOH, PE, and PET were determined to be outside the scope of this assessment. See Ecology's scoping paper[69] for further details.

Performance requirements at the product level

In this AA, we only considered general performance attributes that are relevant to holding and serving freshly prepared food (see Consideration of customized products). At the product level, we addressed two main product performance requirements:

1. **OGR**
    A. Ability of a product to resist the permeation of grease through a substrate as evidenced by a reduction or lack of spotting, staining, or spreading.
2. **Leak/spill resistance**
    A. Ability of a product to resist grease or other fluid by either reduced permeation **and** transfer through the substrate, or the ability to resist leaks through folds or seals (e.g., folded paperboard products).
    B. Leak/spill resistance was only required for:
        i. Wraps (but not liners).
        ii. Sleeves (but not bags).
        iii. Bowls.
        iv. Clamshells.
        v. Interlocking folded containers.

Stakeholders communicated that OGR and leak resistance are the most important properties for selecting food packaging (Appendix G). This is consistent with the Food Packaging Institute's 2019 U.S. Consumer Survey results, which reported that "stopping oil and grease stains" and "leak/spill proofing" are the most important single-use item attributes (FPI, 2019a). These results were based on 800 respondents approximately split between the U.S. and Canada,

[69] https://www.ezview.wa.gov/Portals/_1962/Documents/PFAS-Food/Ecology%20PFAS%20Product%20and%20Alternatives%20Scoping%20Paper%2002-24-2020.docx

ranging in a balance of age (18 – 60 plus), income, education level, gender, and region (FPI, 2019b). This is also consistent with other studies of PFAS in food packaging, which acknowledge that the primary function of PFAS is to improve oil, grease, and moisture resistance (CalEPA, 2020, Nestler et al., 2018, OECD, 2020, Trier et al., 2017).

Assessing many performance parameters will over-complicate the assessment and may not result in an accurate reflection of the current food packaging market. Although other performance attributes such as printability, keeping foods hot and crispy (relating to insulation and vapor transmission), and heat resistance are commonly highlighted in marketing materials, these will not be considered in this performance evaluation.

First, these performance attributes are not specific to PFAS. Insulation, for example, is primarily a performance requirement of the substrate, rather than the coating material. Second, if the performance attribute is specific to PFAS and is not OGR or leak resistance, then it may be an instance where food must be held or served under highly specialized circumstances or in special environments, such as extreme temperatures, requiring a customized product.

During the April 14, 2020 webinar, a case study presented a burrito wrap for a fast food chain that could be placed directly on the grill for cooking. This would constitute a highly specialized circumstance. Other related performance requirements were not included in the general performance requirements used in this AA (Specialty Packaging Inc., 2020).

Separate from the scope of the AA, many businesses and organizations consider environmental attributes such as compostability, recyclability, and recycled content. Some stakeholders believe that these environmental characteristics fall under the umbrella of performance parameters. Stakeholders brought up incorporating these attributes into the performance assessment regularly during webinars. While these are important selection parameters that can help identify environmentally sustainable products, we did not incorporate them in the performance assessment, because they do not directly impact holding and serving freshly prepared food.

Addressing PFAS performance and over-engineering

Due to their molecular structure, which contains highly stable carbon-fluorine bonds, PFAS are very effective as oil, grease, and moisture resistance agents. Several stakeholders have mentioned throughout this process that products containing PFAS can provide OGR properties that exceed what is necessary to meet the performance requirements identified above, and that PFAS use in these products set an unnecessarily high standard for performance. We therefore collected promotional materials and input from end users to evaluate alternative products, rather than performance tests. These data helped us to identify when alternative products met general performance requirements as well as PFAS-containing products and when they did not.

Method to assess product performance

To apply the performance assessment methodology, we compiled a set of PFAS-free alternative products and their promotional materials (see Appendix I, Appendix J, and Appendix K). Per IC2 Level 1 Performance Evaluation Module guidance, we evaluated promotional materials to confirm that these products meet product-level performance requirements (OGR and leak resistance).

We identified the products from:

- Product websites and catalogs of active stakeholders.
- Products identified by stakeholders as PFAS-free.
- Products verified by the Center for Environmental Health as being "No/Low F" (considered to have no added PFAS) (CEH, 2020).
- Products that are certified compostable by Biodegradable Products Institute (BPI), Cedar Grove, or Compost Manufacturer's Alliance (CMA),[70] and thus have certified a total fluorinated chemical content of 100 ppm or less (BPI, 2018; BPI, 2019; CMA, 2020b).

An in-depth technical review of performance is outside the scope of this assessment. The intention is to identify any **gaps in performance**—where alternative products do not perform as well as PFAS-containing products. For each alternative, we evaluated the product-level performance requirements using questions from the IC2 AA Guide for a Level 1 Performance Evaluation Module.

These questions are paraphrased from the IC2 AA Guide:

A. Is the alternative being used for same or similar function?
B. Is the alternative available on the commercial market?
C. Do promotional materials for the alternative state it provides the desired function?
D. Based on A, B, and C is this a favorable alternative? [If yes, the assessment is complete, and the product is determined to be favorable.]
E. Has an authoritative body demonstrated the alternative functions adequately?
F. Are there indications that the alternative does not perform as well?
G. Has an expert identified the alternative as unfavorable for performance?

These questions were answered in order on a yes or no basis, based on qualitative descriptions and promotional materials. Using the IC2 AA Guide, the performance evaluation is complete if the answer to the first three questions (A, B, and C) is favorable. However, if there is an

[70] On January 1, 2020, CMA implemented a PFAS standard for all certified products. Ecology identified the following certified products in the CMA database following this change. However, as of the final technical review of this publication, CMA has not confirmed the presence or absence of PFAS by the following manufacturers:

- Southern Champion Tray (all products).
- Fisher Paper Products (all products).
- Seaman Paper Company (all products).
- AJM Packaging Corporation (bags and sleeves).

indication that these products do not perform as well, then the assessment continues with questions E through G.

Question E refers to an authoritative body that has demonstrated that the alternative functions adequately. An authoritative body that meets the IC2 definition was not identified for the food packaging industry. Therefore, the answer to this question for any product would be “no” or not applicable. If applicable, the assessment will include publicly available data or information about performance (Question F).

Question G refers to “expert sources” identifying this product as unfavorable. For the purposes of this assessment, expert sources who can determine whether a product functions as required are the producers who **make that specific product** (not producers of competing products) and end users who have used the product.

For the purposes of this assessment, we define end users as businesses, individuals, or entities that purchase or use food packaging for their intended use. This can include consumers, retailers, grocers providing prepared foods, cafes, restaurants (quick-service, fast-casual, and dine-in), cafeterias, government agencies, and others.

Qualitative data used to assess performance

To answer Question C, we looked for supportive language in promotional materials. Supportive language for OGR included phrases such as:

- Greaseproof.
- Oil and/or grease resistance.
- References to Kit Test levels or penetration rates.
- Described as “non-stick.”

Supportive language for leak resistance included phrases such as:

- Moisture resistance.
- Leak resistance.
- References to wet strength.
- Products advertised as soup bowls or soup cups.

Appendices I, J, and K include the sample inventory of products and the associated promotional language for each alternative and food packaging category. We used this information to inform the evaluation of the alternative’s performance in this assessment. Find a summary in the following tables.

Performance assessment results

Table 16 through Table 25 summarize the performance results identified for each alternative product type. For a given food packaging application, we evaluated each candidate alternative product type using the seven questions and promotional information (identified in Appendix I to Appendix K).

We used this evaluation to determine whether each candidate alternative product has favorable performance, unfavorable performance, or whether there was not enough data to evaluate performance. **As needed, additional information is provided below the table.**

The analysis is qualitative in nature and uses readily available sources of information. Some products in this evaluation did not include supportive language for OGR or leak resistance in their promotional materials. This does not mean the products do not meet performance requirements. It may indicate the company has not promoted these performance attributes in their promotional materials. Food packaging purchasers commonly receive product samples and conduct their own performance tests, so manufacturers may not need to publicize product performance test results.

Promotional information could not be obtained for all alternative products. In a number of cases, we could not positively identify the alternative products as PFAS-free. These products were not included in the sample product inventories. A number of other products were known PFAS-free products, but we could not confirm the identity of the coating or additive with the manufacturer. In some cases, these products were likely PE- or PET-coated paper, but we could only confirm poly-coated in general. These products were included in Appendices I, J, and K. Although these cannot be used to confirm that specific alternative substances meet the performance requirements of this assessment, these products are available on the market and are marketed for OGR and leak resistance.

Performance evaluations using chemical/material-level information

We sometimes extracted performance-related information from promotional materials related to the alternative technology, rather than the specific product:

- Appendices J and K compile promotional materials for PLA plastic products, but the associated promotional materials for these products did not specify OGR or leak resistance. This is because the base material is a compostable plastic without the permeability concerns of paper-based products, so OGR and leak resistance are assumed for all undamaged PLA plastic.
- Some PLA-lined paper products advertise that they specifically use Natureworks Ingeo® PLA technology but don't specify OGR or leak resistance. In these cases, we used promotional material for Ingeo® to help evaluate performance (Natureworks, 2009). When possible, we asked the manufacturer to confirm they only used Natureworks Ingeo® PLA for their products.
- PVOH- and EVOH-coated products are often grouped under the umbrella term "poly-coated." Kuraray, a PVOH and EVOH copolymer manufacturer, confirmed that their coatings are available for purchase, meet FDA compliance, and are currently used

across all food packaging categories. Therefore, we used promotional materials for PVOH and EVOH coatings and coated paper and paperboard to support the evaluation of PVOH and EVOH alternative products.

Performance evaluations using product-level information

Notes for Table 16 through Table 25:

- + = There is evidence that the alternative product meets the performance attributes.
- n/a = Not applicable.
- N = No.
- Y = Yes.
- No data = Insufficient data to evaluate performance.

Category 1: Food contact paper

Figure 5. An example of a wrap, a type of food contact paper designed to wrap food for food service or for consumption without utensils.

Figure 6. An example of a liner, a type of food contact paper designed to line other serviceware and provide an additional barrier protection against food.

Table 16. Oil and grease resistance and leak resistance performance assessment results for alternative wraps & liners.

Performance assessment question	Wax coated	Siloxane	PVOH coated	EVOH coated	Uncoated
Being used for a similar function?	+	+	+	+	+
Available on the commercial market?	+	+	+	+	+
Promotional materials state this provides the desired function?	+	+	+	+	+
Based on A, B, and C, is this a favorable alternative? (If yes, the assessment is complete, and the product is determined to be favorable.)	+	+	+	+	+
Has an authoritative body demonstrated the alternative functions adequately?	n/a	n/a	n/a	n/a	n/a
Are there indications that the alternative does not perform as well?	n/a	n/a	n/a	n/a	n/a
Has an expert identified the alternative as unfavorable for performance?	n/a	n/a	n/a	n/a	n/a
Is the performance favorable?	Y	Y	Y	Y	Y

Figure 7. An example of a bag, a type of food contact paper with a flat bottom, designed to transport food from a foodservice establishment.

Figure 8. An example of a sleeve, a type of food contact paper with a sealed bottom that can hold food for foodservice or transport food from a foodservice establishment.

Table 17. Oil and grease resistance and leak resistance performance assessment results for alternative bags & sleeves.

Performance assessment question	Wax coated	Siloxane	PVOH coated	EVOH coated	Uncoated
Being used for a similar function?	+	No data	+	+	+
Available on the commercial market?	+	No data	+	+	+
Promotional materials state this provides the desired function?	+	No data	+	+	+

Performance assessment question	Wax coated	Siloxane	PVOH coated	EVOH coated	Uncoated
Based on A, B, and C, is this a favorable alternative? (If yes, the assessment is complete, and the product is determined to be favorable.)	+	No data	+	+	+
Has an authoritative body demonstrated the alternative functions adequately?	n/a	No data	n/a	n/a	n/a
Are there indications that the alternative does not perform as well?	n/a	No data	n/a	n/a	n/a
Has an expert identified the alternative as unfavorable for performance?	n/a	No data	n/a	n/a	n/a
Is the performance favorable?	Y	Y	Y	Y	Y

No bag or sleeve products containing siloxane coatings were located at the time of this assessment. However, we identified several siloxane-coated wraps, and this treated paper can easily be developed into bags or sleeves. Therefore, siloxane bags and sleeves were assumed to have favorable performance based on the data available for wraps and liners.

Category 2: Dinnerware

Figure 9. An example of a plate, a type of dinnerware or flat serviceware used for serving or holding food items during food service.

Table 18. Oil and grease resistance and leak resistance performance assessment results for alternative plates.

Performance assessment question	PLA foam	PLA plastic	Uncoated	Poly coated	Clay coated	PVOH coated	EVOH coated
Being used for a similar function?	+	+	+	+	+	+	+
Available on the commercial market?	+	+	+	+	+	+	+
Promotional materials state this provides the desired function?	+	+	N	+	+	+	+
Based on A, B, and C, is this a favorable alternative? (If yes, the assessment is complete, and the product is determined to be favorable.)	+	+	N	+	+	+	+
Has an authoritative body demonstrated the alternative functions adequately?	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Are there indications that the alternative does not perform as well?	n/a	n/a	no data	n/a	n/a	n/a	n/a
Has an expert identified the alternative as unfavorable for performance?	n/a	n/a	no data	n/a	n/a	n/a	n/a
Is the performance favorable?	Y	Y	No data	Y	Y	Y	Y

We also collected promotional information supporting OGR and leak resistance for PFAS-free molded fiber plates. Since the chemical used to provide this resistance was unknown, we did not include it in this table. Molded fiber is discussed in more detail at the end of the results.

Figure 10. An example of a bowl, a type of dinnerware with a wide opening and a bottom that allows spooning of food.

Table 19. Oil and grease resistance and leak resistance performance assessment results for alternative bowls.

Performance assessment question	PLA foam	PLA coated	Poly-coated	Clay coated	PVOH coated	EVOH coated
Being used for a similar function?	+	+	+	+	+	+
Available on the commercial market?	+	+	+	+	+	+
Promotional materials state this provides the desired function?	+	+	+	+	+	+
Based on A, B, and C, is this a favorable alternative? (If yes, the assessment is complete, and the product is determined to be favorable.)	+	+	+	+	+	+
Has an authoritative body demonstrated the alternative functions adequately?	n/a	n/a	n/a	n/a	n/a	n/a
Are there indications that the alternative does not perform as well?	n/a	n/a	n/a	n/a	n/a	n/a
Has an expert identified the alternative as unfavorable for performance?	n/a	n/a	n/a	n/a	n/a	n/a
Is the performance favorable?	Y	Y	Y	Y	Y	Y

We also collected promotional information supporting OGR and leak resistance for PFAS-free molded fiber bowls. Since the chemical used to provide this resistance was unknown, we did not include it in this table. Molded fiber is discussed in more detail at the end of the results.

Figure 11. An example of a tray, a type of dinnerware or flat serviceware that is typically larger than a plate and may include one large surface (like below) or multiple compartments.

Table 20. Oil and grease resistance and leak resistance performance assessment results for alternative trays.

Performance assessment question	PLA foam	PLA plastic	PLA coated	Poly coated	Clay coated (OGR only)	PVOH coated	EVOH coated
Being used for a similar function?	+	+	+	+	+	+	+
Available on the commercial market?	+	+	+	+	+	+	+
Promotional materials state this provides the desired function?	+	+	+	+	+	+	+
Based on A, B, and C, is this a favorable alternative? (If yes, the assessment is complete, and the product is determined to be favorable.)	+	+	+	+	+	+	+
Has an authoritative body demonstrated the alternative functions adequately?	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Are there indications that the alternative does not perform as well?	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Has an expert identified the alternative as unfavorable for performance?	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Is the performance favorable?	Y	Y	Y	Y	Y	Y	Y

We identified supportive language for clay-coated trays for OGR but not for leak resistance. However, trays are not required to have leak resistance to have favorable performance.

We also collected promotional information supporting OGR and leak resistance for PFAS-free molded fiber trays. Since the chemical used to provide this resistance was unknown, we did not include it in this table. Molded fiber is discussed in more detail at the end of the results.

Figure 12. An example of a boat, a type of dinnerware tray with tall, lipped edges and no compartments.

Table 21. Oil and grease resistance and leak resistance performance assessment results for alternative food boats.

Performance assessment question	Poly coated	Clay coated (OGR only)	PVOH coated	EVOH coated
Being used for a similar function?	+	+	+	+
Available on the commercial market?	+	+	+	+
Promotional materials state this provides the desired function?	+	+	+	+
Based on A, B, and C, is this a favorable alternative? (If yes, the assessment is complete, and the product is determined to be favorable.)	+	+	+	+
Has an authoritative body demonstrated the alternative functions adequately?	n/a	n/a	n/a	n/a
Are there indications that the alternative does not perform as well?	n/a	n/a	n/a	n/a
Has an expert identified the alternative as unfavorable for performance?	n/a	n/a	n/a	n/a
Is the performance favorable?	Y	Y	Y	Y

We identified supportive language for clay-coated food boats for OGR but not for leak resistance. However, food boats are not required to have leak resistance to have favorable performance.

Category 3: Take-out containers

Figure 13. An example of a pizza box, a type of take-out container, typically a folded box made from corrugated paperboard, used for serving, holding, or transporting different sizes of pizza or pizza slices.

Table 22. Oil and grease resistance and leak resistance performance assessment results for alternative pizza boxes.

Performance assessment question	Uncoated	Clay coated	PVOH coated	EVOH coated
Being used for a similar function?	+	+	+	+
Available on the commercial market?	+	+	+	+
Promotional materials state this provides the desired function?	+	N	+	+
Based on A, B, and C, is this a favorable alternative? (If yes, the assessment is complete, and the product is determined to be favorable.)	+	N	+	+
Has an authoritative body demonstrated the alternative functions adequately?	n/a	n/a	n/a	n/a
Are there indications that the alternative does not perform as well?	n/a	No data	n/a	n/a
Has an expert identified the alternative as unfavorable for performance?	n/a	No data	n/a	n/a
Is the performance favorable?	Y	No data	Y	Y

Figure 14. An example of a French fry carton, a type of take-out container with an angular bottom used in quick-service establishments typically to serve, hold, or transport fried foods.

Table 23. Oil and grease resistance and leak resistance performance assessment results for alternative French fry cartons.

Performance assessment question	PLA coated	Clay coated	PVOH coated	EVOH coated
Being used for a similar function?	+	+	+	+
Available on the commercial market?	+	+	+	+
Promotional materials state this provides the desired function?	+	N	+	+
Based on A, B, and C, is this a favorable alternative? (If yes, the assessment is complete, and the product is determined to be favorable.)	+	N	+	+
Has an authoritative body demonstrated the alternative functions adequately?	n/a	n/a	n/a	n/a
Are there indications that the alternative does not perform as well?	n/a	No data	n/a	n/a
Has an expert identified the alternative as unfavorable for performance?	n/a	No data	n/a	n/a
Is the performance favorable?	Y	No data	Y	Y

Figure 15. An example of a clamshell, a type of take-out container that is self-closing and hinged, used to serve, hold, or transport food.

Table 24. Oil and grease resistance and leak resistance performance assessment results for alternative clamshells.

Performance assessment question	PLA foam	PLA plastic	PLA coated	Uncoated (OGR only)	Poly coated	PVOH coated	EVOH coated
Being used for a similar function?	+	+	+	+	+	+	+
Available on the commercial market?	+	+	+	+	+	+	+
Promotional materials state this provides the desired function?	+	+	+	+	+	+	+
Based on A, B, and C, is this a favorable alternative? (If yes, the assessment is complete, and the product is determined to be favorable.)	+	+	N	+	+	+	+
Has an authoritative body demonstrated the alternative functions adequately?	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Are there indications that the alternative does not perform as well?	n/a	n/a	+	n/a	n/a	n/a	n/a
Has an expert identified the alternative as unfavorable for performance?	n/a	n/a	N	n/a	n/a	n/a	n/a
Is the performance favorable?	Y	Y	Y	Y (OGR only)	Y	Y	Y

We identified supportive language for uncoated clamshells for OGR but not leak resistance. Since it is necessary for clamshells to have leak resistance, there is not enough information to say that uncoated paper clamshells perform as well as clamshells that contain PFAS.

We used PLA-coated molded fiber clamshells to evaluate PLA-lined performance. We also collected promotional information supportive of OGR and leak resistance for PFAS-free molded fiber clamshells. Since the chemical used to provide this resistance to other molded fiber clamshells was unknown, we did not include it in this table. The performance of molded fiber is discussed in more detail at the end of the results.

Figure 16. An example of an interlocking food container, a type of take-out container with interlocking top flaps that make a lid—used for serving, holding, and transporting food during foodservice.

Table 25. Oil and grease resistance and leak resistance performance assessment results for alternative interlocking folded containers.

Performance assessment question	PLA coated	Poly coated	PE coated	Clay coated	PVOH coated	EVOH coated
Being used for a similar function?	+	+	+	+	+	+
Available on the commercial market?	+	+	+	+	+	+
Promotional materials state this provides the desired function?	+	+	No data	+	+	+
Based on A, B, and C, is this a favorable alternative? (If yes, the assessment is complete, and the product is determined to be favorable.)	+	+	No data	+	+	+
Has an authoritative body demonstrated the alternative functions adequately?	n/a	n/a	n/a	n/a	n/a	n/a
Are there indications that the alternative does not perform as well?	n/a	n/a	No data	n/a	n/a	n/a
Has an expert identified the alternative as unfavorable for performance?	n/a	n/a	No data	n/a	n/a	n/a
Is the performance favorable?	Y	Y	N	Y	Y	Y

We identified PE-coated interlocking folded containers separately from poly-coated products. They are included here in a separate column.

Performance evaluation uncertainties for specific alternative products

During our evaluation of alternative product performance, we identified two alternative substances that may not be able to meet the performance requirements stakeholders identified (holding and serving freshly prepared food in certain circumstances):

- PLA plastics are not suitable for high heat applications (105°F/40°C) due to their low melting point (VegWare, 2018). However, PLA plastics are still marketed and used in many foodservice applications, particularly for cold food applications. Therefore, we still considered PLA plastics favorable alternatives.
- Some dinnerware and take-out containers that use PFAS-free molded fiber as a base material may not perform as well under high heat and very oily conditions. Promotional material for WorldCentric's No Added PFAS Molded Fiber products (PLA-coated molded fiber) emphasizes that the products are grease resistant, rather than greaseproof (WorldCentric, n.d.). Relatedly, information for EcoProducts' Vanguard line of PFAS-free molded fiber products (unknown chemical additive) notes that these products are less grease resistant than PFAS-containing products in terms of days of prolonged exposure. However, initial trials with their partners have indicated that these products meet the needs of their customers (EcoProducts, 2020b). Furthermore, Footprint, which manufactures a line of PFAS-free molded fiber products (unknown chemical additive) and advertises that they can customize their products to be "oil and water leakproof." Expert users we identified in this assessment confirmed that these products meet at least some performance expectations compared to PFAS-containing products. It is worth noting that we were unable to identify the chemicals used to provide OGR in time to conduct a hazard evaluation. Therefore, with the exception of PLA-coated products, these products do not meet the criteria for safer alternatives at this time.

Section 7. Cost and Availability Module

Overview

To assess PFAS-free alternatives, Ecology conducted a Level 1 Basic Cost and Availability Module based on the IC2 AA Guide. RCW 70A.222.070[71] directs Ecology to perform an AA using IC2 guidance, and requires that the safer alternative is "readily available in sufficient quantity at a comparable cost." To assess cost and availability, we evaluated PFAS and alternatives to PFAS on the product-level (see the Introduction for a brief definition).

Ecology did not purchase or analyze products for this assessment. Instead, in this module, we used the data sources below to identify products that contained either PFAS or one of the alternative substances identified in Section 3:

- Industry, NGO, and government reports.
- Product databases (if they included product testing information about total fluorinated chemical content or the presence of specific PFAS).
- Product certifications.
- State or organization product purchasing lists.
- Case studies.
- Input from manufacturers, distributors, and stakeholders.

First, we used product testing studies and manufacturing information to determine whether specific PFAS-free alternative products are available. We also identified consumer pressures within the U.S. that could influence future availability. Second, we collected and compared unit prices for products containing PFAS with similar products using PFAS-free alternatives. We then used the results from the availability determination and cost comparison to determine which alternative products meet our criteria for cost and availability.

Ecology found PFAS-free food packaging alternatives for sale in all three food packaging categories. Within a food packaging category (food contact paper, dinnerware, and take-out containers), cost comparability and availability depend on both the specific food packaging application and the alternative substance. Although information was limited (see the Introduction for details on challenges), there is reasonable certainty that the data collected are sufficient to make determinations for both the cost and availability of some PFAS-free alternatives at this time.

This module considers the availability and cost of reusable alternatives for dinnerware or take-out containers. Identifying chemical hazards and potential routes of exposure for reusable serviceware was outside the assessment scope. However, reusable serviceware is a viable alternative to PFAS-containing food packaging for some end users.

[71] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.222

Choice of IC2 AA Guide level

The IC2 AA Guide describes four levels for the Cost and Availability Module:

- **Level 1 Basic Cost and Availability Evaluation**: This evaluation asks a few basic questions about whether the alternative is being used in cost-competitive products.
- **Level 2 Extended Basic Cost and Availability Evaluation**: This evaluation builds on the information obtained in Level 1 to determine if the alternative is both available and cost effective. This evaluation goes beyond whether or not the alternative is currently being used to determine if it could be available and cost effective if selected.
- **Level 3 Chemical and Material Cost and Availability Evaluation**: This evaluation expands on the previous level to include not only the cost and availability of the chemical, but also the material in which it will be used. It also introduces lifecycle costing (LCC), and requires an initial review of possible impacts due to LCC.
- **Level 4 Chemical, Material and Re-designed Cost and Availability Evaluation**: This level adds requirements to assess costs and benefits associated with product redesign to accommodate the use of an alternative. The focus is on private costs and benefits. It also includes a more detailed LCC evaluation.

RCW 70A.222.070[72] directs Ecology to perform a PFAS AA using IC2 guidance and also requires that the safer alternative is "readily available in sufficient quantity at a comparable cost." After reviewing the data needs and guiding questions for each level, we determined that that the data requirements and methods for a Level 2 cost and availability evaluation (such as forecasting product or alternative price changes or sourcing suppliers) went beyond the purpose of this AA.

We decided to tailor a Level 1 Cost and Availability Module to meet our directive. A Level 1 assessment asks three questions:

1. Is the alternative currently used in the application of interest?
2. Is the alternative currently offered for sale for the application of interest?
3. Is the price of the alternative close to the current?

We augmented question two to consider whether an alternative is "readily available in sufficient quantity," discussed further in the following section.

[72] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.222

Availability of PFAS and PFAS-free alternatives in the applications of interest

The alternatives we evaluated in this assessment are already sold within the food packaging market (see Section 3). While collecting data for this module, we confirmed that these alternative products were offered for sale in product purchasing lists or online—although it was not possible to confirm all alternative products were PFAS-free.

In addition to confirming these alternative products are offered for sale, RCW 70A.222.070[73] requires that the safer alternative is "readily available in sufficient quantity."

Defining readily available in sufficient quantity

We identified two unrelated Washington state definitions for "readily available." WAC 110-300-0005 (regarding early learning program standards) defines "readily available" to mean "able to be used or obtained quickly and easily." WAC 284-180-130 (regarding pharmacy benefit managers) defines "readily available for purchase" to mean "manufactured supply is held in stock and available for order by more than one pharmacy in Washington state when such pharmacies are not under the same corporate umbrella."

We did not find any applicable Washington state definitions for "sufficient quantity." The "readily available for purchase" definition is instructive nonetheless. The IC2 AA Guide refers to sufficient quantity in the context of either demand or of manufacturing needs. The Ontario Toxics Reduction Program (2011) uses two guiding questions when considering the availability of an alternative:

- Will it be relatively easy to obtain the alternative chemical, and is it available locally or only from suppliers that are great distances away?
- Are there multiple suppliers so that if one supplier shuts down there are other options for obtaining the chemical?

We used these questions to modify Question 2 of the IC2 cost and availability evaluation. Our modification is bolded:

1. Is the alternative currently used in the application of interest?
2. Is the alternative currently offered for sale for the application of interest? **Will it be relatively easy to obtain the alternative from a supplier? Are there other options or suppliers if one supplier cannot meet demand?**
3. Is the price of the alternative close to the current?

To assess whether alternatives are readily available in sufficient quantity, we first looked at available product testing data. We aimed to identify any food packaging applications or materials where PFAS-free alternatives do not appear to be in common use. Then, we assembled a list of product manufacturers for each PFAS-free alternative product, aiming to identify the number and size of the businesses making the alternative. We based the businesses size on its market share for either single-use food packaging generally or a specific food

[73] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.222.070

packaging application. We used this information to determine whether end users would be able to purchase the alternative product easily and in large quantities.

Combining these two parts together, we evaluated each alternative substance for each food packaging application to determine if it met one of the following criteria for ready availability in sufficient quantity:

1) The product testing results for PFAS-free products in a specific food packaging application are greater than 50% of the packaging sampled and at least two manufacturers (or one large manufacturer), make the specific alternative product, **OR**
2) The product testing results for PFAS-free products in a specific food packaging application are at or below 50% of the packaging sampled and at least three manufacturers (or one large manufacturer), make the alternative product.

By requiring, at minimum, that two manufacturers or one large manufacturer make a specific alternative product, we avoided identifying an alternative product with a niche or emerging market as readily available in sufficient quantity. For food packaging applications where prior studies indicate PFAS alternatives are more common, we required a lower burden of proof to demonstrate that end users will be able to acquire the alternative in sufficient quantity. When PFAS-free alternatives are less common, we increased the minimum number of manufacturers that must make a specific alternative product.

Product testing results for PFAS in specific applications

Manufacturers are not currently required to disclose when food packaging products contain PFAS (see Challenges). This makes it difficult to assess the portion of the market that PFAS-containing products currently occupy for each food packaging application. Without a detailed breakdown of food packaging by product type and material, we relied on research that screened food packaging products for fluorinated chemicals to identify any food packaging applications lacking PFAS-free alternatives.

In the last decade, a number of studies have identified PFAS in food packaging sold in grocery stores and quick service restaurants. They use particle-induced γ-ray emission (PIGE) spectroscopy or combustion with ion-selective electrode detection as screening tools to identify products where the concentration of fluorinated chemicals was less than 100 ppm (referred to below as low or no fluorinated chemicals). The concentration of fluorinated chemicals represented a proxy for the presence of PFAS chemicals (Dressler et al., 2002; Ritter et al., 2017; Schaider et al., 2017). These studies provide a snapshot of the prevalence of PFAS in some food packaging applications.

Additionally, the CEH "Database of Single-Use Food Service Ware Products Tested for Fluorinated Additives" has been screening single-use food packaging products for fluorinated chemicals since 2018. Table 26 summarizes the results that correspond to the food packaging applications in this assessment. Each entry in the table includes the total number of chains or manufacturers (brands) from which samples were taken.

For ease of comparison, we grouped the information by food packaging application. To facilitate comparison between data sets, we applied the terminology used in this AA as needed:

- Wraps and liners: sandwich/burger food contact paper, bakery or deli paper.
- Bags and sleeves: dessert/bread food contact paper, dessert/sides food contact paper.
- Bowls: bowls and soup containers.
- Interlocking folded containers: take-out containers.

The CEH database provides information on whether the base material used in the product is molded fiber or folded paperboard. At the bottom of Table 26, we re-categorized products listed in the CEH database as either molded fiber or folded paperboard (we excluded other materials). Schaider et al. (2017) also provided data for folded paperboard in general.

Owing to the limited size of these datasets, we used this information to identify food packaging application where alternatives to PFAS appear to be more common than PFAS-containing products. If different organizations tested products in the same category, we listed it twice to reflect independent results.

Table 26. Percentage of food packaging products tested that do not contain fluorinated chemicals.

Food packaging application	Number of products tested	Number of brands sampled	Percent with low or no fluorinated chemicals	Product testing database/report
Wraps and liners	138	20	62%	Schaider et al., 2017
Wraps and liners	14	5	93%	Schreder & Dickman, 2018; Toxic-Free Future, 2018
Wraps and liners	9	5	78%	Dickman et al., 2020
Bags and sleeves	68	9	44%	Schaider et al., 2017
Bags and sleeves	9	4	89%	Schreder & Dickman, 2018; Toxic-Free Future, 2018
Bags and sleeves	6	4	0%	Dickman et al., 2020
Plates	7	4	86%	Schreder & Dickman, 2018
Plates	94	45	40%	CEH, 2020
Bowls	72	35	50%	CEH, 2020
Bowls	4	3	0%	Dickman et al., 2020
Trays	43	17	35%	CEH, 2020
Food Boats	6	5	100%	CEH, 2020
Pizza boxes[1]	12	9	92%	Toxic-Free Future, 2020
French fry carton	7	3	100%	Dickman et al., 2020
Clamshells	57	24	33%	CEH, 2020

Food packaging application	Number of products tested	Number of brands sampled	Percent with low or no fluorinated chemicals	Product testing database/report
Clamshells (paperboard only)	2	1	50%	Dickman et al., 2020
Clamshells (molded fiber)	2	2	0%	Schreder & Dickman, 2018; Toxic-Free Future, 2018
Interlocking folded containers	12	6	75%	CEH, 2020
Interlocking folded containers	2	2	100%	Schreder & Dickman, 2018; Toxic-Free Future, 2018
Non-molded fiber paperboard	80	15	80%	Schaider et al., 2017
Non-molded fiber paperboard	66	31	97%	CEH, 2020
Molded fiber	182	33	13%	CEH, 2020

Table notes:

1. The original data included both frozen and fresh pizza boxes. We only reported the data for fresh pizza boxes.

Some food packaging applications have multiple sources of product testing data. To compare product testing results, we summed the total number of products tested and the total number of products identified as having low or no fluorinated chemicals from each source. We used that information to determine the overall percentage of products tested that had low or no fluorinated chemicals:

- **Wraps and liners:** 161 products tested, 66% were low or no fluorinated chemicals (Schaider et al., 2017; Schreder & Dickman, 2018; Toxic-Free Future, 2018, Dickman et al., 2020).
- **Bags and sleeves**: 83 products tested, 46% were low or no fluorinated chemicals (Schaider et al., 2017; Schreder & Dickman, 2018; Toxic-Free Future, 2018, Dickman et al., 2020).
- **Plates:** 101 products tested, 44% were no or low fluorine (CEH, 2020; Schreder & Dickman, 2018).
- **Bowls:** 76 products tested, 47% were low or no fluorinated chemicals (Dickman et al., 2020; CEH, 2020).
- **Trays:** 44 products tested, 36% were low or no fluorinated chemicals (Dickman et al., 2020; CEH, 2020). One tray was tested by Dickman et al. (2020) and found to contain fluorinated chemicals. We did not include it in Table 26.

- **French fry carton:** Eight products tested, 100% were low or no fluorinated chemicals (Dickman et al., 2020; CEH, 2020). One French fry carton was tested by CEH and found to contain no or low fluorinated chemicals. We did not include it in Table 26.
- **Clamshells:** 61 products tested, 33% were low or no fluorinated chemicals (CEH, 2020; Dickman et al., 2020; Schreder & Dickman, 2018; Toxic-Free Future, 2018).
- **Interlocking folded containers:** 14 products tested, 79% were low or no fluorinated chemicals (CEH, 2020; Schreder & Dickman, 2018; Toxic-Free Future, 2018).

The prevalence of PFAS in these products may be correlated with the type of base material used. In these studies, PFAS-containing products are less prevalent than alternative products in food packaging applications that commonly use non-molded fiber paperboard (such as French fry cartons, food boats, pizza boxes, and interlocking folded containers). Of the paperboard products CEH tested, they identified 97% of the 66 total as containing low or no fluorinated chemicals.

Conversely, the molded fiber products tested typically appear to contain PFAS. Of 182 molded fiber products CEH tested, they identified only 13% as containing low or no fluorinated chemicals. Although PFAS-free molded fiber products do exist, the molded fiber product market does not widely use them at this time.

For food contact paper applications, PFAS prevalence in these products varied. Schaider et al. (2017) found no or low levels of fluorinated chemicals in 54% of all food contact products tested. (This percentage was calculated using some products that we could not categorize as wraps/liners or bags/sleeves.) The number of restaurant chains sampled for each application could influence these percentages—but the variation could also reflect differences across food packaging applications. Toxic-Free Future's smaller scale studies identified no or low levels of fluorinated chemicals in 78% of wraps and liners used for sandwiches (2020), and 93% of deli papers (2018).

It is worth noting that these product testing data conflict with the Organisation for Economic Co-operation and Development (OECD)'s recent report on PFAS and alternatives in food packaging. Based on conversations with manufacturers about the European Union (EU) market, OECD estimates that 90 – 95% of food packaging products made with paper and paperboard still contain PFAS—though that percentage is falling and is expected to continue decreasing (OECD, 2020).

While the OECD report offers a useful perspective on the current prevalence of PFAS within the food packaging market, its applicability to this report is limited. First, the OECD report focuses on a much more limited set of potential alternatives. All plastics, including plastic coatings and PLA, are not considered in detail. It is unclear how the limited scope does or does not impact the reported PFAS prevalence. Second, the report relies on estimates from manufacturers to determine the prevalence of PFAS in the EU market, whereas the studies we rely on assess products purchased in the U.S.

To summarize the product testing results:

- Greater than 50% of the wraps and liners, food boats, French fry cartons, pizza boxes, and interlocking folded container products tested were found to have low or no fluorinated compounds (defined as a fluorinated chemical concentration of less than 100 ppm).
- Less than or equal to 50% of the plates, bowls, trays, bags, and clamshells tested were found to have low or no fluorinated compounds.

Availability of single-use alternative products based on manufacturer

To determine whether specific alternative products are available in sufficient quantity, we compiled a list of manufacturers, organized by food packaging application and candidate alternative substance (Table 27). We identified PFAS-free product manufacturers using:

- Stakeholder input.
- The CEH Database (CEH, 2020).
- The Biodegradable Packaging Institute certification list (BPI, 2020).
- The Compost Manufacturer's Alliance certification list (CMA, 2020a).[74]

As of 2020, both certifications above verify that products are compostable and do not contain more than 100 ppm of fluorinated chemicals (BPI, 2018; BPI, 2019; CMA, 2020b). We confirmed that all the manufacturers listed actually offer products for sale and verified the alternative substance used.

From this initial list, we used the The Freedonia Group (2017) industry market research study on single-use food serviceware to identify large manufacturers. The report lists manufacturers that occupy a large portion of the market—either for that specific food packaging application, or for single-use food service items in general.

[74] On January 1, 2020, CMA implemented a PFAS standard for all certified products. Ecology identified the following certified products in the CMA database following this change. However, as of the final technical review of this publication, CMA has not confirmed the presence or absence of PFAS by the following manufacturers:

- Southern Champion Tray (all products).
- Fisher Paper Products (all products).
- Seaman Paper Company (all products).
- AJM Packaging Corporation (bags and sleeves).

Table 27. Known manufacturers of specific PFAS-free alternative products.

Food packaging application	Alternative substance	Number of large manufacturers (Freedonia, 2017)	Number of other manufacturers	Source
Wraps and liners	Wax-coated	1 identified Eco-Products, Bagcraft (Novolex)	8 identified Delfort; Dunn Paper; Handywacks Corp.; If You Care; McNairn Pkg.; Seaman Paper Company; Twin Rivers Paper Company; VegWare	Stakeholder input; CMA, 2020; BPI, 2020
Wraps and liners	Uncoated paper	0 identified	4 identified Ahlstrom-Munksjo/Expera; Twin Rivers Paper Company; Domtar Paper; Nordic Paper	Stakeholder input
Wraps and liners	Siloxane-coated	0 identified	1 identified Delfort	Stakeholder input
Bags and sleeves	Uncoated paper	1 identified Eco-Products, Bagcraft (Novolex)	7 identified Ahlstrom-Munksjo; AJM Packaging Corporation; Domtar Paper; Fischer Paper Products; If You Care; Twin Rivers Paper Company; VegWare	CMA, 2020a; Stakeholder input
Bags and sleeves	Wax-coated	1 identified Bagcraft (Novolex)	3 identified Delfort; Fischer Paper Products; McNairn Pkg.	CMA, 2020a; Stakeholder input
Plates	Uncoated paper	1 identified Dixie (Georgia-Pacific)	5 identified AJM Packaging Corporation; Empress; Great Value[1]; Smart & Simple[2]; Value Corner[3]	CEH, 2020; CMA, 2020a
Plates	Molded fiber (unknown chemical)	1 identified Eco-Products (Novolex)	2 identified Footprint; GeoTegrity	BPI, 2020; CEH, 2020; Stakeholder Input

Food packaging application	Alternative substance	Number of large manufacturers (Freedonia, 2017)	Number of other manufacturers	Source
Plates	Kaolin clay-coated	1 identified Solo (Dart)	0 identified	CEH, 2020; CMA, 2020a; Stakeholder Input
Plates	PLA foam	0 identified	2 identified Anhui Hengxin; Earth Maize (Earth-To-Go)	BPI, 2020; CEH, 2020
Plates	PLA plastic	1 identified Eco-Products (Novolex)	0 identified	BPI, 2020
Plates	Poly-coated	1 identified Dixie (Georgia-Pacific)	0 identified	CEH, 2020; Stakeholder input
Bowls	Molded fiber (unknown chemical)	1 identified Eco-Products (Novolex)	2 identified Footprint; GeoTegrity	BPI, 2020; CEH, 2020; Stakeholder Input
Bowls	Kaolin clay-coated	1 identified Solo (Dart)	0 identified	CEH, 2020; CMA, 2020a; Stakeholder Input
Bowls	PLA-coated	3 identified Earthchoice (Pactiv); Eco-Products (Novolex); Solo (Dart)	15 identified Besics Packaging Corporation; Earth Bowl (Earth-To-Go); Eco Guardian; Eco Kloud; Ecotainer; Emerald; G2 by Chef's Choice; Green Century Enterprises; Karat Earth; Stalk Market; PrimeWare; TrueChoicePack; VegWare; World Centric; Yes Eco	BPI, 2020; CEH, 2020; CMA, 2020a; Stakeholder input
Bowls	PLA foam	0 identified	1 identified Earth Maize (Earth-To-Go)	BPI, 2020; Stakeholder input

Food packaging application	Alternative substance	Number of large manufacturers (Freedonia, 2017)	Number of other manufacturers	Source
Bowls	Poly-coated	1 identified Dixie (Georgia-Pacific)	0 identified	CEH, 2020; Stakeholder input
Trays	Molded fiber (unknown)	1 identified Huhtamaki	1 identified GeoTegrity	BPI, 2020; CEH, 2020; Stakeholder Input
Trays	PLA-coated	0 identified	1 identified World Centric	BPI, 2020; CEH, 2020; Stakeholder Input
Trays	PLA foam	0 identified	2 identified Earth Maize (Earth-To-Go); Anhui Hengxin	BPI, 2020; CEH, 2020; Stakeholder input
Trays	PLA plastic	1 identified EcoProducts	2 identified Stalk Market; World Centric	BPI, 2020; CEH, 2020; Stakeholder input
Trays	Kaolin clay-coated	1 identified Southern Champion Tray	0 identified	CMA, 2020a; Stakeholder Input
Trays	Poly-coated	1 identified Dixie (Georgia-Pacific)	0 identified	Stakeholder input
Food Boats	Kaolin clay-coated	2 identified Eco-Products (Novolex); Southern Champion Tray	1 identified Vegware	CMA, 2020a; CEH, 2020; Stakeholder input
Food Boats	Poly-coated	1 identified Dixie (Georgia-Pacific)	0 identified	CEH, 2020; Stakeholder input
Food Boats	PVOH-coated	0 identified	1 identified Sustainable Fiber Solutions	Stakeholder input
Pizza Boxes	Uncoated/ Corrugated paper	0 identified	2 identified G2 by Chef's Choice; U.S. Foods	BPI, 2020; Stakeholder input

Food packaging application	Alternative substance	Number of large manufacturers (Freedonia, 2017)	Number of other manufacturers	Source
Pizza Boxes	Kaolin clay-coated	1 identified Southern Champion Tray	0 identified	CMA, 2020a; Stakeholder input
French Fry Cartons	Kaolin clay-coated	1 identified Southern Champion Tray	0 identified	CMA, 2020; Stakeholder input
French Fry Cartons	PLA-coated	1 identified Eco-Products (Novolex)	0 identified	BPI, 2020; CEH, 2020; Stakeholder input
Clamshells	Molded fiber (unknown)	1 identified Eco-Products (Novolex)	2 identified CKF, Inc.; Karat Earth	CEH, 2020; CMA, 2020a; Stakeholder Input
Clamshells	PLA-coated	0 identified	1 identified World Centric	BPI, 2020; CEH, 2020; Stakeholder Input
Clamshells	PLA foam	0 identified	2 identified Anhui Hengxin; Earth Maize (Earth-To-Go)	BPI, 2020; CEH, 2020; Stakeholder Input
Clamshells	PLA plastic	2 identified Eco-Products (Novolex); Pactiv	4 identified Greensafe Products; Stalk Market; VegWare; World Centric	BPI, 2020; CEH, 2020; CMA, 2020a
Clamshells	Poly-coated	1 identified Dixie (Georgia-Pacific)	0 identified	Stakeholder input
Interlocking folded containers	PLA-coated	0 identified	1 identified Inno-Pak	BPI, 2020; Stakeholder input
Interlocking folded containers	Kaolin clay-coated	0 identified	1 identified VegWare	BPI, 2020; CMA, 2020a; Stakeholder input
Interlocking folded containers	PE-coated	1 identified EarthChoice (Pactiv)	0 identified	CEH, 2020; Stakeholder input

Food packaging application	Alternative substance	Number of large manufacturers (Freedonia, 2017)	Number of other manufacturers	Source
Interlocking folded containers	Poly-coated	3 identified Dixie (Georgia-Pacific); Fold-Pak (WestRock); Southern Champion Tray	1 identified EcoSource	Stakeholder input; CEH, 2020

Table notes:

1. This is Walmart's in-house label—the company does not provide information on the manufacturer.
2. This is Dollar General's in-house label—the company does not provide information on the manufacturer.
3. This is Safeway's in-house label—the company does not provide information on the manufacturer.

The list we compiled may not represent all possible PFAS-free food packaging products. If we could not identify any manufacturers of a confirmed PFAS-free alternative product, then we did not list the alternative substance in the table above for that food packaging application. This meant that we could not include several large suppliers (such as Westrock and Arvco Container, which manufacture uncoated pizza boxes) in the list, even though product testing found several large pizza chains using boxes with low or no fluorinated chemicals (Freedonia, 2017; Toxic-Free Future, 2020). Additionally, we could not include some products that were identified as clay-coated paper products in databases, because we could not be verify the coating. We will work to expand this list and verify the alternatives used in products in future AAs.

The Freedonia market report identified companies that produce the highest volume of food packaging products—both generally and for specific food packaging applications. Six companies accounted for a combined 39% of the single-use food packaging market in 2016:

- Dart Container
- Pactiv
- Georgia-Pacific
- International Paper
- Novolex
- Westrock

Above, we note these companies, as well as a few others the report identifies as manufacturing large volumes of specific food packaging products (Southern Champion Tray, Huhtmäki, and Arvco Container). Most of these companies offer a large variety of products and material types. Some also produce the paper or plastic materials other companies use to make foodservice products.

These companies have the capacity and capital to produce large quantities of a specific alternative product. They will be better able to respond to changes in market demands compared to smaller food packaging manufacturers, so they should be able to scale up production of an alternative product in response to increased demand.

Alternatives that are readily available in sufficient quantity

Using the data in Table 26 and Table 27 and the criteria outlined above, Ecology identified alternative products that are readily available in sufficient quantity. To be readily available in sufficient quantity, an alternative product must meet one of the following criteria:

1) The percentage of PFAS-free alternative products in a specific food packaging application is above 50% and at least two manufacturers (or one large manufacturer), make a PFAS-free version of this alternative product, **OR**
2) The percentage of PFAS-free alternative products in a specific food packaging application is at or below 50% and at least three manufacturers (or one large manufacturer), make a PFAS-free version of this alternative product.

Greater than 50% of the wraps and liners, food boats, French fry cartons, pizza boxes, and interlocking folded containers tested were found to have low or no fluorinated chemicals (Table 26). Therefore, we identified the below alternative products as meeting the criteria for ready availability in sufficient quantity. We identified at least two manufacturers (or one large manufacturer) in Table 27 for each one.

- Wraps and liners: Uncoated paper, wax-coated.
- Food boats: Kaolin clay-coated.
- Pizza boxes: Uncoated paper, Kaolin clay-coated.
- French fry cartons: Kaolin clay-coated, PLA-coated.
- Interlocking folded containers: PE-coated.

In the product testing studies we reviewed, bags and sleeves, plates, bowls, trays, and clamshells had lower percentages of products that do not contain intentionally added fluorinated chemicals (less than or equal to 50%; Table 26). However, we identified the below alternative products as meeting the criteria for ready availability in sufficient quantity. We have identified at least three manufacturers (or one large manufacturer) in Table 27 for each one.

- Bags: Uncoated paper, wax-coated.
- Plates: Uncoated paper, Kaolin clay-coated, PLA plastic.
- Bowls: Kaolin clay-coated, PLA-coated.
- Trays: Kaolin clay-coated, PLA plastic.
- Clamshells: PLA plastic.

Poly-coated cannot be tied to specific candidate alternatives (e.g., PE-coated paper), these products cannot be used to determine the availability of specific alternative products. Therefore, most PE- and PET-coated alternative products are categorized as “insufficient data.” We also identified molded fiber products with unknown coatings as available for plates, bowls, trays, and clamshells. However, we did not assess these products further, because the unknown coating or additive cannot be tied to specific candidate alternative substances.

In this assessment, we prioritized alternative materials and substances that are already established within the market (see Section 3). Some stakeholders expressed concern that supply may limit the availability of alternatives made using PLA. PLA is used for manufacturing bioplastic and foam serviceware, as well as PLA-lined paper products. The global PLA market demand in 2019 was estimated to be around 400,000 tons, up from the estimated 120,000-ton market volume in 2014 (Jem, 2020).

Since 2018, there has been a PLA supply shortage—due to both PLA manufacturing plants operating under capacity and a lack of raw materials (Jem, 2020). PLA and raw material plants currently under construction are expected to reduce, but not eliminate, the shortage (Jem, 2020). This indicates that PLA alone may not be able to fully meet market demand if PFAS-containing options were eliminated.

This AA aims to determine whether there are sufficient alternatives that meet the criteria for safer established in RCW 70A.222.070.[75] Therefore, we determined that the potential raw material shortage should not completely eliminate PLA-based alternatives from consideration. The number of companies currently producing products with PLA reflects significant interest that will continue to drive PLA capacity. Consequently, we designated PLA-based alternatives that otherwise met our criteria for ready availability in sufficient quantity as “yes for some users.” This label reflects that PLA-based alternatives will be readily available in sufficient quantity (and therefore may meet our criteria for safer) for some manufacturers and end-users, but not necessarily all.

We summarize these results in Table 29 through Table 31.

Availability of reusable products

Reusable food packaging is a non-chemical alternative to PFAS that suits some businesses. While it cannot completely replace all single-use food packaging at this time, we should consider it as another possibility to replace PFAS-containing foodservice products. The food packaging application, industry type, and size of the business influence whether a reusable version of a food packaging application will meet our criteria for ready availability in sufficient quantity.

For businesses that transition, there are several benefits to using reusable food packaging. Reusable products are durable and often have less environmental impact than single-use food packaging when compared on a lifecycle basis (Chiang et al., 2018). ReThink Disposable published the Reusable Food Serviceware Guide, which provides information on how to perform a cost-benefit analysis focusing on the disposable items that the business wants to replace (ReThink Disposable, 2015). Reusable dinnerware options (plates, bowls, trays, and food boats) are readily available in sufficient quantity because they are widely available for purchase (ReThink Disposable, 2015).

There are also options for businesses interested in implementing a reusable take-out container system (Chiang et al., 2018):

- Deposit-based container exchange programs.
- Discounts for customers who bring their own reusable containers.

[75] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.222

- Fees for customers requesting a disposable item.

Reusable take-out container businesses like GO Box and OZZI represent new models for providing reusable take-out containers in place of single-use disposables. GO Box is a reusable container system for take-out food at foodservice businesses in the Portland, Oregon area (GO Box, 2020). OZZI is another reusable container system used at military installations, universities, business parks, and campuses (OZZI ,2020).

However, whether reusable take-out container businesses are available currently depends highly on location. Further, reusable take-out container programs may not be feasible for all businesses (ReThink Disposable, 2015). Therefore, at this time, we do not consider reusable take-out containers readily available throughout Washington state.

Emerging market shift to PFAS-free products

There is evidence that fast-casual chain restaurants are responding to increased pressure to avoid PFAS-containing products. Whole Foods, Trader Joe's, Panera Bread, and the grocery chains Albertsons and Ahold-Delhaize all committed to phasing out PFAS-containing products in their stores (Mind the Store, 2019; Schade & Belliveau, 2020). Chipotle and Sweetgreen also announced programs to replace PFAS-containing bowls (Fassler, 2020).

Several new PFAS-free molded fiber products emerged on the market in response to increasing awareness among consumers and chains. Footprint by Gilbert is producing PFAS-free molded fiber bowls for all Sweetgreen locations by the end of 2020 (Fassler, 2020). Eco-Products released a line of PFAS-free, sugarcane-molded fiber products, called Vanguard, that use alternative chemicals to provide grease resistance (EcoProducts, 2020a). World Centric has several PFAS-free bowls and other products, including products from the No Tree line (BPI, 2020).

These commitments, coupled with changes in the food packaging regulatory landscape (see the Introduction for details), will likely increase the demand for PFAS-free alternatives within the food packaging market. That, in turn, will likely drive increased interest in producing more PFAS-free alternatives.

Summary of availability analysis

Ecology evaluated alternatives in each food packaging application according to:

- The percentage of PFAS-free products (which we determined through publicly available product testing results).
- The number and size of manufacturers producing specific PFAS-free alternative products.

Studies assessing samples from large grocery stores and fast food chains demonstrated the presence of PFAS-free alternatives in several food packaging applications we are considering. Furthermore, identifying several smaller manufacturers or at least one large manufacturer using a specific PFAS-free alternative indicates that the alternative product meets the criteria for ready availability in sufficient quantity. Finally, several high-volume businesses have removed PFAS-containing products from their stores. This suggests that the market supply of single-use, PFAS-free alternatives is able to respond to increasing demand.

We summarize our conclusions in Table 29 through Table 31.

Cost comparability of PFAS and PFAS-free alternatives

Defining comparable cost

Identifying "comparable cost" for alternatives is difficult, given regional variability, competition, current economic circumstances, and future cost reductions that can occur as markets expand. The statute does not define "comparable" or "close to current" cost, nor does the IC2 AA Guide, or economic theory.

We looked to other laws and state government actions to inform our definition for cost comparability. In legislation concerning biodegradable disposable diapers, the state of Nebraska defined cost comparability as "at a cost not in excess of 5% above the average price for products of comparable quality," but only when "the price of such products is reasonably competitive" (NE Code § 69-2011 (2018)).

Another statute defines "reasonably competitive" as "the cost of the recycled product does not exceed a cost premium of 10% above the cost of a comparable product that is not a recycled product" or "15% above the cost of a comparable product that is not a [New York waste-derived] recycled product" (see NY Gen Mun L § 104-A (2015), NY Cty L § 626 (2014), and NY Vill L § 5-525 (2012)).

We found this approach reasonable and consistent with the plain meaning of the words in the Washington state statute. Ten percent is the middle of the range (a low of 5% and a high of 15%) and is the same as the presumed comparable cost for the New York statutes. Therefore, Ecology will identify alternatives as cost comparable when data suggest the price of a PFAS-free alternative will not be more than 10% more than the cost of a comparable PFAS-containing product.

We sought price information from manufacturers about alternative substances and products. We also collected unit price information from products in each food packaging application that contained either PFAS or a specific alternative substance under consideration.

Cost comparison information provided by manufacturers

To establish the cost of alternatives to PFAS, Ecology first sought cost information from chemical and product manufacturers. Manufacturers often consider pricing information confidential, and many hesitated to provide it for specific products. As a result, some of the information manufacturers provided is specific for their company, while some addresses the food packaging industry as a whole.

Natureworks LLC published a case study showing that large corporations have been able to switch to all PFAS-free disposable food serviceware while keeping total cost increases below 10%. In 2010, Taco Time switched to fully compostable (PFAS-free) food serviceware in response to a Seattle ordinance requiring all single-use food serviceware in dine-in facilities be compostable or recyclable. From 2012 – 2015, higher store operating costs resulted in a 6.7% retail price increase that was absorbed by a 47% increase in sales between 2010 and 2015. Reduced disposal costs resulted in a net cost increase of only 0.2% after full implementation of the program (Natureworks, 2016).

However, this example does not necessarily mean smaller businesses or consumers would be able to make a similar switch without incurring higher costs. Small companies often cannot commit to buying large quantities, and may be purchasing products through distributors. Consequently, large companies are often able to negotiate deals for a lower unit price per product than smaller companies. According to one manufacturer, distributor markups can increase the price of a product anywhere from 10 to 40% (personal communication—source confidential).

One manufacturer of paper products coated with non-PET polymers (they did not specify whether the material was a PVOH, EVOH, PE, or polypropylene coating) stated that their products range from 10% lower to 30% higher in price compared to PFAS-containing paper products. Another manufacturer stated that a new product line, which became available for purchase in 2020, costs approximately 30% more than comparable PFAS-containing products.

These percentages loosely agree with the 11 – 32% cost increase manufacturers identified in the OECD report (OECD 2020). After consulting with stakeholders, the OECD reported that chemical-based alternatives in paper food packaging cost 11% more than comparable products that contain PFAS. The OECD also reported that PFAS-free uncoated paper sheets (such as liners) cost 30% more than comparable products that contain PFAS.

Beyond the price estimation for uncoated paper, it is difficult to use this information to assess comparability for specific alternatives. For this reason—and to confirm that switching to PFAS-free alternatives would not overburden low-consumption end users—we compared product purchase prices to determine which alternative products could be purchased at comparable cost.

Price comparison of products

To determine whether PFAS-free alternatives met the cost comparable benchmark for any end user, we compared available unit prices of confirmed PFAS-free products versus similar PFAS-containing products. We repeated this process for each food packaging application. We identified products containing PFAS using the CEH database (CEH 2020), and PFAS-free alternatives using the CEH database as well as databases for BPI- or CMA-certified products.

For each product, we verified the alternative material or chemical and unit price through independent research. We compared the unit prices for similar products in a food packaging application to see if products containing an alternative material or chemical were available at comparable cost to PFAS-containing options.

When we could identify pricing for comparable products that contained either PFAS or PFAS-free alternatives under assessment, we charted prices using box plots for easier qualitative comparison (Figure 17). In these plots, the box edges are the 25th and 75th percentile. The median is represented by the line within the box, and the mean is represented by the X. The vertical bars outside the boxes represent the minimum and maximum of the data. Any dots beyond those bars are outliers, calculated as greater than 1.5 times the interquartile range. The label for each box plot can be found directly above it.

Manufacturers often treat product formulation and pricing as trade secrets (see Challenges). If pricing information was not identified for products that contained PFAS, then we considered the relative likely prevalence of PFAS-free alternatives. For some food packaging items, such as paperboard French fry cartons, it is likely that the method described earlier would identify a conventional product that has not been tested for fluorinated chemicals as PFAS-free (see Table 26). If we identified these alternative products as readily available in the previous section, then they would be cost-comparable with conventional products. Therefore, they can be considered cost-comparable to similar PFAS-containing products. For applications where a conventional product would be as likely or more likely to contain PFAS than not, we find that there is insufficient information to determine cost comparability.

We did not find prices for all products in the above databases. In many cases, product pricing is set by contracts that are not publicly available. Furthermore, when multiple price points for the same product were publicly available, the listed price could vary significantly.

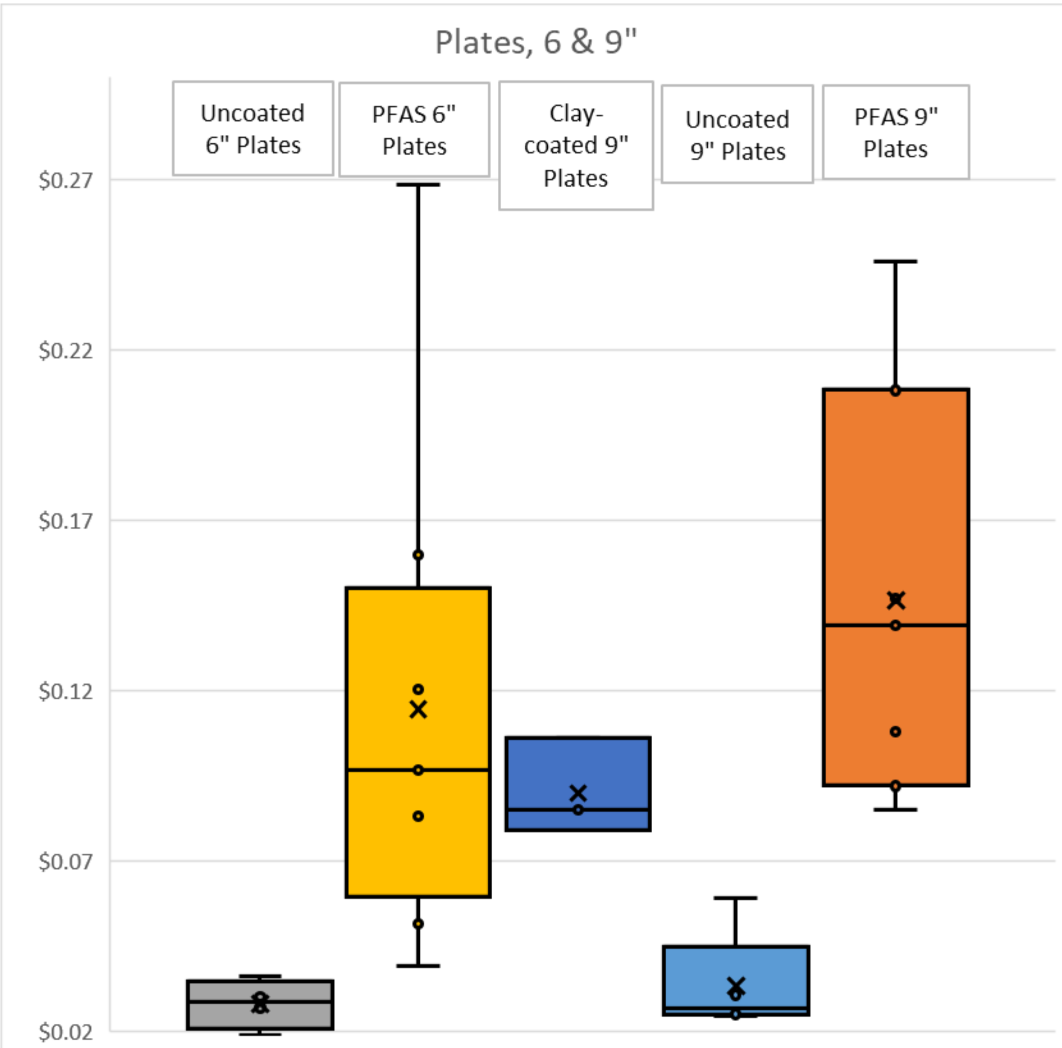
The limited availability and reproducibility of this data meant we could not perform quantitative or statistical analyses. Viewed qualitatively, however, the price points we identified indicate that end users can purchase some products made from PFAS-free alternative substances at comparable cost to similar PFAS-containing products.

Food Packaging Category 1, Wraps and Liners: PFAS-free wraps and liners appear to be a large percentage of the market—waxed and uncoated paper sheets were the most widely identified. We could not identify the price for any product confirmed to contain PFAS. We used the OECD report's price comparison estimate to determine that uncoated wraps and liners would not be cost comparable with PFAS-containing products (OECD, 2020). The prices for PFAS-free, wax-coated liners range from one to seven cents. Seventeen out of 34 items cost one cent, which is a comparable minimum price to conventional deli sheets (which were not tested for PFAS). We identified wax-coated wraps and liners as cost comparable (Table 29). There were insufficient data to evaluate siloxane-, PVOH-, and EVOH-coated products (Table 29).

Food Packaging Category 1, Bags and Sleeves: In the previously cited studies, more than half of the bags and sleeves tested contained PFAS. However, we could not identify prices for confirmed PFAS-containing bags or sleeves. With product testing finding more than half of bags and sleeves contained fluorinated chemicals, we determined that there is insufficient information to evaluate the cost comparability of wax-coated bags or sleeves. There were also insufficient data to evaluate uncoated and siloxane-, PVOH-, and EVOH-coated products (Table 29).

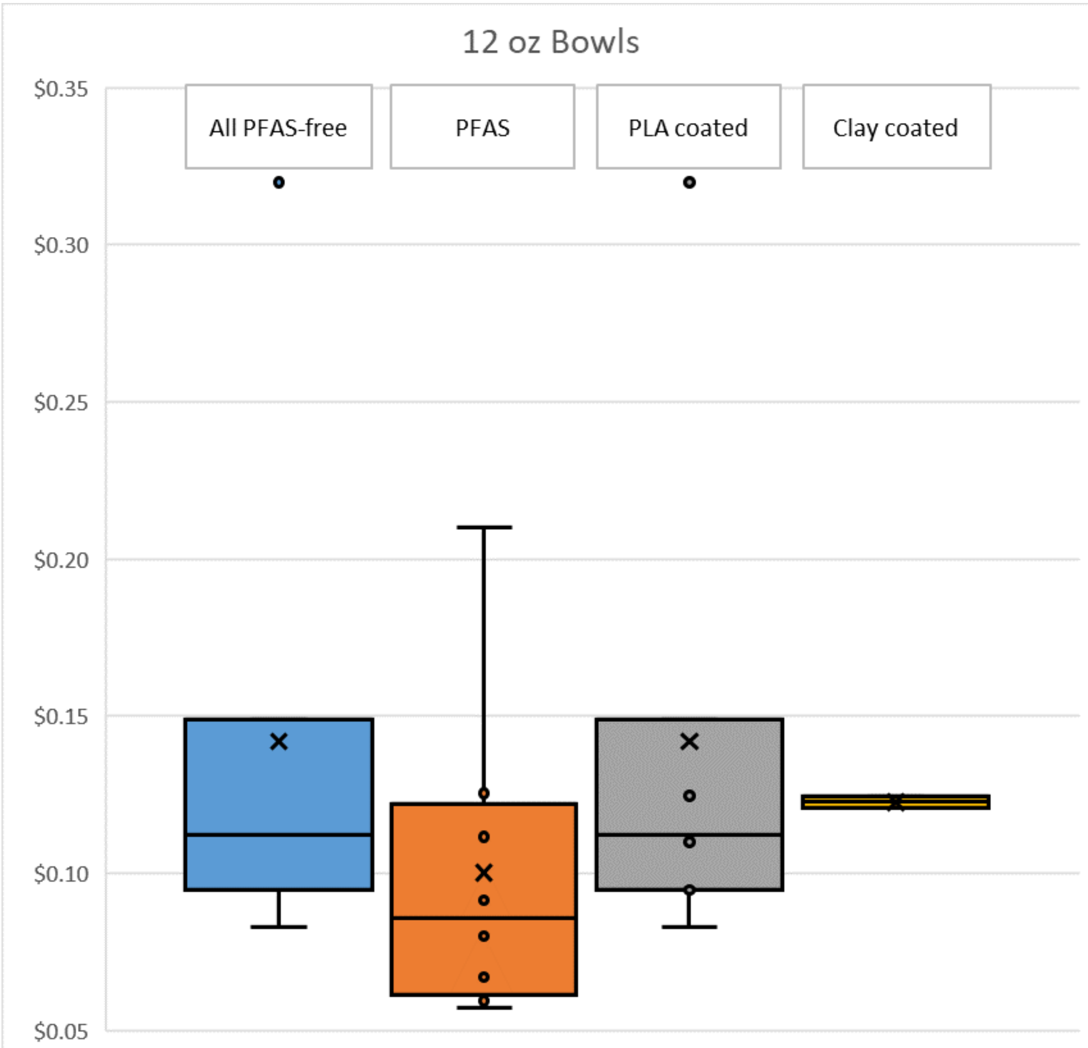
Food Packaging Category 2, Plates: We collected and compared unit price information for both 6” and 9” diameter plates using box plots (Figure 17). Using this plot, we identified uncoated paper (6” and 9” diameter plates), and clay-coated paper (9” diameter plates) as cost comparable alternative materials for plates (Figure 17). There were insufficient data to evaluate PLA plastic and PLA foam, as well as PVOH-, EVOH-, PE-, and PET-coated plates (Table 30).

Figure 17. Cost comparison by size of PFAS-containing and PFAS-free plates.



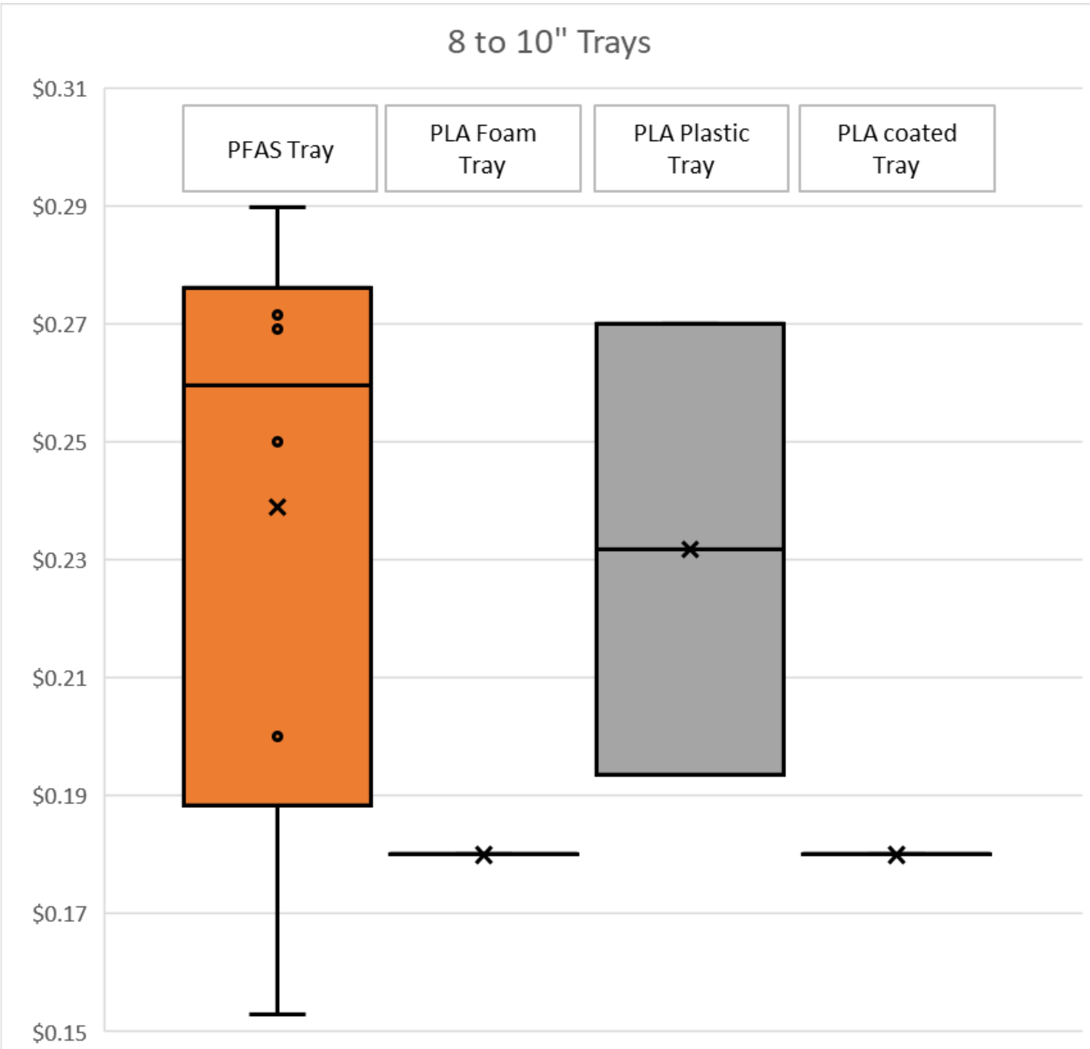
Food Packaging Category 2, Bowls: We collected and compared unit price information for 12-ounce bowls. Using a 10%price increase, we identified clay- and PLA-coated paper as cost incomparable materials for bowls (Figure 18). There were insufficient data to evaluate PLA foam, and PVOH-, EVOH-, PE-, and PET-coated bowls (Table 30).

Figure 18. Cost comparison of PFAS-containing and PFAS-free bowls.



Food Packaging Category 2, Trays: We collected and compared unit price information was for 8'' to 10'' food trays. We identified PLA-coated, PLA foam, and PLA plastic trays as cost comparable materials for trays (Figure 19). There were insufficient data to evaluate clay-, PVOH-, EVOH-, PE-, PET-coated paper trays (Table 30).

Figure 19. **Cost comparison of PFAS-containing and PFAS-free molded trays.**



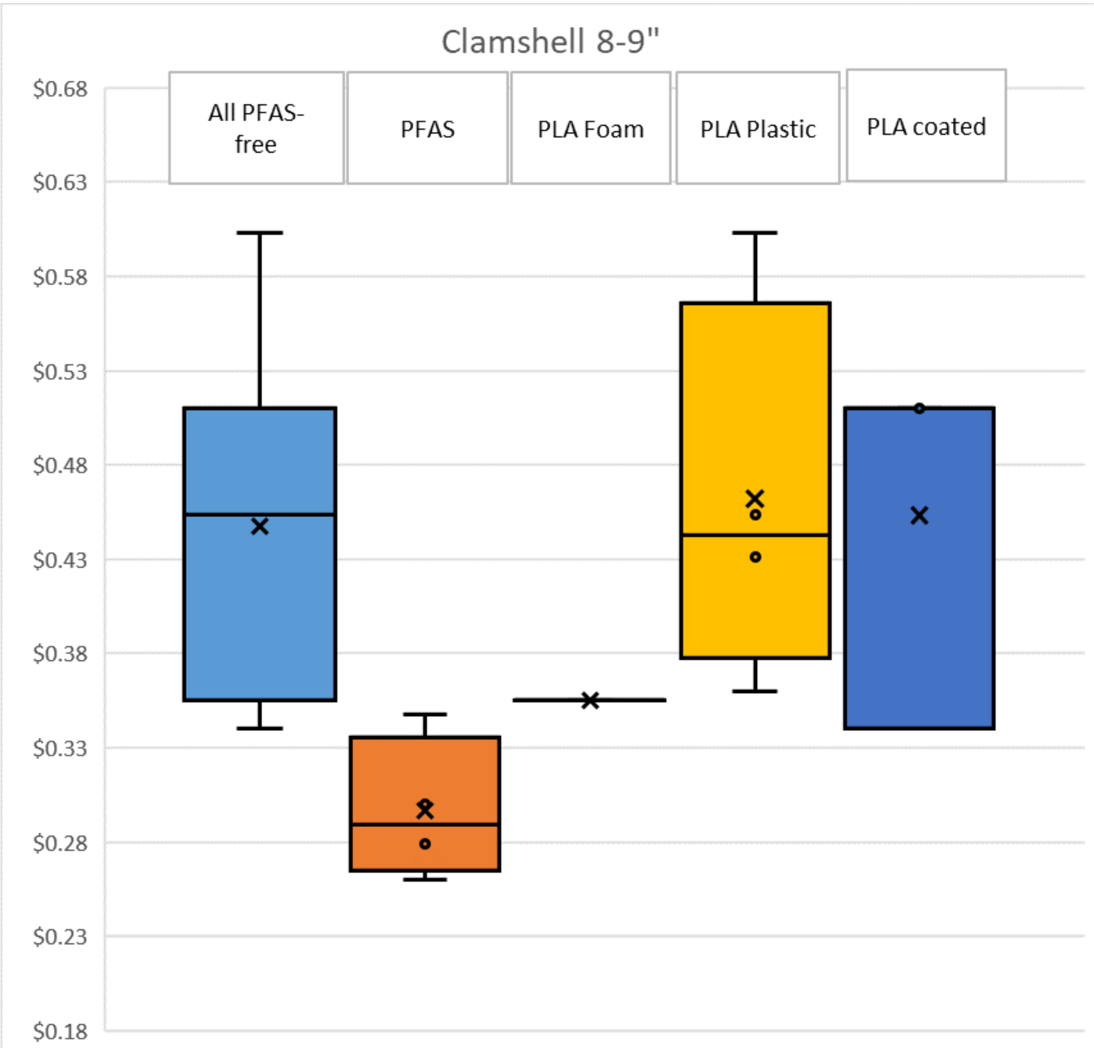
Food Packaging Category 2, Food Boats: PFAS-free paperboard containers are likely to be found among conventional products—we identified clay-coated paper as readily available. Since we did not identify any product that contained PFAS, and PFAS-free alternatives appear to be a large percentage of the market, we determined that clay-coated food boats were cost comparable. There were insufficient data to evaluate PVOH-, EVOH-, PE- and PET-coated paper (Table 30).

Food Packaging Category 3, Pizza Boxes: PFAS-free pizza boxes are likely to be found among conventional products —we identified clay-coated paperboard and uncoated corrugated cardboard as readily available. Since we did not identify any product that contained PFAS, and PFAS-free alternatives appear to be a large percentage of the market, we determined that uncoated and clay-coated pizza boxes were cost comparable. There were insufficient data to evaluate PVOH- and EVOH-coated paper (Table 31).

Food Packaging Category 3, French Fry Cartons: PFAS-free paperboard containers are likely to be found among conventional products—we identified clay- and PLA-coated paperboard as readily available. Since we did not identify any product that contained PFAS, and PFAS-free alternatives appear to be a large percentage of the market, we determined that clay-coated and PLA-coated French fry cartons were cost comparable. There were insufficient data to evaluate PVOH- and EVOH-coated paper (Table 31).

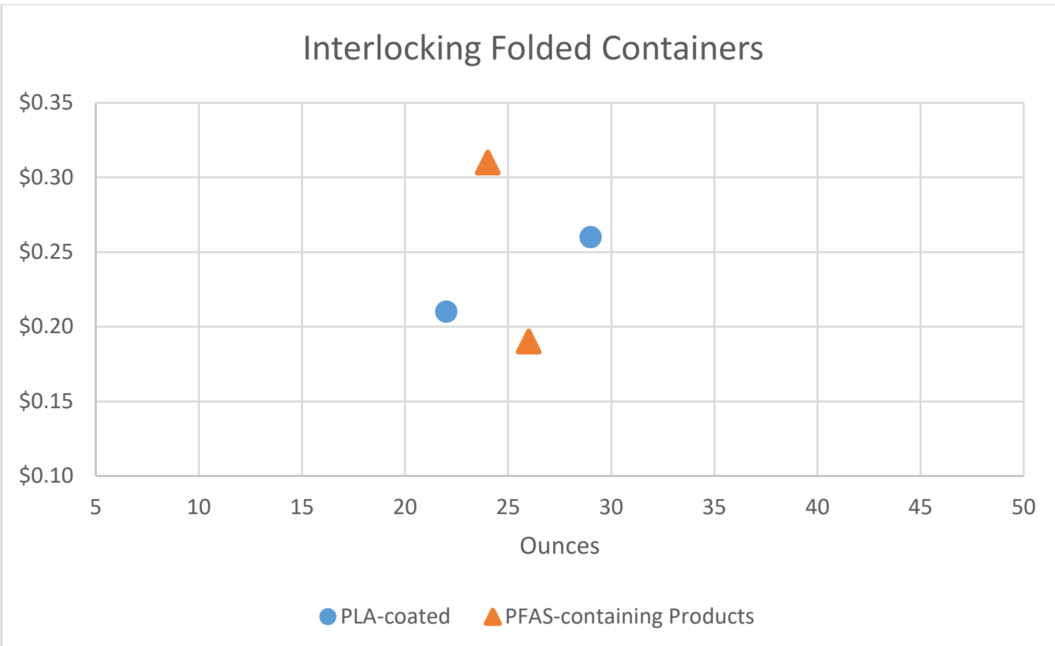
Food Packaging Category 3, Clamshells: We collected and compared unit price information for 8 – 9” clamshells. Using a 10% price increase, we identified PLA-coated paper, PLA foam, and PLA plastic clamshells as not cost comparable (Figure 20). There were insufficient data to evaluate uncoated, PVOH-, EVOH-, and PE-coated paper (Table 31).

Figure 20. Cost Comparison of PFAS-containing and PFAS-free large clamshell containers.



Food Packaging Category 3, Interlocking folded containers: PFAS-free paperboard containers are likely to be found among conventional products. We identified unit price information for PFAS-free alternatives (22 – 29 oz.) and PFAS-containing products (24 – 26 oz.). Although direct comparisons were not possible, PLA-coated interlocking folded containers appeared to be cost comparable with those containing PFAS (Figure 21). Data gaps exist for clay-, PVOH-, EVOH-, and PE-coated paper (Table 31).

Figure 21. Cost comparison of PFAS-containing and PFAS-free interlocking folded containers.



Cost comparability of reusable serviceware

We analyzed reusable versions of some food packaging applications in this assessment module. We aimed to identify whether they represent a reasonable alternative to single-use versions. However, reusable food packaging items are a system alternative to single-use food packaging (see Section 3). As such, it is difficult to directly compare cost or availability between reusable packaging items and similar products that contain PFAS.

ReThink Disposable reported several case studies that examined the cost for foodservice businesses to transition from single-use, disposable food packaging items to reusable dinnerware (plates, bowls, trays, and boats). Overall, they concluded that businesses are expected to experience a monetary savings after implementing a reusable dinnerware system, as shown in the table below.

Table 28. **Results of Rethink Disposable cost-benefit analyses for implementing reusable food serviceware systems at foodservice businesses.**

Business type	Annual cost savings (after payback period)	Payback period	Pounds of waste diverted per year	Case study
Pizza shop (fast casual)	$3,043	Under 4.1 months	2,955	ReThink Disposable, 2018c
High school (breakfast, lunch, snacks)	$6,459	1 month	3,376	ReThink Disposable, 2015, 2016
Elementary school (breakfast and lunch; 12 total schools)	$16,523 (year 1) $25,000 (year 2)	Under 42 months	8,152	ReThink Disposable, 2019d
Gelato shop	$2,301	Under 9 months	655	ReThink Disposable, 2016a
Take-out cafe	$13,963	0 months	4,804	ReThink Disposable, 2019b
Business campus café	$12,496	Under 10 months	11,582	ReThink Disposable, 2017a
Chicken shack (fast casual)	$3,205	Under 12 months	1,400	ReThink Disposable, 2016b
University café	$157,883	Under 1 month	26,926	ReThink Disposable, 2017b
Food truck	$2,028	Under 1 month	2,568	ReThink Disposable, 2014
Burger joint (fast casual)	$3,981	Under 16 months	2,477	ReThink Disposable, 2018b
Deli sandwich chain	$7,458	Under 3 months	4,367	ReThink Disposable, 2019c
Restaurant	$1,713	Under 2 months	920	ReThink Disposable, 2019a

Some businesses may not be able to justify the capital investment to support the transition (ReThink Disposable Foodware Calculator, n.d.). In these case studies, expected investments ranged from $170 (to replace disposable plates, utensils, and cups with reusable options) to $636 (to replace disposable plates, bowls, sauce cups, and water cups with reusable options) (ReThink Disposable, 2018a).

Continuing costs can also vary—depending on the business and the food packaging application that they are transitioning from single-use to reusable.

- Waste and waste hauling costs may change.
- Lost or damaged reusable containers must be replaced.
- Business operations may have to be restructured and additional training may be needed for employees.

While businesses may experience a decrease in overhead costs for single-use items and their subsequent disposal, an increase in cost for labor, water, soap, and energy to wash items may also occur (CEH, 2018). The overall impact of these costs will vary depending on the user and the system implemented. To reflect this, we identified the cost comparability of reusable alternatives as "yes to some users" for dinnerware applications in Table 40.

There is currently insufficient data to determine whether individual reusable take-out containers (Food Packaging Category 3) are cost comparable.

Summary of cost analysis

Ecology evaluated the cost comparability of PFAS-free alternatives in each food packaging application. Food packaging products are not currently required to list their chemical composition, which complicates the process of identifying whether a product contains PFAS or PFAS-free alternatives. Manufacturers did not supply cost information related to specific products or alternative substances. Owing to this difficulty, we relied on product testing databases and compostability certifications to supply a list of products for this analysis.

Comparing the unit prices for PFAS-containing and PFAS-free alternatives showed there are PFAS-free alternatives that are cost comparable with known PFAS-containing products. We summarize our conclusions in Table 29 through Table 31.

Favorability of alternative with respect to cost and availability

For each alternative material in each food packaging category, we answered the following questions to determine whether the criteria for comparable cost and sufficient availability were met:

1. Is the alternative currently used in the application of interest?
2. Is the alternative currently offered for sale for the application of interest? Will it be relatively easy to obtain the alternative from a supplier, and if that supplier cannot meet demand, are there other options?
3. Is the price of the alternative close to the current (defined as a price increase of 10% or less)?

For an alternative to be favorable in terms of both cost and availability, the answer to all three questions must be yes. The answer to question one is yes for all alternatives, by design (see Section 3 for more information on how we selected alternatives). We report the answers to questions two and three Table 29 through Table 31.

When we did not identify data to answer a question for a specific alternative, we recorded that as "insufficient data" in the tables. If the answer to any question is no or insufficient data, then the alternative is not favorable in terms of cost and availability in this AA. However, we could identify it as a favorable alternative in future AAs as cost or availability information change.

Table 29. Summary of responses to Questions 2 and 3, and favorable cost/availability determination, for applications in food packaging Category 1.

Food packaging application	Alternative material candidate class	Readily Available (Question 2)?	Cost comparable (Question 3)?	Favorable in terms of cost and ready availability?
Wraps and liners	Uncoated paper	Yes	No	No
Wraps and liners	Wax-coated	Yes	Yes	Yes
Wraps and liners	Siloxane-coated	Insufficient data	Insufficient data	Insufficient data
Wraps and liners	PVOH-coated	Insufficient data	Insufficient data	Insufficient data
Wraps and liners	EVOH copolymer-coated	Insufficient data	Insufficient data	Insufficient data
Bags and sleeves	Uncoated paper	Yes	Insufficient data	Insufficient data
Bags and sleeves	Wax-coated	Yes	Insufficient data	Insufficient data
Bags and sleeves	Siloxane-coated	Insufficient data	Insufficient data	Insufficient data
Bags and sleeves	PVOH-coated	Insufficient data	Insufficient data	Insufficient data
Bags and sleeves	EVOH copolymer-coated	Insufficient data	Insufficient data	Insufficient data

Table 30. Summary of responses to Questions 2 and 3, and favorable cost/availability determination, for applications in food packaging Category 2.

Food packaging application	Alternative material candidate class	Available (Question 2)?	Cost comparable (Question 3)?	Favorable in terms of cost and availability?
Plates	Uncoated paper	Yes	Yes	Yes
Plates	Clay-coated	Yes	Yes	Yes
Plates	PVOH-coated	Insufficient data	Insufficient data	Insufficient data
Plates	EVOH copolymer-coated	Insufficient data	Insufficient data	Insufficient data
Plates	PE-coated	Insufficient data	Insufficient data	Insufficient data
Plates	PET-coated	Insufficient data	Insufficient data	Insufficient data
Plates	PLA foam	Insufficient data	Insufficient data	Insufficient data
Plates	PLA plastic	Yes for some users	Insufficient data	Insufficient data
Plates	Reusable plates	Yes	Yes for some users	Yes for some users
Bowls	Clay-coated	Yes	No	No

Food packaging application	Alternative material candidate class	Available (Question 2)?	Cost comparable (Question 3)?	Favorable in terms of cost and availability?
Bowls	PVOH-coated	Insufficient data	Insufficient data	Insufficient data
Bowls	EVOH copolymer-coated	Insufficient data	Insufficient data	Insufficient data
Bowls	PE-coated	Insufficient data	Insufficient data	Insufficient data
Bowls	PET-coated	Insufficient data	Insufficient data	Insufficient data
Bowls	PLA-coated	Yes for some users	No	No
Bowls	PLA foam	Insufficient data	Insufficient data	Insufficient data
Bowls	Reusable bowls	Yes	Yes for some users	Yes for some users
Trays	Clay-coated	Yes	Insufficient data	Insufficient data
Trays	PVOH-coated	Insufficient data	Insufficient data	Insufficient data
Trays	EVOH copolymer-coated	Insufficient data	Insufficient data	Insufficient data
Trays	PE-coated	Insufficient data	Insufficient data	Insufficient data
Trays	PET-coated	Insufficient data	Insufficient data	Insufficient data
Trays	PLA-coated	Insufficient data	Yes	Insufficient data
Trays	PLA foam	Insufficient data	Yes	Insufficient data
Trays	PLA plastic	Yes for some users	Yes	Yes for some users
Trays	Reusable trays	Yes	Yes for some users	Yes for some users
Food boats	Clay-coated	Yes	Yes	Yes
Food boats	PVOH-coated	Insufficient data	Insufficient data	Insufficient data
Food boats	EVOH copolymer-coated	Insufficient data	Insufficient data	Insufficient data
Food boats	PE-coated	Insufficient data	Insufficient data	Insufficient data
Food boats	PET-coated	Insufficient data	Insufficient data	Insufficient data
Food boats	Reusable boats	Yes	Yes for some users	Yes for some users

Table 31. Summary of responses to Questions 2 and 3, and favorable cost/availability determination, for applications in food packaging Category 3.

Food packaging application	Alternative material candidate class	Available (Question 2)?	Cost comparable (Question 3)?	Favorable in terms of cost and availability?
Pizza boxes	Uncoated paper	Yes	Yes	Yes
Pizza boxes	Clay-coated	Yes	Yes	Yes
Pizza boxes	PVOH-coated	Insufficient data	Insufficient data	Insufficient data

Food packaging application	Alternative material candidate class	Available (Question 2)?	Cost comparable (Question 3)?	Favorable in terms of cost and availability?
Pizza boxes	EVOH copolymer-coated	Insufficient data	Insufficient data	Insufficient data
French fry carton	Clay-coated	Yes	Yes	Yes
French fry carton	PVOH-coated	Insufficient data	Insufficient data	Insufficient data
French fry carton	EVOH Copolymer-coated	Insufficient data	Insufficient data	Insufficient data
French fry carton	PLA-coated	Yes for some users	Yes	Yes for some users
Clamshells	Uncoated paper	Insufficient data	Insufficient data	Insufficient data
Clamshells	PVOH-coated	Insufficient data	Insufficient data	Insufficient data
Clamshells	EVOH copolymer-coated	Insufficient data	Insufficient data	Insufficient data
Clamshells	PE-coated	Insufficient data	Insufficient data	Insufficient data
Clamshells	PLA foam	Insufficient data	No	No
Clamshells	PLA-coated	Insufficient data	No	No
Clamshells	PLA Plastic	Yes for some users	No	No
Clamshells	Reusable clamshells	No	Insufficient data	No
Interlocking folded containers	Clay-coated	Insufficient data	Insufficient data	Insufficient data
Interlocking folded containers	PVOH-coated	Insufficient data	Insufficient data	Insufficient data
Interlocking folded containers	EVOH copolymer-coated	Insufficient data	Insufficient data	Insufficient data
Interlocking folded containers	PE-coated	Yes	Insufficient data	Insufficient data
Interlocking folded containers	PLA-coated	Insufficient data	Yes	Insufficient data
Interlocking folded containers	Reusable containers	No	Insufficient data	No

Section 8. Identification of Safer Alternatives from AA Module Results

Overview

We used a simultaneous decision framework for this AA, which involves concurrently analyzing the results from the four assessment modules to identify safer alternatives. We collected the results from the Hazard, Exposure Assessment, Performance Evaluation, and Cost and Availability Modules in the tables below. This section includes a table for each food packaging application, reporting conclusions from the four modules for each potential alternative substance.

To perform the simultaneous analysis, we looked at results from each assessment module for a specific alternative, and determined whether that alternative substance met the criteria for a safer alternative. To meet the criteria for safer as defined by RCW 70A.222.070,[76] the alternative:

- Must be less hazardous than the comparator according to the Hazard Module (labeled as “low concern” or “BM-3” in the summary tables).
- Must have a lower exposure risk than the comparator or be a sufficiently low hazard concern according to the Exposure Assessment Module (labeled as “low concern” or “not applicable” in the summary tables).
- Must perform as well or better than PFAS according to the Performance Evaluation Module (labeled as “favorable” in the summary tables).
- Must be readily available in sufficient quantity, and be cost comparable with similar PFAS-containing products, according to the Cost and Availability Module (labeled as “favorable” in the summary tables).

Sections 4 through 7 include more information on each module. If we could not assess an alternative in a module, we labeled that alternative as having “insufficient data,” and did not identify it as a safer alternative. This does not mean the alternative is not a safer alternative, only that the data available to Ecology for this AA was not enough to make a determination.

Based on results of the four evaluations, we selected one of four outcomes for each alternative:

- Yes, this is a safer alternative.
- Yes, this is a safer alternative, with a restriction such as “for some end users.”
- No, this is not a safer alternative or it does not meet the criteria for safer at this time.
- There is insufficient data to assess the alternative.

[76] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.222.070

Table 32. Summary of assessment modules outcomes for wraps and liners (Category 1).

Alternative substance	Hazard module	Exposure module	Performance module	Cost & availability	Safer alternative?
Uncoated paper	Low concern – Favorable	Not applicable	Favorable	No	No
Wax-coated	Low concern – Favorable	Not applicable	Favorable	Favorable	Yes
Siloxane-coated	BM 1 – Not favorable	Not applicable	Favorable	Insufficient data	No
PVOH-coated	Low concern – Favorable	Not applicable	Favorable	Insufficient data	Insufficient data
EVOH copolymer-coated	Insufficient data	Insufficient data	Favorable	Insufficient data	Insufficient data

Table 33. Summary of assessment modules outcomes for bags and sleeves (Category 1).

Alternative substance	Hazard module	Exposure module	Performance module	Cost & availability	Safer alternative?
Uncoated paper	Low concern – Favorable	Not applicable	Favorable	Insufficient data	Insufficient data
Wax-coated	Low concern – Favorable	Not applicable	Favorable	Insufficient data	Insufficient data
Siloxane-coated	BM 1 – Not favorable	Not applicable	Favorable	Insufficient data	No
PVOH-coated	Low concern – Favorable	Not applicable	Favorable	Insufficient data	Insufficient data
EVOH copolymer-coated	Insufficient data	Insufficient data	Favorable	Insufficient data	Insufficient data

Table 34. Summary of assessment modules outcomes for plates (Category 2).

Alternative substance	Hazard module	Exposure module	Performance module	Cost & availability	Safer alternative?
Uncoated Paper	Low concern – Favorable	Not applicable	Insufficient data	Favorable	Insufficient data
Kaolin clay-coated	Low concern – Favorable	Not applicable	Favorable	Favorable	Yes
PVOH-coated	Low concern – Favorable	Not applicable	Favorable	Insufficient data	Insufficient data
EVOH copolymer-coated	Insufficient data	Insufficient data	Favorable	Insufficient data	Insufficient data
PE-coated	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data

Alternative substance	Hazard module	Exposure module	Performance module	Cost & availability	Safer alternative?
PET-coated	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data
PLA foam	Consistent with BM-3 – Favorable	Not applicable	Favorable	Insufficient data	Insufficient data
PLA plastic	Consistent with BM-3 – Favorable	Not applicable	Favorable	Insufficient data	Insufficient data
Reusable plates	Not applicable	Not applicable	Not applicable	Favorable for some end users	Yes for some end users

Table 35. Summary of assessment modules outcomes for bowls (Category 2).

Alternative substance	Hazard module	Exposure module	Performance module	Cost & availability	Safer alternative?
Kaolin clay-coated	Low concern – Favorable	Not applicable	Favorable	No	No
PVOH-coated	Low concern – Favorable	Not applicable	Favorable	Insufficient data	Insufficient data
EVOH copolymer-coated	Insufficient data	Insufficient data	Favorable	Insufficient data	Insufficient data
PE-coated	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data
PET-coated	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data
PLA-coated	Consistent with BM-3 – Favorable	Not applicable	Favorable	No	No
PLA foam	Consistent with BM-3 – Favorable	Not applicable	Favorable	Insufficient data	Insufficient data
Reusable bowls	Not applicable	Not applicable	Not applicable	Yes for some end users	Yes for some end users

Table 36. Summary of assessment modules outcomes for trays (Category 2).

Alternative substance	Hazard module	Exposure module	Performance module	Cost & availability	Safer alternative?
Kaolin clay-coated	Low concern – Favorable	Not applicable	Favorable	Insufficient data	Insufficient data
PVOH-coated	Low concern – Favorable	Not applicable	Favorable	Insufficient data	Insufficient data

Alternative substance	Hazard module	Exposure module	Performance module	Cost & availability	Safer alternative?
EVOH copolymer-coated	Insufficient data	Insufficient data	Favorable	Insufficient data	Insufficient data
PE-coated	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data
PET-coated	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data
PLA-coated	Consistent with BM-3 – Favorable	Not applicable	Favorable	Insufficient data	Insufficient data
PLA foam	Consistent with BM-3 – Favorable	Not applicable	Favorable	Insufficient data	Insufficient data
PLA plastic	Consistent with BM-3 – Favorable	Not applicable	Favorable	Yes for some end users	Yes for some end users
Reusable trays	Not applicable	Not applicable	Not applicable	Yes for some end users	Yes for some end users

Table 37. Summary of assessment modules outcomes for food boats (Category 2).

Alternative substance	Hazard module	Exposure module	Performance module	Cost & availability	Safer alternative?
Kaolin clay-coated	Low concern – Favorable	Not applicable	Favorable	Favorable	Yes
PVOH-coated	Low concern – Favorable	Not applicable	Favorable	Insufficient data	Insufficient data
EVOH copolymer-coated	Insufficient data	Insufficient data	Favorable	Insufficient data	Insufficient data
PE-coated	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data
PET-coated	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data
Reusable boats	Not applicable	Not applicable	Not applicable	Yes for some end users	Yes for some end users

Table 38. Summary of assessment modules outcomes for pizza boxes (Category 3).

Alternative substance	Hazard module	Exposure module	Performance module	Cost & availability	Safer alternative?
Uncoated paper	Low concern – Favorable	Not applicable	Favorable	Favorable	Yes
Kaolin clay-coated	Low concern – Favorable	Not applicable	Insufficient data	Favorable	Insufficient data

Alternative substance	Hazard module	Exposure module	Performance module	Cost & availability	Safer alternative?
PVOH-coated	Low concern – Favorable	Not applicable	Favorable	Insufficient data	Insufficient data
EVOH copolymer-coated	Insufficient data	Insufficient data	Favorable	Insufficient data	Insufficient data

Table 39. Summary of assessment modules outcomes for open/French fry cartons (Category 3).

Alternative substance	Hazard module	Exposure module	Performance module	Cost & availability	Safer alternative?
Kaolin clay-coated	Low concern – Favorable	Not applicable	Insufficient data	Favorable	Insufficient data
PVOH-coated	Low concern – Favorable	Not applicable	Favorable	Insufficient data	Insufficient data
EVOH copolymer-coated	Insufficient data	Insufficient data	Favorable	Insufficient data	Insufficient data
PLA-coated	Consistent with BM-3 – Favorable	Not applicable	Favorable	Yes for some end users	Yes for some end users

Table 40. Summary of assessment modules outcomes for clamshells (Category 3).

Alternative substance	Hazard module	Exposure module	Performance module	Cost & availability	Safer alternative?
Uncoated paper	Low concern – Favorable	Not applicable	Insufficient data	Insufficient data	Insufficient data
PVOH-coated	Low concern – Favorable	Not applicable	Favorable	Insufficient data	Insufficient data
EVOH copolymer-coated	Insufficient data	Insufficient data	Favorable	Insufficient data	Insufficient data
PE-coated	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data
PLA-coated	Consistent with BM-3 – Favorable	Not applicable	Favorable	No	No
PLA foam	Consistent with BM-3 – Favorable	Not applicable	Favorable	No	No
PLA plastic	Consistent with BM-3 – Favorable	Not applicable	Favorable	No	No
Reusable clamshell	Not applicable	Not applicable	Not applicable	No	No

Table 41. Summary of assessment modules outcomes for interlocking folded containers (Category 3).

Alternative substance	Hazard module	Exposure module	Performance module	Cost & availability	Safer alternative?
Kaolin clay-coated	Low concern – Favorable	Not applicable	Favorable	Insufficient data	Insufficient data
PVOH-coated	Low concern – Favorable	Not applicable	Favorable	Insufficient data	Insufficient data
EVOH copolymer-coated	Insufficient data	Insufficient data	Favorable	Insufficient data	Insufficient data
PE-coated	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data
PLA-coated	Consistent with BM-3 – Favorable	Not applicable	Favorable	Insufficient data	Insufficient data
Reusable container	Not applicable	Not applicable	Not applicable	No	No

Summary of safer alternatives by food packaging application

To find that safer alternatives are available for each food packaging application, at least one alternative must meet the criteria for safer with no restrictions (noted as "Yes" in the tables in this section). We identified the following safer alternatives for each food packaging application:

Food packaging application: wraps and liners

- Wax-coated paper

Food packaging application: plates

- Kaolin clay-coated
- Reusable plates (for some end users)

Food packaging application: boats

- Kaolin clay-coated
- Reusable boats (for some end users)

Food packaging application: pizza boxes

- Uncoated paper

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Appendix A. Participating Stakeholders

The organizations below participated as stakeholders in this AA and agreed to be publicly acknowledged. We did not include additional stakeholders who did not agree to be acknowledged in this report. Ecology would like to gratefully acknowledge all stakeholders for supplying time and information to support this assessment.

Food packaging producers

- Dunn Paper
- Earth To Go
- Seaman Paper Company
- Transitions2earth
- World Centric

Chemical manufacturers

- Kuraray America
- NatureWorks LLC

Trade organizations

- Washington Food Industry Association
- Washington Hospitality Association

Government agencies

- City of Sedro Woolley
- Island County Public Health
- Minnesota Pollution Control Agency
- Seattle and King County Public Health
- U.S. EPA Region 10

Non-governmental organizations (NGOs)

- Center for Environmental Health
- ChemForward
- Clean Production Action
- National Environmental Management Academy
- National Sierra Club
- Toxic-Free Future
- Whidbey Island Water Systems Association
- Zero Waste Washington

Others

- Aquagga Inc.
- BeachEdge Consulting
- Biodegradable Products Institute
- Compost Manufacturing Alliance
- Environmental & Public Health Consulting

Appendix B. Stakeholder Recruitment Survey

Overview

We invited stakeholders via email and the Chemical Action Plan (CAP) website[77] to participate in a web-based survey (available from February 13, 2019 to August 2, 2019) aiming to identify and recruit interested parties for this AA. Thirty-three people completed the survey.

Stakeholder and suggested contacts survey questions

In 2018, Washington state passed a law to prohibit all per- and polyfluorinated substances (PFAS) in plant fiber-based food packaging. The ban takes effect following the identification of safer alternatives (not limited to paper)—as specified in the toxics in packaging law (RCW 70A.222[78]).

Ecology will be assessing PFAS materials and potential alternatives in food packaging products, and will consider chemical hazard, exposure, performance, cost and availability. An established alternatives assessment model that emphasizes stakeholder engagement will be used. In doing so, we are seeking to build an inclusive and representative list of stakeholders to provide input/feedback on this effort.

Stakeholders may provide information covering Alternative substances identification, Function and performance, Manufacturing considerations, Cost considerations (as it conforms to anti-trust best practices), Hazard and exposure data, and General experiences concerning use. The time commitment will be flexible and driven by the stakeholder.

Stakeholder engagement will consist of two scheduled webinars and individual interactions, as needed. Ecology can provide protections for CBI, should stakeholders be interested in providing that information. If you are interested in participating in this effort, please fill out and submit this questionnaire by Friday, February 22, 2019.

1. Q1: Are you interested in participating as a stakeholder? (Yes/No/Maybe)
2. Q2: Stakeholder background (click best that applies):
   - Chemical manufacturer/processor/importer
   - Supplier
   - NGO
   - Trade organization
   - Product manufacturer (B2B)
   - Product manufacturer (consumer-facing)
   - Retailer
   - Government
   - Academia/research groups
   - Other [text]
3. Q3: Are there data/information/perspective that you would like to contribute? (Yes/No)

[77] https://www.ezview.wa.gov/?alias=1962&pageid=37105

[78] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.222

Appendix C. End User and Consumer Questionnaire

Introductory food packaging questions for purchasers or end users

1. Approximately, how much paper food packaging do you purchase?

2. What types of food packaging products do you purchase most often (select all that apply)?

- Paper wrappers/sleeves
- Bags
- Trays
- Food Boats
- Clamshells (single or multi-compartment)
- Folded containers (including pizza boxes)
- Plates/bowls
- Cups
- Other: [Please specify]

3. When purchasing a paper food packaging product, what factors do you consider important in your decision (1 - disagree; 2 - neutral; 3 - agree):

- Factor
- Price
- Aesthetics
- Brand
- Brand reputation
- Material sourcing (i.e., recycled content)
- Sustainability certifications or ecolabels
- Grease-proofing
- Recyclable
- Compostable
- Keeps food hot
- Keeps food crisp
- Ability to hold shape
- Leak proof

4. When purchasing products requiring oil and grease resistance, how do you determine which products will meet your needs? (Examples: previous use history; performance testing results; product descriptions)

5. Have you ever intentionally substituted or selected a food packaging product to avoid perfluoroalkyl substances (PFAS)?

Appendix D. Stakeholder Product Scoping Survey

Overview

We solicited stakeholder input and information to help identify a scoping strategy that balanced assessment requirements under IC2 guidelines with the project budget and time constraints. The goal was to limit the scope of this assessment to product/market sectors of food packaging that met the goals of the project and the requirements of the law.

We conducted a survey to help inform product scoping strategies (released on July 1, 2019 to all stakeholders via the PFAS CAP email list, PFAS CAP website,[79] and direct email). We accepted responses through July 31, 2019. Twenty-two stakeholders submitted responses.

At the time of this survey, we were considering three scoping strategies: prioritizing products by either market share size, packaging application, or whether the product was made from molded fiber.

Product scoping survey questions presented to stakeholders

Introduction

In 2018, Washington state passed a law to prohibit all PFAS in plant fiber-based food packaging. The PFAS ban takes effect following the identification of safer alternative products, as described in the Toxics in Packaging law (RCW 70A.222[80]). The law requires an alternatives assessment (AA) be conducted and that it must consider chemical hazard, performance, cost and availability, and exposure. Alternatives may include chemical substitutions, alternative materials, or product redesign eliminating the need for PFAS substances.

While initial screening for the identification of alternatives will be as broad and inclusive as possible (and include both existing and emerging alternatives), there is a need to apply a scoping strategy to balance assessment requirements under IC2 guideline within the budget and time constraints of this project. SRC's goal is to limit the scope of this assessment to product/market sectors for food packaging that results in a scientifically justifiable assessment whilst meeting the goals of the project and the intent of the law.

This survey discusses several perspectives for scoping, and allows for feedback and questions from stakeholders. This survey is only one method of research we are performing to frame the scope. These are not the only perspectives that may be considered for scoping. This survey intends to obtain stakeholder insights. We appreciate any insights or information you can provide on any or all the following perspectives on this critical topic:

1. **Limit the focus on molded fiber chemical pulp additives**: Molded fiber products produced without PFAS additives appear to be limited. Therefore, alternatives for wet-end pulp additives for molded fiber applications would be outside the scope of this assessment.

[79] https://www.ezview.wa.gov/Portals/_1962/Documents/PFAS-Food/PFAS%20AA%20July%202019%20update.pdf
[80] https://app.leg.wa.gov/RCW/default.aspx?cite=70A.222

2. **Focus on alternatives for larger market segments by product type:** Focus on identification of viable alternatives for the most prevalent product types where the use of PFAS for oil, grease, and water repellency is commonplace—thus, maximizing reach and impact.
3. **Focus on market sectors with largest impact:** If justified, the scope of the assessment could be narrowed by market segments, such as Quick-Service Restaurants (QSRs) vs. Consumer-Packaged Goods, particularly if there is a notable delineation of technologies used for these types of markets.

Disclaimer: Any information or insights disclosed in this survey that are proprietary or CBI are not protected and will be considered part of the public record.

Scoping perspectives

Perspective 1: Limit Focus on Alternatives for Molded Fiber Additives.

Molded fiber products consistently test positive for fluorine regardless of the base fiber material used (Chiang et al., 2018). Based on publicly available information and stakeholder feedback, there appears to be limited alternatives for wet-end chemical additives for molded fiber products that provide grease-proofing function. While manufacturers may be currently developing non-PFAS solutions to meet updated Building Performance Institute (BPI) certifications on compostability, the number of alternatives to assess for this application appear to be limited (Blake et al., 2018; Chiang et al., 2018). Although base material alternatives (i.e., PLA plastics) may offer avenues of substitution for this product type.

Questions to consider:

- Do you agree that there are limited options for molded fiber products produced without PFAS additives for the purposes of grease, oil, and water repellency?
- Have you successfully adopted a non-PFAS alternative that would apply to this perspective or do you know of examples of successful adoption? Explain.
- As a stakeholder, what barriers or concerns do you have, or have you encountered for adopting alternatives to molded fibers produced with PFAS additives?
- Do you have any additional comments or insights for applying this perspective to the scoping strategy?

Perspective 2: Focusing on alternatives for larger market segments by product type (pizza boxes, cartons, food wraps/liners, clamshells, pastry boxes).

Certain product types have alternative materials and treatments currently available, including bowls, take-out containers, plates, clamshells, trays, bags, wraps, and liners (CPA, 2018a; CPA, 2018d; CPA, 2018e). Corrugated and paperboard boxes and cartons make up a large percentage of foodservice single-use containers used in the U.S., with trends toward more use of paperboard take-out containers. Clamshells are also a large single-use container product segment (The Freedonia Group 2017). This perspective would focus on identifying viable alternatives for the most prevalent product types where the use of PFAS for grease-proofing is commonplace—therefore, maximizing potential impact of the assessment.

Questions to consider:

- Are the products that have been reported as containing higher levels of fluorine or PFAS consistent with your perspective on the use of PFAS for oil, grease, and water repellency in these product types?
    - For example: Schaider et al. (2017) detected fluorine (as a potential marker for PFAS) in 56% of sampled dessert/bread wrappers, 38% sampled sandwich/burger wrappers, and 20% of sampled paperboard.
- From your perspective, what types of products have challenging or specific performance requirements concerning oil, grease, and water repellency that may make substitution difficult (i.e., microwave popcorn bags)?
- As a stakeholder, what barriers or concerns do you have, or have you encountered for adopting alternatives in these product types?
- Have you successfully adopted a non-PFAS alternative that would apply to this perspective or do you know of examples of successful adoption? Explain.
- Do you have any additional comments or insights for applying this perspective to the scoping strategy?

Perspective 3. Focusing on market sectors.

According to an industry study (The Freedonia Group, 2017), in 2016 quick service restaurants (QSRs) accounted for 41% of the U.S. foodservice single-use products market, followed by full service (14%), retail (11%), institutional (9%), coffee and snack (8%), fast casual (5%), and hospitality (5%) markets. This perspective would narrow the scope to larger market segments, like QSR's, where PFAS has documented use—thus, maximizing potential impact.

Questions to consider:

- Do performance requirements or product offerings differ between market segments (i.e., QSR's vs. institutional)?
- Have you successfully adopted a non-PFAS alternative that would apply to this perspective or do you know of examples of successful adoption? Please explain.
- As a stakeholder, what do you see as barriers or concerns for adopting alternatives in these market sectors?
- Do you have any additional comments or insights for applying this perspective to the scoping strategy?
- Other: Do you have any other thoughts concerning product scoping for this assessment?

Please indicate if:

1. You would like us to contact you regarding scoping of the alternatives? (Yes/No)
2. Participate in a moderated group call? (Yes/No)
    - Alternatively, you can provide comment via email.
3. Is this your first time participating in this stakeholder engagement process? (Yes/No)
4. Contact Information (name, organization or affiliation, email, phone number optional).

Appendix E. Stakeholder Responses to the Product Scoping Survey

Responses to Product Scoping Survey

Perspective 1: Limit focus on alternatives for molded fiber additives.

Q: Do you agree that there are limited options for molded fiber products produced without PFAS additives for the purposes of grease, oil, and water repellency?

1. No, there are plenty of molded fiber products without PFAS in them. We need to have this in the mix it makes the most sense and it is likely the most recyclable of all the products out there now.
2. Yes.
3. Strictly speaking, this question answers itself. To the more useful question of whether there is a paucity of options for producing molded fiber products without PFAS, I don't have the expertise to really say, but with the incredible variety of substances and structures in nature that exhibit oil, grease, and/or water repellence, I am skeptical that this is truly the case.
4. From my base of general knowledge, yes.
5. Yes
6. Yes. There is performance, compliance, sustainability, and cost considerations.
7. The nature of molded fiber products may not provide long lasting repellency, but for most purposes (short-term use) their use may be sufficient. However, an alternative to the molded products could be better from both a use and chemical perspective.
8. From my current knowledge and understanding, yes. The way PFAS chemistry physically works is different enough that an alternative would be introduced into the molded fiber manufacturing process differently and physically function differently.
9. We do not participate in that portion of the industry, but we have been told by both suppliers and manufacturers that solutions are not readily available.
10. Yes.
11. Yes, absolutely.
12. Yes, but that's not the question we should be asking. The question is: Do we really need all this supposed grease, oil, and water repellency? I would answer no. All of this is just to further wasteful practices of single-use stuff.
13. Yes.
14. Based on SME's experience with pulp and paper manufacturing facilities and food packaging companies, we agree that there are limited or no "safer alternatives" to PFAS available for use in molded fiber articles that can be practicably and economically substituted.
15. Yes.

Q: Have you successfully adopted a non-PFAS alternative that would apply to this perspective or do you know of examples of successful adoption? Explain.

1. I have not done enough research at this time.
2. Not yet—we are working on one, however, the performance isn't nearly the same. There is a competitor that has launched a limited line of PFAS free products. We are only aware of one.
3. No.
4. We get what the vendors send us.
5. My company does not produce additives for paper products, however PTFE which is used for other types of packaging applications seems to be in scope now. I don't know if this is intentional or an "unintended consequence."
6. Not applicable to my stakeholder food packaging categories.
7. No.
8. Yes. We have a coating binder that provides oil and grease, moisture, and oxygen barrier resistance. The material has strong binder properties and barrier properties. It is also a sustainable material, e.g., recyclable, repulpable, biodegradable.
9. Yes. Taco Time has all PFAS-free food compostable packaging and they sell soups and stews that come in cups that are grease, oil, and water repelling. These may not be molded, but are promising alternatives.
10. No
11. We have not. I have been told by several chemistry providers that they believe they have a solution in development.
12. No, still under development.
13. I know of only one molded fiber product that is in the marketplace that uses a non-PFAS wet-end alternative (Eco-Products's Vanguard line).
14. Quit buying stuff that is single-use junk. Let businesses know you don't like treated single-use packaging.
15. No.
16. Not aware of any safer alternatives to PFAS for use in molded fiber applications that can be practicably and economically substituted.
17. No.
18. Yes this information appears to be accurate.
19. We agree that, for molded fiber products, there are few, if any, alternatives that provide performance benefits (oil and grease resistance) equal to those offered by FDA-approved PFAS additives. The potential alternatives that we are aware [cut off].

Q: As a stakeholder, what barriers or concerns do you have or have you encountered for adopting alternatives to molded fibers produced with PFAS additives?

1. The alternatives all have challenges that are worse than the PFAS additives.
2. I'm concerned that business profit will be prioritized over negative impacts to human health and the environment.

3. Packaging continues to get weaker and weaker, which has significantly increased damage and safety concerns when loading and unloading product for delivery.
4. Not applicable to my stakeholder food packaging categories.
5. The challenges are in finding alternatives that meet all key attributes, i.e., barrier performance, cost effectiveness, food contact compliance, and sustainability needs.
6. None. I think this is an adaptable market and consumers and restaurants can adjust accordingly. If non-molded materials are better alternatives, they should be considered.
7. For technologies we evaluated on non-treated but dry molded fiber articles, the substrate was so porous that the aqueous liquid system to apply low concentrations of additive absorbed too deeply into the container. The amount of additive needed was high relative to a PFAS that rests on the top surface without soaking in. The physical nature of that alternative was too different for such an absorbent system as untreated molded fiber. (Soaked up additives like a sponge.)
8. We have been told by basically all molded fiber producers that a solution has not been determined/found.
9. Criteria for solution adoption includes: cost/price structure, aesthetic, feasibility (based on current technology), efficiency, product performance.
10. Cost, performance, and market availability.
11. Perceived convenience and necessity—but false.
12. No current technology to replace PFAS with adequate grease resistance for paper.
13. No safer alternatives to PFAS additives have been identified that can be practicably and economically substituted in molded fiber applications. It is worth noting that short-chain PFAS are approved for use by FDA in food packaging. As recently announced by the FDA, they have continued to perform extensive testing on PFAS, and have not found any indication that these substances are a human health concern.
14. (1) Will the PFAS alternative be considered safer (i.e., will it avoid regrettable substitutions)? (2) Will grease-resistant functionality perform as well or better than PFAS? (3) Will packaging treated with PFAS alternatives be available at scale and at a similar cost?
15. No, I am not familiar with alternatives for molded fiber products.
16. We are not aware of the successful adoption of non-PFAS alternatives at any scale. Generally speaking, the types of barrier chemistries that are available for use in these applications are:
    a. Film (physical) barriers
    b. Hydrocarbon
    c. LDPE, PP, wax
    d. Synthetic
    e. PVAc, PET, cPET, PVOH
    f. Latex acrylic, styrene acrylic, SB, vinyl acrylic
    g. Natural modified starches
    h. Chemical barriers

i. Perfluoroacrylate copolymers
j. Perfluoropolyethers (PFPE)
k. Other
l. Pigment hyper-platy kaolin
m. None of the other options highlighted here provide equivalent performance to the 'chemical barrier' food packaging categories that are also compostable (ASTM 6868), FDA-approved, and have acceptable cost-in-use, which is why they are not in widespread commercial use.

Q: Do you have any additional comments or insights for applying this perspective to the scoping strategy?

1. Yes. That the burden of proving that there are safe ways to package falls on the state is a shame to our democracy and our society. Of course there are safe ways to package, and the state can legitimately require that packaging be safe. If industry is truly so creative, surely a few ways to package without using dangerous chemicals can be achieved. If we had any sense, we would require manufacturers to prove that their packaging products are safe before selling or distributing them, rather than our current system of requiring the state to prove moving away from toxic constituents is not too expensive—and even requiring the state to come up with viable technical solutions for industry. Weren't they supposed to be the creative ones?
2. PTFE is a stable, solid polymer which, when used for packaging applications, would be bound in the film of coatings.
3. Should try to include independent labs as stakeholders, i.e., independent groups who understand evaluate sustainability, product manufacturing, product performance, barrier performance (recyclability, repulpability, biodegradability, compostability) as well as barrier performance. One such organization is the Paper Lab at Western Michigan University. There are others. This requires an understanding of product (e.g., paper, paperboard, packaging), of barrier, and other key end-use performance properties, and of sustainability properties (e.g., recyclability, repulpability, biodegradability, and compostability).
4. Do not limit the alternatives to only molded fiber products if other materials exist that would provide PFAS free alternatives.
5. None.
6. Molded fiber articles provide a valuable use for recycled fiber and should continue to be considered separately from other paperboard products.
7. No.
8. None.
9. There are no treatments of which we are aware, for molded fiber products, that provide barriers to oil and grease that are as effective as those provided by FDA-approved PFAS compounds. Non-molded fiber alternatives, including, for [cut off].

Perspective 2: Focusing on alternatives for larger market segments by product type.

Q: Are the products that have been reported as containing higher levels of fluorine or PFAS consistent with your perspectives on the use of PFAS for oil, grease, and water repellency in these product types?

1. They do not need the repellent properties as the industry is claiming just use paper fiber without PFAS, if my burger leaks it leaks, my apologies if this comment doesn't exactly fit here.
2. No.
3. I don’t know.
4. Yes, products used for greasy/oily foods have the treatments.
5. Yes.
6. Yes.
7. The first 2 categories indicate the food which I expect to be used with a grease resistant paper product. The 3rd, paperboard, doesn't include any rationale for why some had a fluorinated and presumably cost efficient grease resistant treatment. I don't regard fluorine as essential for grease resistant structures, but it was long accepted to economically treat some paper structures.
8. Yes. PFAS chemistry is widely used by the paper industry for food packaging production.
9. Yes, but should also be noted that the study did not look for PFAS—only fluorine. And, a number of the items included in the study would not use PFAS, i.e., paper cups, as instead they use a poly lining.
10. Yes, while not conducting as extensive a survey as that sited, testing of many of those products has consistently shown the presence of fluorine in a number of the samples.
11. I cannot cite the stats off the top of my head, but generally yes it's in keeping with my research on the topic. What is so obvious here, but generally not discussed is just not using any oil, grease, and water repellency. If only 56% of these products have PFAS, then 44% do not. So if 44% of products don't have PFAS it clearly demonstrates it’s not really needed—it's some perceived convenience.
12. It seems that the tests detect fluorine atoms but don't identify the source. Is any fluorine coming from fluoridated waters. Is any fluorine coming from the trees that are pulling it from their environment?
13. SME does not recommend reliance on any studies where conclusions are based solely on total fluorine concentrations. This is an unreliable indicator.
14. Yes.
15. No.
16. No.

Q: From your perspective, what types of products have challenging or specific performance requirements concerning oil, grease, and water repellency that may make substitution difficult (i.e., microwave popcorn bags)?

1. Need a list and then I can go one by one and describe specific requirements and the alternatives if any are needed.
2. Take-out boxes used for very greasy foods; plates for room service that are heated up or held for long periods of time.
3. There is nothing wrong or anti-capitalistic with allowing the natural consequences of higher prices or decreased frequency of production and consumption to occur for products that are inherently difficult or expensive to safely package. Allowing those natural consequences to occur without subsidizing the cost down by allowing toxic packaging materials would actually be the most free-market (and ecologically responsible) thing to do.
4. Not applicable to my stakeholder food packaging categories.
5. Pizza boxes & clamshells.
6. All have their challenges. Hot temperature, high humidity's, high moisture, long shelf life, thin structures, heavy products, etc. are all big factors, and combinations of these factors are significant challenges. Therefore microwaveables, hot.
7. Alternatives exist that can fulfill multiple use substitutions. All should be explored to determine feasibility.
8. Generally speaking, the more constraints—more requirements that are not negotiable—the fewer solutions there would be. With microwave popcorn bags, the arcing concerns with metal, the need for paper, the need for a package that unfolds and expands in shape during the cooking, the need to have solid grease included as an ingredient and contained for a lengthy shelf life, the need to have a right side up orientation for cooking, and a heat concentration cooking base in the package -- all these resulted in a very focused if not unique solution.
9. Kit test specifications provide good visibility to this. The low kit products (kit 5 and lower targets) are relatively available by a wide range of suppliers. Higher kit targets (kit 7 and above) are more difficult to achieve and there are fewer suppliers who can develop the approaches. Microwave popcorn is one of the most difficult applications, but solutions do still exist.
10. Interlocking folded containers for use with oil-based or high moisture food applications.
11. Microwave popcorn bags would be at the top of the list, although we are working with suppliers for microwave safe coatings and paper that could potentially provide a solution. The coating is undergoing a compliance review at this time to confirm FDA suitability.
12. Microwave popcorn bags and certain pet food bags.
13. Yes, several products that go directly into formed fiber packaging would require specific grease repellency performance or considerations. For example: salad bars containers

need to hold our dressing, pizza packaging, bakery goods, if used for deli items such as meats and salads, bulk nuts, etc.

14. Yes, these represent the largest segments for the use of fluorine/ PFAS at higher levels.
15. Based on our experience in the market, the following types of packaging applications account for a major share of PFAS used in food packaging nationally: 1) quick service restaurant (QSR) food packaging (clamshells, folded boxes, sandwich wrap, French fry/hash brown/dessert sleeve),2) popcorn bags (particularly movie theater bags and/or microwavable bags with/without microwave receptors), 3) pet food bags (multi-wall construction bags with and/or without plastic liners), and 4) retail food packaging (e.g., cracker & snack food/cookie boxes, pastry boxes and inner liners, and cake/icing mix boxes, inner liners and bags). In order to maximize the utility and effectiveness of the AA, priority should be placed on the specific food packaging types that have the greatest volumes of sales in the state of Washington.

Q: As a stakeholder, what barriers or concerns do you have, or have you encountered for adopting alternatives in these product types?

1. I am concerned that customers will just go back to Styrofoam.
2. I'm concerned that business profit will be prioritized over negative impacts to human health and the environment.
3. Weak cardboard, or 100% plastic packaging has made it extremely difficult to select, convey, and load the product without excessive damage and safety concerns.
4. Concern is that PTFE seems to have been brought into scope of PFAS materials, but it is a different type of material than that used for grease-proofing of paper, etc.
5. Not applicable to my stakeholder food packaging categories.
6. Price competitiveness (PFAS free liners are generally 20 – 30% more expensive; only one mill in U.S. currently selling PFAS & non PFAS at same price), NGOs lobbying on behalf of mills who make PFAS claiming no health concerns.
7. As a coating additive, the biggest challenge is meeting performance at cost-effective coat weights. The significant factor for this is having a substrate surface that keeps the coating on top, i.e., minimize penetration. This optimization performance and cost.
8. Knowing which ones are PFAS free.
9. Performance aesthetics. Most brands are very inflexible on the visual appearance of the materials, regardless of true performance. Performance of alternatives will be barrier based versus chemical repellency of PFAS. Performance will be different. Cost. Cost continues to be a challenge as many of the alternative products are in their infancy so costs are high now in comparison to a very mature PFAS industry.
10. Criteria for solution adoption includes: cost/price structure, aesthetic, feasibility (based on current technology), efficiency, product performance.
11. Cost and performance of an alternative.
12. Pricing has been the largest barrier “brands historically did not want to pay for PFAS alternatives that might have been slightly higher in cost (about 10%).

13. If you decide to buy a fast food product, you'll likely get some PFAS coated packaging. The average person doesn't know or care about PFAS—they just want their hamburger.
14. Performance level and accepted as a food contact indirect additive.
15. (1) Will the PFAS alternative be considered safer (i.e., will it avoid regrettable substitutions)? (2) Will grease-resistant functionality perform as well or better than PFAS? (3) Will packaging treated with PFAS alternatives be available at scale and at a similar cost?
16. Chicken buckets, microwave popcorn bags.
17. The premise of this survey question is troubling because it appears to be inconsistent with the plain language of the law. The law requires the AA to assess whether, for any given food packaging application, a proposed alternative performs "as well as or better than" PFAS. The law does not allow Ecology to assess, as part of its comparative performance analysis, whether certain market sectors or users of packaging have performance requirements that are more or less "demanding" in terms of oil and grease resistance. Since the alternative must, under the law, provide oil and grease resistance equal to PFAS, rather than focusing on "specific performance requirements concerning oil, grease and water repellency," the AA should consider whether specific food packaging types have other performance requirements (beyond oil and grease resistance) that can or cannot practically be satisfied by non-PFAS alternatives. Each of the packaging categories identified in our response to Question #5 has at least one additional performance aspect that is essential, along with the general requirement to provide oil and grease penetration resistance. As an example, QSR clamshells must provide thermal insulation during their useful service life (typically under 10 minutes). This requires the clamshell to have a fluted construction to provide insulation. In order to create this construction, the grease & oil repellant paper used must be able to absorb the glue used to hold the fluting to the paper. This glue has oleophilic components. The balance of animal-based oil and grease repellency with the ability to still absorb the glue required to construct the clamshell is a secondary performance aspect that is only achievable with polymeric C6-based fluororepellents.

Q: Have you successfully adopted a non-PFAS alternative that would apply to this perspective or do you know of examples of successful adoption? Explain.

1. No. Eco-Products launched a PFAS free line but don't know if it works well.
2. No.
3. Currently evaluating.
4. Not applicable to my stakeholder food packaging categories.
5. In process. We are giving our customers who currently use PFAS papers the option to switch with no up-charge. We are using a lower basis weight sheet with comparable strength properties to negate increased costs. We have successfully.
6. Yes. As mentioned above, we have a coating binder that has demonstrated performance at acceptable cost in full-scale trials. It is already a commercial product used extensively

in other coating type applications, i.e., adhesives for barrier needs. It also a sustainable product, which for the paper and paperboard industry is very important, i.e., repulpable, recyclable, biodegradable.

7. Talk to the supplier for Taco Time.
8. There are of course other materials—glass, metal, plastic, that have potential. To remain in paper or paperboard, there are plastic coatings of varying coating weights or the potential to metallize or use SiOx (chemically like glass) barrier
9. Yes, we have a very broad range of products that meet requirements from low kit specifications all the way up to microwave popcorn applications. We have worked with all the significant brand owners in the QSR and CPG spaces, understanding the challenges of their position.
10. No, still under development.
11. I understand there are several (many?) non-PFAS alternatives when it comes to wraps. However, I understand it may not perform as well, and it costs more.
12. Yes, such an adoption was successfully completed for hot dog sleeves and other QSR sandwich packaging. In addition, lab testing demonstrated that the substitute products could be successful in replacing PFAS containing packaging in a multitude of applications.
13. Yes, I don't buy that stuff. If people just limited their use and expressed concern whenever they received it, it would change.
14. No alternatives successfully adopted at this time.
15. No.
16. Testing methodology for OGR performance is the Kit Test, which is not a suitable/ accurate method for non-Fluorine materials. The Kit Test relies upon measure of/ changes to the contact angle for dilutions of Toluene, which is unique to Fluorine-based products primarily. As such, performance requirements are based upon a non-suitable test method for performance and represent a difficult row to hoe for alternatives. Modification of Kit Test or an alternate test(s) are necessary. These are being identified by individual players/ producers versus the industry group as a whole.
17. Generally, alternative treatments do not provide the same degree of performance benefits (oil and grease resistance) as FDA-approved PFAS additives. In addition, alternative materials and/or coatings, including plastic and/or wax, are typically either substantially more expensive (which would be a particularly onerous burden for small businesses) and/or less recyclable and/or compostable than paper packaging treated with FDA-approved PFAS compounds and they may not provide other performance characteristics that are essential for a given type of packaging (as discussed in our response to Question #6).

Q: Do you have any additional comments or insights for applying this perspective to the scoping strategy?

1. I would like to see the scope look at [whether] these products that need these properties even need the repellency they claim they do. Is it for consumers? The consumers do not care just make the packaging recyclable and safe, as I stated earlier if it leaks it leaks the consumer does not care!
2. Yes. That the burden of proving that there are safe ways to package falls on the state is a shame to our democracy and our society. Of course there are safe ways to package, and the state can legitimately require that packaging be safe. If industry is truly so creative surely a few ways to package without using dangerous chemicals can be achieved. If we had any sense, we would require manufacturers to prove that their packaging products are safe before selling or distributing them, rather than our current system of requiring the state to prove moving away from toxic constituents is not too expensive—and even requiring the state to come up with viable technical solutions for industry. Weren't they supposed to be the creative ones?
3. I think that PTFE or other stable, high molecular weight fluoropolymers should not be in scope.
4. PFAS-free liner grades are readily available and perform the same as PFAS papers. Many of the mills making PFAS-free, however, are gouging the market, in my opinion to deter transitioning from PFAS.
5. There are many laminate and film based packaging structures that can provide sufficient barrier properties. However, these fall short when you add in the need for sustainability. A coating system that has components and a structure that is sustainable and provides the needed barrier performance is the ideal system. That's why I favor a coating based barrier system.
6. Focusing on the materials with the biggest use makes sense for an initial step. This seems like the best strategy of those suggested in this survey.
7. I believe this segmented product approach is a good approach and allows for maximum coverage of the majority of the current PFAS treated applications.
8. No.
9. None other than the technology and production capabilities exist to provide PFAS-free products for a host of QSR/take-out packaging.
10. Most of PFAS use was not a decision made by consumers. It was hidden decision made by manufacturers so they could market their products better. Those hidden decisions should be mandated to be revealed.
11. Yes, we have implemented non-PFAS alternatives with producers of OGR packaging materials. Starch-based films can be applied using the same application techniques for OGR paper production for the last decade. Successful adoption requires implementation of testing techniques that can be used for QC testing that are not exclusively based upon

Kit Test requirements, but rather a variety of oil testing methods that correlate to the application of the paper product; i.e., french fry bags, burger wrap, etc.

12. We are not aware of the successful adoption of non-PFAS alternatives at any scale. FDA-approved PFAS polymer-treated paper and paperboard satisfy the key requirements of the packaging market for solutions that: meet performance requirements, are safe for their intended use, are cost effective, and reduce waste. Currently-available alternatives to FDA-approved PFAS polymer-treated paper and paperboard cannot meet all of these key requirements.

Q: Do performance requirements or product offerings differ between market segments (i.e., QSR vs. institutional)?

1. No.
2. It's host food and hold time dependent, not necessarily dependent upon the segment.
3. Yes, but there are also similarities.
4. I do not believe that PTFE is used in these applications.
5. Not applicable to my stakeholder food packaging categories.
6. No, the same PFAS papers used in QSR get used for institutional, fast casual, etc.
7. Yes. Some applications need longer performance shelf life. Some have harsher conditions. Some have requirements of high strength. Each of these types of end-use requirements will dictate product structure and feature, i.e., substrate.
8. I think the industry study wasn't focused on your issue of PFAS elimination because the asserted focus was single-use foodservice products. PFAS is a paper based foodservice product issue not a single-use foodservice product issue.
9. Yes. QSR's have the broadest use of PFAS, and also have a wide range of performance attributes. My opinion is that there is better understanding of the application requirements of the QSR market than institution for example, and that the QSR market is better suited for change in this way.
10. Performance consistent, product offering marginal difference.
11. No.
12. Not to a great extent and the technology exists to address both, ideally with the same solution for volume advantages but with the option to have two solutions for a given application/segment.
13. Don't know. We provide consumer products.
14. The type of food going into a package (vs. the type of segment) strongly influence performance requirements. However, there may also be some different needs depending on how long the food item is expected to be in the packaging. For instance, QSR might pack in fiber with the expectation food will be consumed sooner than later so barrier would not need to withstand the same amount of time. On the contrary, if it's something that would be packaged and displayed for any length of time the performance requirements may be different.

15. Adoption of alternative testing methodology beyond Kit Test is challenging as producers aren't open and about sharing techniques that give them a competitive edge. Thus, producers are using multiple alternative tests to support their performance.
16. The AA must be conducted in a manner that conforms to the letter and the intent of the law. Among other things, this means that the AA must examine specific packaging applications and, for each application, determine whether alternatives are available that (i) provide oil and grease resistance that is at least as effective as FDA-approved PFAS compounds; and (ii) satisfy other performance requirements at least as well as FDA-approved PFAS compounds. In addition, to maximize the utility of the AA, priority should be placed on the specific food packaging types that have the greatest volumes of sales in the state of Washington. Consistent with the law, the AA should focus on sales of packaging in Washington, as opposed to sales of packaged food. Thus, for example, the AA should examine sales of popcorn bags, rather than sales of microwave popcorn on supermarket shelves.

Q: Have you successfully adopted a non-PFAS alternative that would apply to this perspective or do you know of examples of successful adoption? Explain.

1. No.
2. No.
3. Currently evaluating for other applications.
4. Not applicable to my stakeholder food packaging categories.
5. Yes, we transitioned a mid-sized C-store to PFAS-free without issue. They use an off-site facility to make sandwiches, which are distributed to stores, our paper is used to wrap the sandwiches and we have had no complaints since transitioning. We are targeting mid-sized QSR's who want to switch without increased cost and mid-sized QSR's in geographies impacted by PFAS in food packaging bans.
6. Coatings can be applied to most all substrates. These can control key properties and end uses, i.e., strength, converting, moldability, environmental conditions, impact resistance, etc. Being a coating binder that can provide barrier [cut off].
7. Yes, we have been able to develop PFAS alternative solutions for almost every portion of the QSR market. There have been several chains/brands that have already adopted PFAS free solutions, and almost all of them are working on them in some way.
8. No, still under development.
9. Yes, as noted in an earlier response such an adoption was successfully completed for hot dog sleeves and other QSR sandwich packaging. In addition, lab testing demonstrated that the substitute products could be successful in replacing PFAS containing packaging in a multitude of applications.
10. No.
11. No.
12. Yes, using the Kit Test as an example, paper products that have a high Kit Test requirement do so to overcome the grease penetration challenge of the application. The

greater the grease penetration requirement, the higher the Kit Test that is required; ranging from somewhat resistant to grease to completely impervious to hot grease.

13. This question seems to miss the fundamental point that performance requirements and product needs may vary greatly within a given market sector, depending upon the types of food being offered, the manner in which the food is prepared, local customer preferences, and similar factors. Moreover, as stated previously, with respect to product performance, the law requires the AA to assess "for any given food packaging type" whether a proposed alternative provides oil and grease resistance that is as good as or better than the protection offered by FDA-approved PFAS compounds. This requirement applies across all packaging types and all market sectors.

Q: As a stakeholder, what do you see as barriers or concerns for adopting alternatives in these market sectors?

1. Product will not perform as well and customers will go to options that are worse for the environment.
2. I'm concerned that business profit will be prioritized over negative impacts to human health and the environment.
3. Price, if PFAS-free were cost neutral all QSRs would switch. Supply, the mill making cost neutral PFAS-free might lose all capacity to one end user.
4. Generally, across the various alternatives being studied, it's sustainability, durability, strength, shelf life, and meeting the high levels of barrier performance while also being cost effective.
5. Specification requirements. PFAS alternatives will need new specifications and will require changes to the visual appearance (at times to a product). Cost will be an issue. The QSR market is extremely cost sensitive. This cost sensitivity may limit alternatives or may drive the alternatives to have less performance.
6. Criteria for solution adoption includes: cost/price structure, aesthetic, feasibility (based on current technology), efficiency, product performance
7. Cost (especially for low-cost QSR items), performance and market availability (especially for large QSR chains).
8. None. Initially there would likely be production limitations depending on the adoption rate/plan, but that could be coordinated to minimize any such disruptions/concerns.
9. (1) Will the PFAS alternative be considered safer (i.e., will it avoid regrettable substitutions)? (2) Will grease-resistant functionality perform as well or better than PFAS? (3) Will packaging treated with PFAS alternatives be available at scale and at a similar cost?
10. Yes, my employer produces non-PFAS alternatives that can be used for the market segments that you have outlined; QSR and institutional. PFAS materials are very effective at matching the requirements of these applications, and therefore the application costs are known and predictable and have been made cost effective over the last 20 years. Application of alternatives are more of a challenge for the producers;

which requires producers and supplier companies to push the application limitations of the manufacturing equipment, which can be a significant challenge in terms of handling the engineering capabilities and manufacturing costs, as more of alternative materials are required to achieve the same level of performance.

11. As explained in our response to Question #8, we are not aware of the successful adoption of non-PFAS alternatives at any scale. FDA-approved PFAS polymer-treated paper and paperboard satisfy the key requirements of the packaging market for solutions that: meet performance requirements, are safe for their intended use, are cost effective, and reduce waste. Currently-available alternatives to FDA-approved PFAS polymer-treated paper and paperboard cannot meet one of these key aspects, such as higher cost or weight, loss of recyclability, and/or lower performance.

Q: Do you have any additional comments or insights for applying this perspective to the scoping strategy?

1. Yes. That the burden of proving that there are safe ways to package falls on the state is a shame to our democracy and our society. Of course there are safe ways to package, and the state can legitimately require that packaging be safe. If industry is truly so creative, surely a few ways to package without using dangerous chemicals can be achieved. If we had any sense, we would require manufacturers to prove that their packaging products are safe before selling or distributing them, rather than our current system of requiring the state to prove moving away from toxic constituents is not too expensive—and even requiring the state to come up with viable technical solutions for industry. Weren't they supposed to be the creative ones?
2. The industry needs testing standards for sustainability. There needs to be consistency in describing performance and demonstrating true correlations.
3. It might be helpful to think about the effort as scoping for a PFAS in paper-based food packaging assessment. Then you might clarify if the alternative solutions are also paper-based or not.
4. Best strategy. Target the places where PFAS is most heavily used.
5. No.
6. Not at this time.
7. Speaking the same language in the absence of Kit Test as the gold standard for measuring performance. There needs to be a standard test or tests for measuring performance accepted by industry players. Managing the cost implications of using alternatives, which are not a 1:1 replacement, while under the Kit Test umbrella. In some applications, producers of OGR papers will not be able to produce these grades without addition of capital or moving to converters to "finish" application steps.
8. Similar concerns apply across all market sectors: generally speaking, alternative treatments do not provide the same degree of performance benefits (oil and grease resistance) as FDA-approved PFAS additives. In addition, alternative materials and/or coatings, including plastic and/or wax, are typically either substantially more expensive

(which would be a particularly onerous burden for small businesses) and/or less recyclable than paper packaging treated with FDA-approved PFAS compounds and they may not provide other performance characteristics that are essential for a given type of packaging.

Additional comments

Q: Do you have any other thoughts or insights concerning product scoping for the PFAS in Food Packaging Alternatives Assessment?

1. Yes. That the burden of proving that there are safe ways to package falls on the state is a shame to our democracy and our society. Of course there are safe ways to package, and the state can legitimately require that packaging be safe. If industry is truly so creative, surely a few ways to package without using dangerous chemicals can be achieved. If we had any sense, we would require manufacturers to prove that their packaging products are safe before selling or distributing them, rather than our current system of requiring the state to prove moving away from toxic constituents is not too expensive—and even requiring the state to come up with viable technical solutions for industry. Weren't they supposed to be the creative ones?
2. Concern is that PTFE seems to have been brought into scope of PFAS materials, but it is a different type of material than that used for grease-proofing of paper, etc. I do not believe that PTFE is used in these applications.
3. Is there a plan for more direct, in-person interaction with stakeholders?
4. Nothing I haven't mentioned already, PFAS-free papers are readily available and perform well. Price and availability are the main barriers.
5. Already mentioned, products need the appropriate level of barrier performance, while also being cost-effective, sustainable, versatile, durable, strong, etc. These are a challenging combination for any alternative product and system.
6. I would focus on biggest use products first. Sector makes less sense and molded fiber products should not be considered the standard needed.
7. I'm willing to be contacted, but not sure what useful insights I have. I know a lot about plastics and their role in food packaging, but not so much about paper and not much at all about fluorochemicals.
8. Many. We have been working on this for more than 15 years. We are very close to the QSR and CPG market as a supplier. Too many to list!
9. No.
10. Thank you for asking for thoughts from the foodservice packaging supply chain!
11. Depending on the application, there is the potential to provide effective solutions that would be recyclable thereby further improving the overall approach.
12. No.
13. I would again note as above, that FDA has continued to perform extensive testing on PFAS, and have not found any indication that these substances are a human health concern.

Appendix F. Summary of PFAS in Food Packaging AA Stakeholder Webinars

Table 42. An overview of the stakeholder webinars hosted by the PFAS in Food Packaging AA team.

Date	Topic	Summary	Number of participants
May 15, 2019	Stakeholder webinar #1[81]	Introduced the PFAS in Food Packaging AA, IC2 AA Guide, and the assessment modules. Discussed stakeholder status and representation, progress, approach, and next steps. Presented results of initial stakeholder survey, solicited additional stakeholders, and requested information from stakeholders. Proposed the PFAS comparator (initially called the "base-case"). Presented initial candidate alternatives, product scopes, CBI protocol, and data needs.	142
September 11, 2019	Stakeholder discussion: product scoping[82]	Discussed results of the Product Scoping survey (released on July 1, 2019 to all stakeholders) and invited the 22 respondents who participated in the scoping survey to participate. Stakeholders who did not participate in the survey could request an invitation to the group call (per the August 23, 2019 update newsletter). Summarized survey responses were summarized, and presented major themes. Shared and discussed a tentative scoping strategy (to include paper liners and wraps). Additional stakeholder discussions included alternatives available in the market, concerns regarding scoping strategy, and non-scoping-related responses to the survey.	27
November 25, 2019	Stakeholder discussion: follow up to product scoping[83]	Discussed the expansion of the product scope based on stakeholder feedback. Addressed questions, feedback, and concerns about expanded scope. Discussion also included identifying overlap between formulation treatments and products included in the scope.	Approx. 90

[81] https://www.ezview.wa.gov/Portals/_1962/Documents/PFAS-Food/PFAS%20AA%20Webinar_05152019.pdf
[82] https://www.ezview.wa.gov/site/alias__1962/37610/pfas_in_food_packaging_alternatives_assessment.aspx
[83] https://www.ezview.wa.gov/site/alias__1962/37610/pfas_in_food_packaging_alternatives_assessment.aspx

Date	Topic	Summary	Number of participants
January 28, 2020	Stakeholder webinar: PFAS in Food Packaging AA – Jan. update[84]	Clarified the expanded product scope, project timeline, stakeholder engagement efforts, end-user engagement, cost and availability assessment overview, and refinements to the hazard and exposure methodologies.	96
February 11, 2020	Stakeholder webinar: PFAS in Food Packaging AA – Feb. update[85]	Discussed proposed alternative chemicals and substance prioritized for hazard evaluation, hazard assessment methodology (confirmed the use of GreenScreen® for Safer Chemicals), provided updates on cost and availability assessment and end-user and consumer stakeholder engagement.	71
March 3, 2020	Stakeholder webinar: PFAS in Food Packaging AA – March update[86]	Discussed hazard assessment data needs (including CBI submission protocols, the draft exposure assessment methodology and data needs, and cost and availability data needs), solicited data and information from stakeholders.	82
April 14, 2020	Stakeholder webinar: PFAS in Food Packaging AA – April update[87]	Discussed project status and announcements, performance assessment module methodology and requirements, updated CBI submission guidance, new eComment[88] feature on PFAS AA website,[89] and potential impacts from COVID-19. During the webinar, we asked participants to respond to several poll questions.	94
May 26, 2020	Stakeholder webinar: PFAS in Food Packaging AA – May update[90]	Discussed project timeline and contingencies for hazard evaluation, performance assessment recap and update. Announced technical documents. Shared results of interactive survey questions from the April 14 webinar. Identified key performance requirements as oil, grease, and water resistance.	82

[84] https://www.ezview.wa.gov/Portals/_1962/Documents/PFAS-Food/PFAS%20AA%20Project%20Update%201-28-2020.mp4
[85] https://www.ezview.wa.gov/Portals/_1962/Documents/PFAS-Food/PFAS%20AA%20Project%20Update%20Webinar%20Recording%202-11-2020.mp4
[86] https://www.ezview.wa.gov/Portals/_1962/Documents/PFAS-Food/PFAS%20AA%20Project%20Update%20Webinar%20Recording%203-3-2020.mp4
[87] https://www.ezview.wa.gov/Portals/_1962/Documents/PFAS-Food/PFAS%20in%20Food%20Contact%20AA%20Apr%2014%202020_FINAL.pdf
[88] http://hwtr.ecology.commentinput.com/comment/extra?id=a8U4i
[89] https://www.ezview.wa.gov/site/alias__1962/37610/DesktopDefault.aspx?alias=1962&PageID=37610
[90] https://www.ezview.wa.gov/Portals/_1962/Documents/PFAS-Food/PFAS%20AA%20Update%20Webinar%20Recording%205-26-2020.mp4

Date	Topic	Summary	Number of participants
June 30, 2020	Stakeholder webinar: PFAS in Food Packaging AA – June update[91]	Discussed project status, public comment website, and provided an overview of the AA process and GreenScreen® hazard evaluation methodology. The technical documents available on the on PFAS AA website.[92]	51
August 11, 2020	Stakeholder webinar: PFAS in Food Packaging AA – August update	Discussed project status and timeline. Reviewed the general methodologies and high-level results for the performance and cost and availability evaluation modules.	58
September 22, 2020	Stakeholder webinar: PFAS in Food Packaging AA – September update	Reviewed AA process, including methods used in four evaluation modules (hazard, performance, cost and availability, and exposure) and criteria for safer. Discussed the peer review process in greater detail.	71

[91] https://www.ezview.wa.gov/Portals/_1962/Documents/PFAS-Food/PFAS%20AA%20Update%20Webinar%206-30-2020.mp4

[92] https://www.ezview.wa.gov/site/alias__1962/37610/DesktopDefault.aspx?alias=1962&PageID=37610

Appendix G. Product Performance Webinar Polling Questions

The April 14, 2020 webinar focused on the Performance Assessment Module. During the webinar, we asked participants to respond to several poll questions:

1. How would you categorize yourself? (stakeholder type)
   - Chemical manufacturer
   - Packaging product manufacturer
   - Product vendor/broker/supplier
   - Government agency
   - End-user/Consumer
   - NGO
   - Trade or professional organization
   - Consultant
   - Academia
   - Other
   - No answer
2. What are the top three performance requirements for wraps, liners, bags, dinnerware, and take-out containers?
   - OGR (penetration and spreading)
   - OGR (duration)
   - Leakproof
   - Printable
   - Keeps food hot
   - Keeps food crispy
   - Heat resistance
   - Compostable/recyclable
   - Depends on the product
   - No answer
3. Have you successfully substituted an alternative for the products categories under this assessment?
   - Yes, for wraps/liners/bags/sleeves
   - Yes, for dinnerware
   - Yes, for take-out containers
   - No, haven't tried
   - No, wasn't successful
   - No answer

Results of the polling questions

Question 1: How would you categorize your organization?

- Packing product manufacturer: 13%
- Government agency: 10%
- Consultant: 10%
- NGO: 9%
- Chemical manufacturer: 7%
- Product vendor/broker/supplier: 7%
- Trade or professional organization: 6%
- End user/consumer: 2%
- Academia: 1%
- No answer: 22%
- Other: 13%

Question 2: What are your personal top 3 performance requirements?

- End-of-life: 36%
- OGR (penetration and spreading): 32%
- Leakproof: 32%
- Depends on the product: 30%
- OGR (duration): 20%
- Keeps food hot: 11%
- Heat resistance: 7%
- Printable: 5%
- Keeps food crispy: 4%
- No answer: 32%

Question 3: Have you tested or successfully substituted an alternative for the products categories under this assessment?

- No, haven't tried: 27%
- No, wasn't successful: 12%
- Yes, for take-out containers: 11%
- Yes, for dinnerware: 9%
- Yes, for wraps/liners/bags/sleeves: 9%
- No answer: 49%

The results from the poll questions and discussion from the webinar indicated:

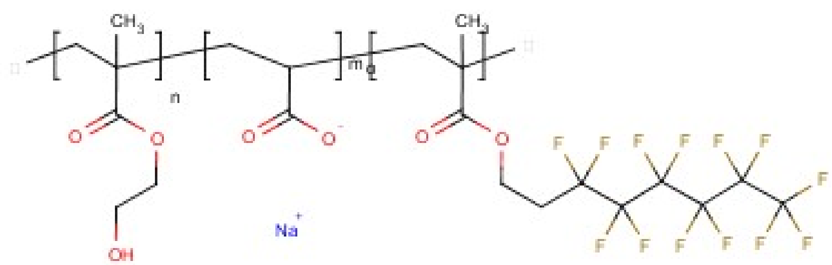
- The key performance requirements include oil and grease resistance and leak resistance.
- There appears to be some success in substituting PFAS-free products in the product categories within the scope of the project.
- PFAS-free packaging is currently being used and is meeting some customer needs.

Appendix H. Representative Structures of PFAS that FDA Approved for Use in Food Packaging

2-propenoic acid, 2-methyl-, 2- hydroxyethyl ester, polymer with 2-propenoic acid and 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl 2-methyl-2- propenoate, sodium salt

- CAS Registration Number: 1878204-24-0.
- FCN or FCS number: 1676.
- This substance will be voluntarily phased out as per FDA agreement released July 31, 2020.[93]

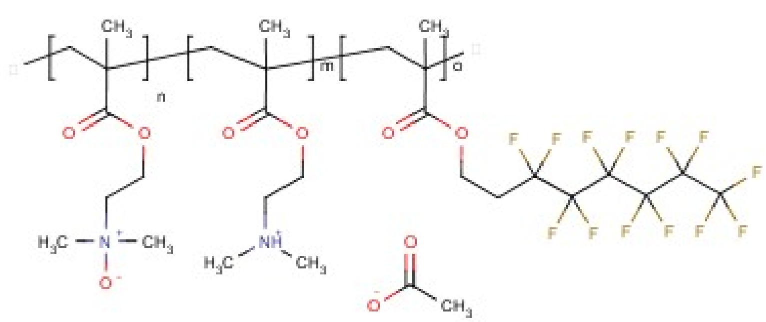
Figure 22. Representative structure of CAS 1878204-24-0.



Copolymer of 2- (dimethylamino) ethyl methacrylate with 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl methacrylate, N-oxide, acetate

- CAS Registration Number: 1440528-04-0.
- FCN or FCS number: 1493.
- This substance will be voluntarily phased out as per FDA agreement released July 31, 2020.

Figure 23. Representative structure of CAS 1440528-04-0.



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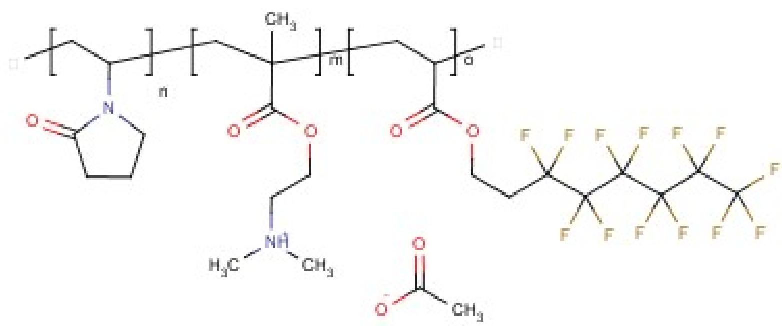
[93] https://www.fda.gov/food/cfsan-constituent-updates/fda-announces-voluntary-phase-out-industry-certain-pfas-used-food-packaging

2-Propenoic acid, 2-methyl-, 2- (dimethylamino)ethyl ester, polymer with 1-ethenyl-2-pyrrolidinone and 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl 2-propenoate, acetate

- CAS Registration Number: 1334473-84-5.
- FCN or FCS numbers: 1451 (1360).
- This substance will be voluntarily phased out as per FDA agreement released July 31, 2020.

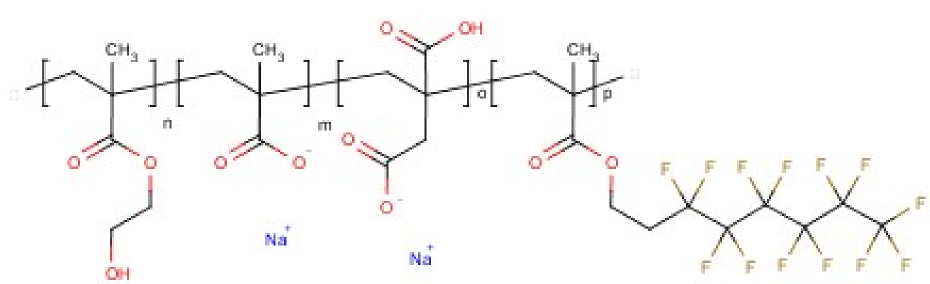
Figure 24. Representative structure of CAS 1334473-84-5.



Butanedioic acid, 2-methylene-, polymer with 2-hydroxyethyl, 2- methyl-2-propenoate, 2-methyl- 2-propenoic acid and 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl 2-methyl-2-propenoate, sodium salt

- CAS Registration Number: 1345817-52-8.
- FCN or FCS number: 1186.
- This substance will be voluntarily phased out as per FDA agreement released July 31, 2020.

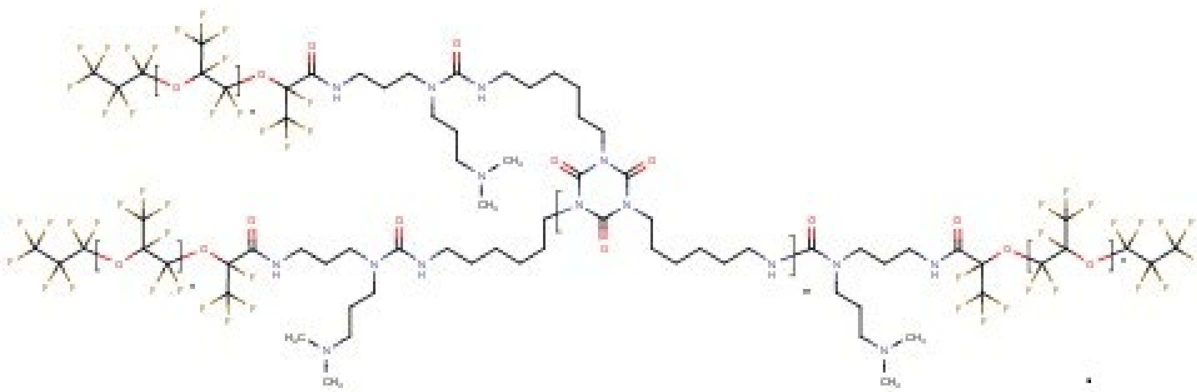
Figure 25. Representative structure of CAS 1345817-52-8.



Hexane, 1,6-diisocyanato-, homopolymer, α-[1-[[[3-[[3 (dimethylamino)propyl]amino]propyl]amino]carbonyl]-1,2,2,2- tetrafluoroethyl]-ω-(1,1,2, 2,3,3,3-heptafluoropropoxy) poly[oxy[trifluoro(trifluoromet-hyl)-1,2-ethanediyl]]-blocked

- CAS Registration Number: 1279108-20-1.
- FCN or FCS number: 1097.

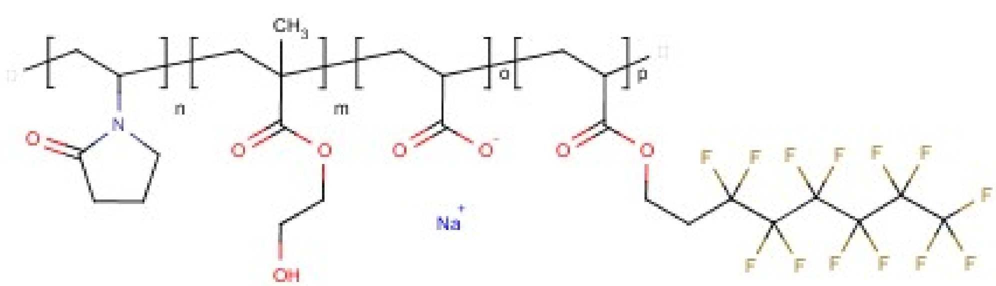
Figure 26. Representative structure of CAS 1279108-20-1



2-propenoic acid, 2-methyl-, 2- hydroxyethyl ester polymer with 1-ethenyl-2-pyrrolidinone, 2-propenoic acid and 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl 2-propenoate sodium salt

- CAS Registration Number: 1206450-10-3.
- FCN or FCS number: 1044.
- This substance will be voluntarily phased out as per FDA agreement released July 31, 2020.

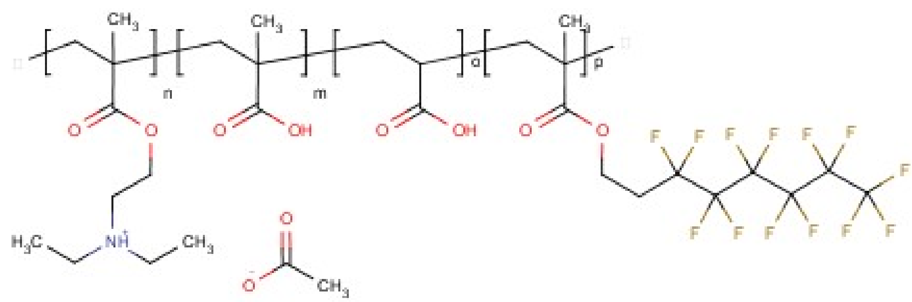
Figure 27. Representative structure of CAS 1206450-10-3.



2-propenoic acid, 2-methyl-, polymer with 2- (diethylamino)ethyl 2-methyl-2- propenoate, 2-propenoic acid and 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl 2-methyl-2- propenoate, acetate

- CAS Registration Number: 1071022-26-8.
- FCN or FCS numbers: 1027 (885).
- This substance will be voluntarily phased out as per FDA agreement released July 31, 2020.

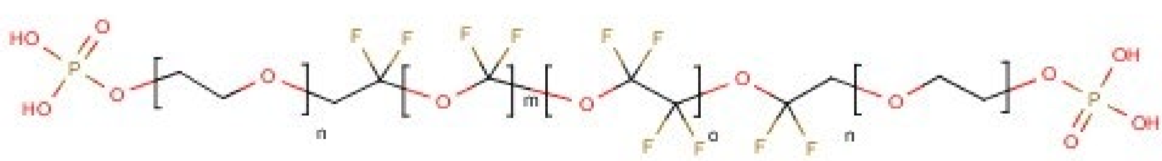
Figure 28. Representative structure of CAS 1071022-26-8.



Diphosphoric acid, polymers with ethoxylated reduced Me esters of reduced polymerized oxidized tetrafluoroethylene

- This substance is also known as: phosphate esters of ethoxylated perfluoroether, prepared by reaction of ethoxylated perfluoroether diol (CAS Reg. No. 162492-15-1) with phosphorous pentoxide (CAS Reg. No. 1314-56-3) or pyrophosphoric acid (CAS Reg. No. 2466-09-3).
- CAS Registration Number: 200013-65-6.
- FCN or FCS numbers: 962 (416 and 195).

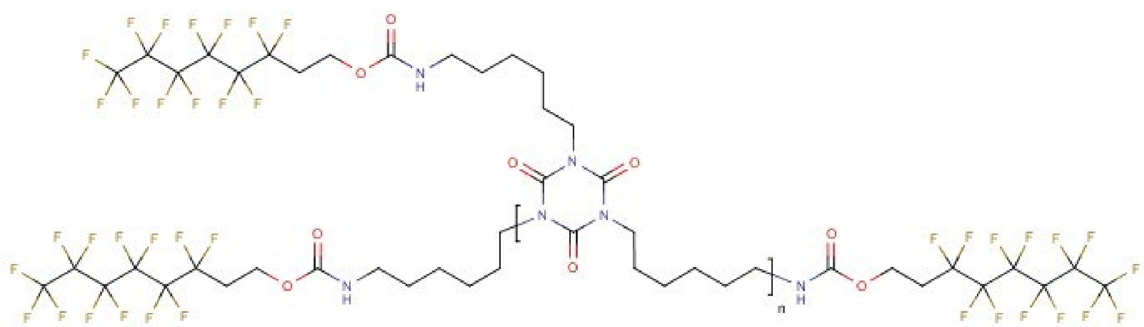
Figure 29. Representative structure of CAS 200013-65-6.



Hexane, 1,6-diisocyanato-, homopolymer, 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluoro-1-octanol-blocked

- CAS Registration Number: 357624-15-8.
- FCN or FCS number: 940.
- This substance will be voluntarily phased out as per FDA agreement released July 31, 2020.

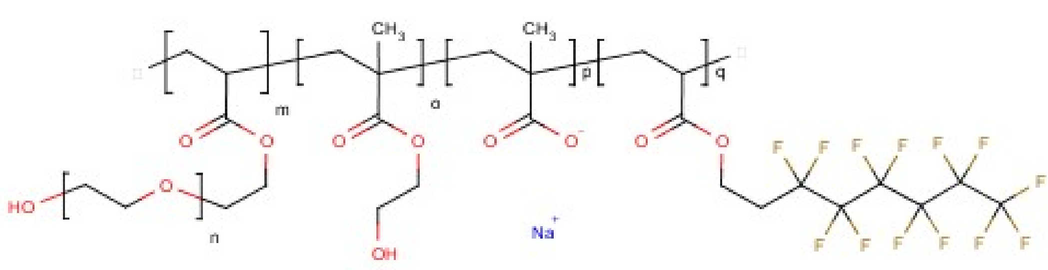
Figure 30. Representative structure of CAS 357624-15-8.



2-propenoic acid, 2-methyl-, polymer with 2-hydroxyethyl 2-methyl-2-propenoate, α-(1-oxo-2-propen-1-yl)-ω-hydroxypoly(oxy-1,2-ethanediyl) and 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl 2-propenoate, sodium salt

- CAS Registration Number: 1158951-86-0.
- FCN or FCS number: 933.
- This substance will be voluntarily phased out as per FDA agreement released July 31, 2020.

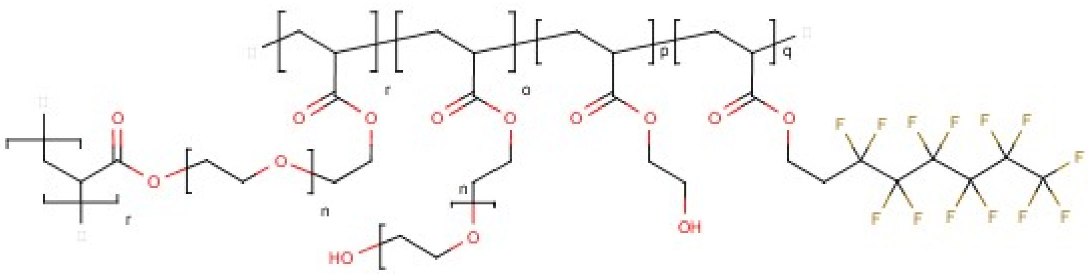
Figure 31. Representative structure of CAS 1158951-86-0.



2-propenoic acid, 2- hydroxyethyl ester, polymer with α-(1-oxo-2-propen-1-yl)-ω-hydroxypoly(oxy-1,2- ethanediyl), α-(1-oxo-2-propen- 1-yl)-ω-[(1-oxo-2-propen-1-yl)oxy]poly(oxy-1,2-ethanediyl) and 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl 2-propenoate

- CAS Registration Number: 1012783-70-8.
- FCN or FCS numbers: 888 (827).
- This substance will be voluntarily phased out as per FDA agreement released July 31, 2020.

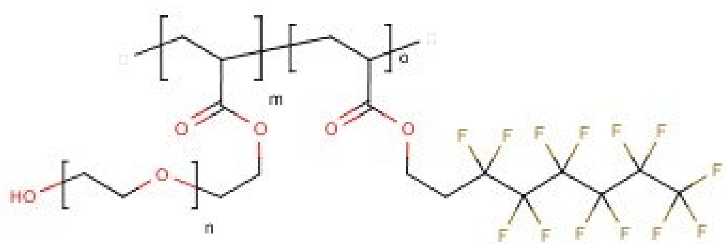
Figure 32. Representative structure of CAS 1012783-70-8.



2-Propenoic acid, 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl ester, polymer with α-(1-oxo-2-propen-1-yl)-ω- hydroxypoly(oxy-1,2- ethanediyl)

- FCN or FCS number: 820.
- This substance will be voluntarily phased out as per FDA agreement released July 31, 2020.

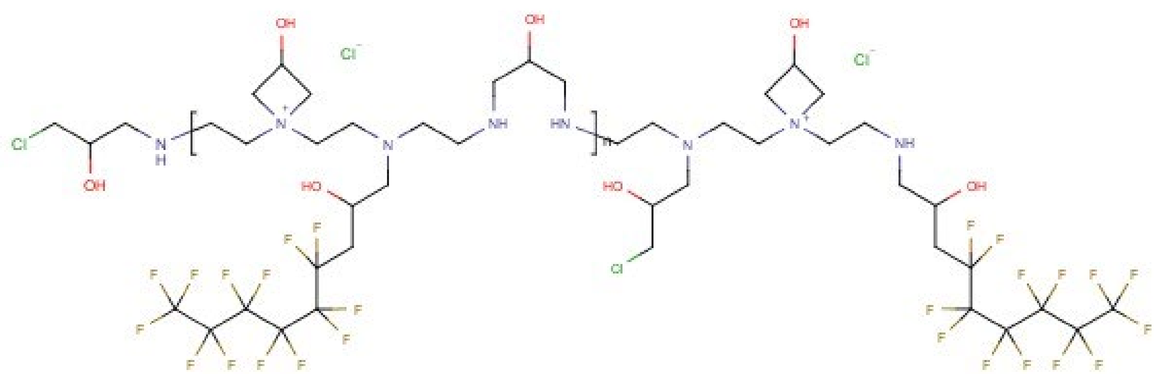
Figure 33. Representative structure of 2-Propenoic acid, 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl ester, polymer with α-(1-oxo-2-propen-1-yl)-ω- hydroxypoly(oxy-1,2- ethanediyl).



2-propen-1-ol, reaction products with 1,1,1,2,2,3,3,4,4,5,5,6,6-tridecafluoro-6-iodohexane, dehydroiodinated, reaction products with epichlorohydrin and triethylenetetramine

- CAS Registration Number: 464178-94-7.
- FCN or FCS numbers: 783 (746 and 542).

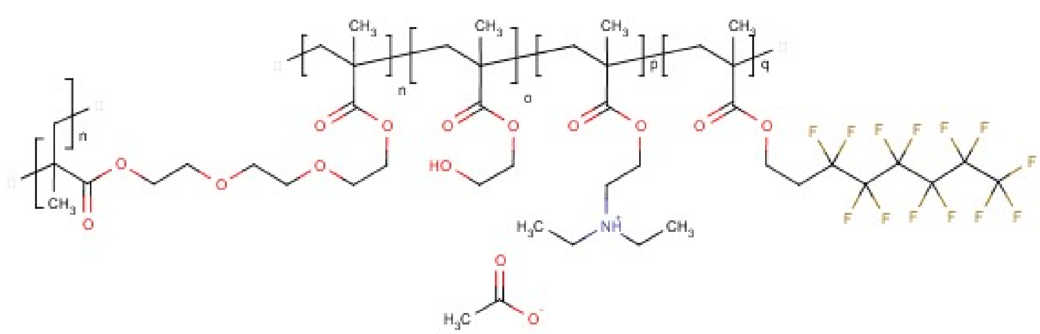
Figure 34. Representative structure of CAS 464178-94-7.



Copolymer of perfluorohexylethyl methacrylate, 2-N,N- diethylaminoethyl methacrylate, 2-hydroxyethyl methacrylate, and 2,2'-ethylenedioxydiethyl dimethacrylate, acetic acid salt

- CAS Registration Number: 863408-20-2.
- FCN or FCS numbers: 604 (599).
- This substance will be voluntarily phased out as per FDA agreement released July 31, 2020.

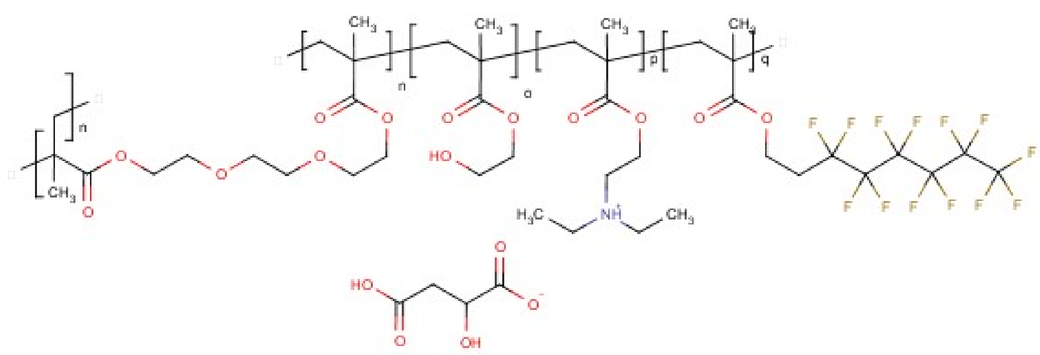
Figure 35. Representative structure of CAS 863408-20-2.



Copolymer of perfluorohexylethyl methacrylate, 2-N,N- diethylaminoethyl methacrylate, 2-hydroxyethyl methacrylate, and 2,2'-ethylenedioxydiethyl dimethacrylate, malic acid salt

- CAS Registration Number: 1225273-44-8.
- FCN or FCS numbers: 604 (599).
- This substance will be voluntarily phased out as per FDA agreement released July 31, 2020.

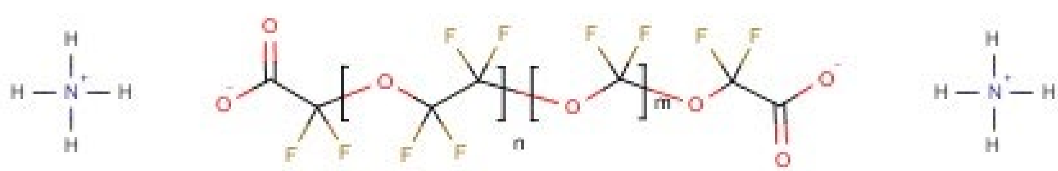
Figure 36. Representative structure of CAS 1225273-44-8.



Perfluoropolyether dicarboxylic acid (CAS Reg. No. 69991-62-4), ammonium salt.

- CAS Registration Number: 69991-62-4.
- FCN or FCS number: 538 (398).

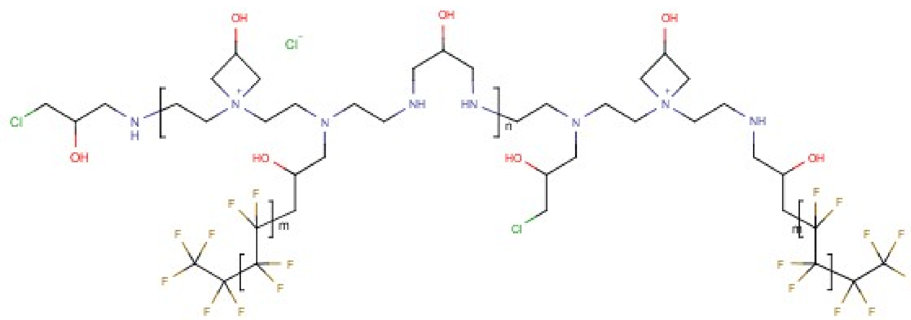
Figure 37. Representative structure of CAS 69991-62-4.



2-propen-1-ol, reaction products with pentafluoroiodoethane- tetrafluoroethylene telomer, dehydroiodinated, reaction products with epichlorohydrin and triethylenetetramine (CAS Reg. No 464178-90-3)

- CAS Registration Number: 464178-90-3.
- FCN or FCS numbers: 518 (487, 314).

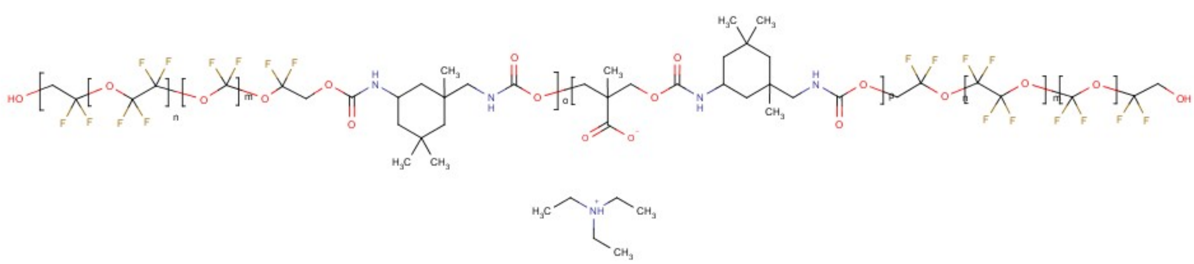
Figure 38. Representative structure of CAS 464178-90-3.



Fluorinated polyurethane anionic resin prepared by reacting perfluoropolyether diol (CAS Reg. No. 88645-29-8), isophorone diisocyanate (CAS Reg. No. 4098-71-9), 2,2-dimethylolpropionic acid (CAS Reg. No. 4767-03-7), and triethylamine (CAS Reg. No. 121-44-8)

- CAS Registration Number: 328389-91-9.
- FCN or FCS number: 187.

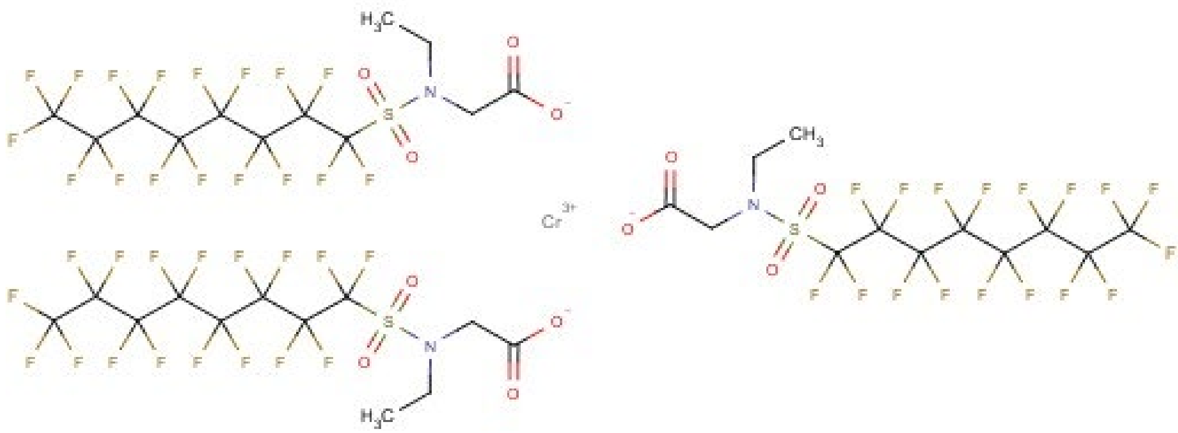
Figure 39. Representative structure of CAS 328389-91-9.



Chromium (Cr III) complex of N-ethyl - N -heptadecylfluoro- octane sulfonyl glycine containing up to 20 percent by weight of the chromium (Cr III) complex of heptadecylfluoro- octane sulfonic acid may be safely used as a component of paper for packaging dry food when used in accordance with the following prescribed conditions

- CFR section: 176.160.

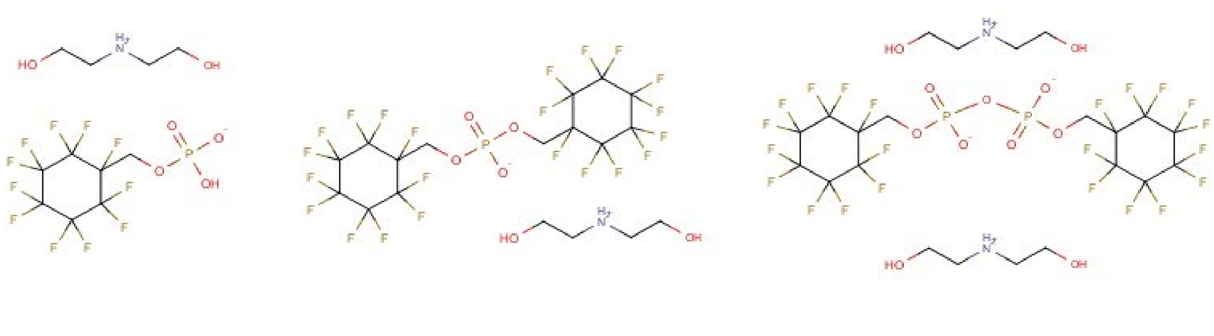
Figure 40. Representative structure of chromium (Cr III) complex of N-ethyl - N -heptadecylfluoro- octane sulfonyl glycine (drawn as 2.88% chromium (Cr III).



Undecafluorocyclohexanemethanol ester mixture of dihydrogen phosphate, compound with 2,2′ iminodiethanol (1:1); hydrogen phosphate, compound with 2,2′- iminodiethanol (1:1); and P,P′- dihydrogen pyrophosphate, compound with 2,2′- iminodiethanol (1:2); where the ester mixture has a fluorine content of 48.3 pct to 53.1 pct as determined on a solids basis

- CFR section: 176.170.

Figure 41. Representative structure of undecafluorocyclohexanemethanol ester mixture of dihydrogen phosphate (drawn as 46.14% fluorine).



Appendix I. Food Packaging Category 1 – Sample Performance Inventory

We developed this is an inventory of PFAS-free products to support the Performance Evaluation Module. The products in these tables all fall within Category 1 (food contact paper). (The product type listed may differ slightly from the name used to define the food packaging application.)

Table 43. A sample performance inventory for Category 1: Food contact paper, waxed wraps and liners.

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Food paper/ deli wrap	Waxed paper sheets	EcoCraft Deli Paper/ Tissue - Natural, Interfold[94]	Eco-Products	N	N	None specific to OGR/leak resistance
Food paper	Waxed paper sheets; Lightweight Dry Wax Food paper	EcoLite Bakery Pick-Up/Basket Liners[95]	Seaman Paper Company; Restaurant Wraps	Y	N	FDA approved; Grease resistant food paper; Suitable for direct food contact
Food paper	Waxed paper sheets; High Performance Dry Wax Food paper	EcoLite Basket Liner/ Sandwich Wrap	Seaman Paper Company; Restaurant Wraps	Y	N	FDA approved; Grease resistant food paper; Suitable for direct food contact
Food paper	Waxed paper sheets; Ultra Performance Dry Wax Food paper	EcoLite Sandwich Wrap/ Basket Liner	Seaman Paper Company; Restaurant Wraps	Y	N	FDA approved; Grease resistant food paper; Suitable for direct food contact

[94] https://www.ecoproducts.com/deli_wrap.html
[95] https://www.restaurantwraps.com/new-index#stock-products

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Food paper/ food wraps	Waxed paper sheets	EcoLite Sandwich Wrap	Seaman Paper Company; Restaurant Wraps	Y	N	FDA approved; Grease resistant food paper; Suitable for direct food contact
Food paper/ food wraps	Vegetable-based paper with biopolymer coating	thinbarrier® eco; Hamburger wrapping; Bags/ wrapping for food & pastries[96]	Delfort	Y	N	Greaseproof; grease resistant coating; good grease barrier[97]
Food paper/ deli wrap	Waxed deli paper; unbleached	Waxed kraft deli sheets in various sizes[98]	Vegware	Y	N	Greaseproof; better grease resistance; waxed deli sheets are made from greaseproof FSC-certified paper
Food paper/ food wraps	Soy wax blend coated paper; unbleached	GreenWacks Earth Friendly Deli paper[99]	Handywacks	N	N	None specific to OGR/leak resistance
Waxed paper; Food paper/ food wraps	Waxed paper coated with 100% natural soybean wax; unbleached	Unbleached waxed paper[100]	If You Care	N	N	None specific to OGR/leak resistance

[96] https://www.delfortgroup.com/en/products-industries/food-and-cooking/;
[97] https://www.delfortgroup.com/en/creative-collaboration-blog/time-to-step-up-food-wrap-standards/
[98] https://www.vegwareus.com/us/catalogue/waxed_deli_paper/
[99] http://www.handywacks.com/assets/brochures/POS-GreenWacks.pdf
[100] https://www.ifyoucare.com/baking-cooking/waxed-paper/

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Food paper/ food wraps	Waxed Paper	Ecowax® by Clondalkin Group, Paraflex NoWax™ by Paramelt[101] (specific paper products not found)	Clondalkin Group	N	N	None specific to OGR/leak resistance
Waxed paper	Vegetable-based, fully biodegradable alternative to traditional wax for chocolate packaging, confectionery packaging and bakery packaging	Ecowax® [102] (specific paper products not found)	Clondalkin Group	N	N	None specific to OGR/leak resistance
Food paper/ deli paper	Sandwich wraps, deli interfolded, patty, microwavable sheets, basket liners with a wide range of wax coatings for various food service applications	Waxed; Dry & Wet Waxed Products; MG Wax Base[103]	Dunn paper	Y	N	Oil, grease resistant products for food service applications

[101] https://www.paramelt.com/packaging/flexible-packaging-waxes-coatings-adhesives/
[102] https://www.clondalkingroup.com/locations/clondalkin-rotterdam/
[103] http://dunnpaper.com/specialty-papers/

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Food paper; Parchment baking paper	Unbleached totally chlorine-free (TCF) greaseproof baking paper; treatment not specified	Parchment Baking Paper; Parchment Baking Sheets[104]	If You Care	Y	N	Greaseproof
Food paper/ food wraps (sandwich, taco, burger wraps)	Ultra-lightweight packaging paper ideal for dry or wet wax pickup	Acadia® Waxing[105]	Twin Rivers Paper Company	Y	Y	High absorbency for dry wax pickup; Good holdout for wet wax pickup
Food paper/ deli wrap; Grease resistant papers, wraps, liners	Waxed paper; Interfolded deli sheets; Tray liners	Dry Wax, MXM (wax)[106]	McNairn Pkg.	Y	Y	Grease resistant; moisture resistant

Table 44. A sample performance inventory for Category 1: Food contact paper, waxed bags and sleeves.

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Food bags; Plastic roasting bags	Non-stick parchment roasting bag	Parchment Roasting Bags;[107] extra Large for holiday turkeys, hams and large roasts, and medium for chicken, fish, medium roasts, vegetables	If You Care	Y	Y	Greaseproof paper; seal in the juices

[104] https://www.ifyoucare.com/baking-cooking/parchment-baking-paper/
[105] https://www.twinriverspaper.com/products/packaging-paper/acadia-waxing-base/
[106] https://www.mcnairnpackaging.com/catalogs.html
[107] https://www.ifyoucare.com/roastingbags/

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Quick service restaurant bags; Food bags; Dry food pouches (one side-coated paper)	Vegetable-based paper with biopolymer coating	thinbarrier® eco[108]	Delfort	Y	N	Greaseproof; grease resistant coating; good grease barrier [109]
Grease resistant sandwich bags	Waxed paper	Waxed Sandwich Bag[110]	Fischer Paper Products	Y	Y	Provides superior grease and moisture resistance
Grease resistant sandwich bags and sleeves	Waxed paper	Waxed sandwich bags & sleeve[111]	McNairn Pkg.	Y	N	Grease resistant

Table 45. A sample performance inventory for Category 1: Food contact paper, siloxane wraps and liners.

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Professional baking paper	Two-side, one-side and non-siliconized grades	Sheets and reels;[112] High-performance, greaseproof base papers for various end products	Delfort	Y	Y	High wet-strength grades available; superior grease-proofness and heat resistance
Household baking paper	Two-side siliconized; highly hygienic and heat-resistant base paper	Consumer roll, sheets-in-roll; oven baking; steam boiling; cake layering; microwave; lunch wrapping	Delfort	Y	N	Non-stick performance
Food preparation paper	Two-side siliconized food paper	Fresh/frozen dough (for production lines)	Delfort	N	N	None specific to OGR/leak resistance

[108] https://www.delfortgroup.com/en/products-industries/food-and-cooking/
[109] https://www.delfortgroup.com/en/creative-collaboration-blog/time-to-step-up-food-wrap-standards/
[110] https://fischerpaperproducts.com/products/waxed-sandwich-bag-514/
[111] https://www.mcnairnpackaging.com/catalogs.html
[112] https://www.delfortgroup.com/en/products-industries/food-and-cooking/

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Food preparation paper	Two-side, one-side and non-siliconized food paper	Paper for meat interleaving; pan frying; steam cooking	Delfort	Y	N	Highly greaseproof
Household baking paper	Parchment baking rounds coated with silicone which is derived from sand and quartz	If You Care Parchment Rounds[113]	If You Care	Y	N	Unbleached totally chlorine-free (TCF) greaseproof paper
Greaseproof paper	Two-side silicone treated natural greaseproof paper	Silidor; Eco Bake[114]	Nordic Paper	Y	Y	Natural Greaseproof paper;[115] environmental friendly baking paper; protecting against fat and moisture

[113] https://buyifyoucare.com/products/parchment-baking-rounds
[114] https://www.nordic-paper.com/our-paper/natural-greaseproof-paper
[115] https://paper-selector.nordic-paper.com/baking-cooking-paper

Table 46. A sample performance inventory for Category 1: Food contact paper, PVOH- and EVOH Copolymer-coated food contact paper.

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Paper coating	PVOH food wrapping paper; PVOH- or EVOH-coated paper	KURARAY[116] POVAL and EXCEVAL;[117] wide range of coating grades and versatility	Kuraray	Y	Y	Excellent barrier against oxygen and grease;[118] FDA certified product and can be used in paper coating formulas and will be the best candidate of non-fluoro chemical barrier agents in the next generation of grease-proof papers. High water resistance.

Table 47. A sample performance inventory for Category 1: Food contact paper, uncoated wraps and liners.

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Food paper/ food wraps; Tray and pizza liners	100% FC-free, manufactured without the use of fluorochemicals, oil and grease resistant paper; uncoated, machine-finished paper that is non-fluorinated	Acadia® EcoBarrier®;[119] for greasy fast food wrapping applications	Twin Rivers Paper Company	Y	Y	High performance grease resistance properties for demanding OGR applications; wet-strength and fiber certification upon request

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116 https://www.kuraray-poval.com/fileadmin/user_upload/KURARAY_POVAL/technical_information/brochures/poval/Kuraray_Application Flyer_Paper.pdf
117 https://www.kuraray-poval.com/fileadmin/user_upload/KURARAY_POVAL/technical_information/brochures/elvanol/kuraray_poval_barrier_coatings_for_packaging.pdf
118 https://www.kuraray-poval.com/fileadmin/user_upload/KURARAY_POVAL/technical_information/brochures/poval/Flyer-Poval-Exceval-Paper-Kuraray.pdf
119 https://www.twinriverspaper.com/products/packaging-paper/acadia-ecobarrier/

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Food paper/ food wraps/ food liners; Food packaging paper	Fluorochemical-free options (PFOA-Free)	Acadia® OGR[120]	Twin Rivers Paper Company	Y	Y	Grease-resistant paper; oil and grease resistant packaging paper; available in three levels of oil resistance and grease resistance, and in wet strength up to 8%
Food paper/ food wraps; Basket liners	Natural looking, unbleached pulp paper; Fluorochemical-free options (PFOA-Free)	Acadia® Natural OGR[121]	Twin Rivers Paper Company	Y	Y	Oil and grease resistant (OGR) packaging paper; three levels of oil and grease resistance and is available in wet-strength up to eight percent
Food paper/ food wraps; Food packaging paper	Butcher wrap paper	Domtar Butcher Wrap Paper[122]	Domtar Paper	Y	Y	Grease-resistant papers; excellent dry & wet strength properties; grease resistance; high & low water resistance
Food paper/ food wraps/ food liners	Genuine vegetable parchment	Unibake®;[123] Unibake® Grillon; Culinera®; Sulpack®	Ahlstrom-Munksjo	Y	Y	Complete grease barrier; natural wet strength

[120] https://www.twinriverspaper.com/products/packaging-paper/acadia-oil-grease-resistant/
[121] https://www.twinriverspaper.com/products/packaging-paper/acadia-natural-oil-grease-resistance/
[122] https://www.domtar.com/sites/default/files/2020-04/Domtar_Butcher_Wrap_Spec_Sheet_EN.pdf
[123] https://www.ahlstrom-munksjo.com/products/technologies/genuine-vegetable-parchment-technology/

Table 48. A sample performance inventory for Category 1: Food contact paper, uncoated bags and sleeves.

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Carry-out bags; Fried food bags	Natural looking, unbleached pulp paper; Fluorochemical-free options (PFOA-Free)	Acadia® Natural OGR[124]	Twin Rivers Paper Company	Y	Y	Oil and grease resistant (OGR) packaging paper; three levels of oil and grease resistance and is available in wet-strength up to eight percent
Fried food bags; bakery bags; QSR pouches	100% FC-free, manufactured without using fluorochemicals, oil and grease resistant paper; uncoated, machine-finished paper that is non-fluorinated	Acadia® EcoBarrier®;[125] for greasy fast food wrapping applications	Twin Rivers Paper Company	Y	Y	High performance grease resistance properties for demanding OGR applications; wet-strength and fiber certification upon request
Food service bags; concession bags; consumer bags; laminated food pouches; QSR pouches	Fluorochemical-free options (PFOA-Free)	Acadia® OGR[126]	Twin Rivers Paper Company	Y	Y	Grease-resistant paper; oil and grease resistant packaging paper; available in three levels of oil resistance and grease resistance, and in wet strength up to 8%

[124] https://www.twinriverspaper.com/products/packaging-paper/acadia-natural-oil-grease-resistance/
[125] https://www.twinriverspaper.com/products/packaging-paper/acadia-ecobarrier/
[126] https://www.twinriverspaper.com/products/packaging-paper/acadia-oil-grease-resistant/

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Bread bag; Bakery bag; Dry food/snack bags	Uncoated bleached Kraft freesheet	Domtar® Bagstock[127]	Domtar Paper	Y	Y	Grease-resistant papers; excellent dry & wet strength properties; grease resistance; high & low water resistance[128]
Food bags; Sandwich Bags	Grease-resistant unbleached paper from spruce trees	Sub/Mini-Baguette Sandwich Bags[129]	If You Care	Y	N	Greaseproof
Hot bags & wraps	Glassine (uncoated paper)	Glassine bags with or without clear compostable window[130]	Vegware	Y		Great grease resistance
Paper Sleeves/ Sandwich Bags	Paper sleeves	Paper Sleeve - 9 in.[131]	ECO Products	N	N	Perfect for concession foods like hot dogs or sandwiches
Quick Serve Restaurant packaging	Natural looking, unbleached pulp paper; Fluoro-chemical-free options (PFOA-Free)	Acadia® Natural OGR[132]	Twin Rivers Paper Company	Y		Oil and grease resistant paper; available with post-consumer fiber, wet-strength and fiber certification upon request

[127] https://www.domtar.com/sites/default/files/2020-05/Domtar_Direct_Food_Contact_Bag_Stock_Spec_Sheet_EN.pdf
[128] https://www.domtar.com/en/what-we-make/paper/technical-and-specialty-papers/food-papers
[129] https://buyifyoucare.com/collections/baking-cooking/products/if-you-care-sub-mini-baguette-sandwich-bags
[130] https://www.vegwareus.com/us/catalogue/hot_bags_wraps/
[131] https://www.ecoproducts.com/paper_sleeves.html
[132] https://www.twinriverspaper.com/products/packaging-paper/acadia-natural-oil-grease-resistance/#:~:text=Acadia%C2%AE%20Natural%20OGR%20is,strength%20up%20to%20eight%20percent.

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Ovenable to-go bags; Fried food bags	Genuine vegetable parchment	Unibake®;[133] Unibake® Grillon; Culinera®; Sulpack®	Ahlstrom-Munksjo	Y	Y	Complete grease barrier; natural wet strength
Bags	Non-chemical paper bag	Paper bag made from cellulose[134]	Liven	Y	N	Impermeable to fat

Table 49. A sample performance inventory for Category 1: Food contact paper, unknown coating paper.

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Bakery bags; Sandwich bags	Kraft bags with windows made from plant-based PLA; recycled Kraft bags	Paper PLA window bags[135]	Vegware	N	N	None specific to OGR/leak resistance
Bakery bags; Sandwich bags	Recycled paper bags	Recycled kraft gusset bag	Vegware	N	N	None specific to OGR/leak resistance
Bakery bags; Sandwich bags	NatureFlex, a clear greaseproof film made from wood pulp; recycled Kraft bags	NatureFlex; eco bags for sandwiches, cookies, and paninis	Vegware	Y	N	NatureFlex is a clear greaseproof film made from wood pulp
Food paper/ food wraps/ food liners; Food packaging paper		"Natural" or Nature's Choice[136]	McNairn Pkg.	Y	N	Grease resistant

[133] https://www.ahlstrom-munksjo.com/products/technologies/genuine-vegetable-parchment-technology/
[134] https://marketplace.chemsec.org/articles/news/2018/10/24/the-danish-popcorn-revolution-of-2015/
[135] https://www.vegwareus.com/us/catalogue/bags_to_go/
[136] https://www.mcnairnpackaging.com/catalogs.html

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Food paper/ food wraps/ food liners; Food packaging paper	Coated flexible wrap paper	Eco Wrap;[137] Lightweight paper - Butcher Wrap, Food Wrap	Sustainable Fiber Solutions	Y	Y	Wrap paper - OGR, low MVTR; oil and grease resistance; canola oil: no penetration in 20 mins; peanut oil: no penetration in 16 mins; MVTR*: standard conditions (50% RH; 73 F): 75 – 100 gms/sq m/24 hrs. moisture resistance

[137] https://sustainablefibersolutions.com/ecowrap/

Appendix J. Food Packaging Category 2 – Sample Performance Inventory

We developed this is an inventory of PFAS-free products to support the Performance Evaluation Module. The products in these tables all fall within Category 2 (dinnerware). (The product type listed may differ slightly from the name used to define the food packaging application.)

Table 50. A sample performance inventory for Category 2: Dinnerware, PLA foam and plastic dinnerware.

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Foam plates, bowls, trays	PLA Foam	Earth Maize Compostable plates, bowls, trays [138]	Biodegradable Food Service, LLC	Y	Y	Moisture resistant; grease resistant
Foam bowls	Ingeo PLA Foam	Portion bowls;[139] can produce almost any shape	GrowPlastics	Y	Y	Moisture barrier properties; Paper Coating Alternatives Ingeo™ functions well… with good moisture, grease and oil resistance. (Ingeo Brochure)
Foam tray	Ingeo PLA foam	Natureworks™ Ingeo biopolymer Custom trays[140]	GrowPlastics	Y	Y	Moisture barrier properties; paper coating alternatives Ingeo™ functions well… with good moisture, grease and oil resistance. (Ingeo Brochure)

[138] https://earth-to-go.org/earth-maize/earth-maize
[139] http://growplastics.com/products.html
[140] https://www.natureworksllc.com/~/media/News_and_Events/NatureWorks_TheIngeoJourney_pdf.pdf

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Foam tray	Ingeo PLA foam	Dyne-a-pak Nature®[141]	dyne-A-Pak	Y	Y	Moisture barrier properties; Paper Coating Alternatives Ingeo™ functions well… with good moisture, grease and oil resistance. (Ingeo Brochure)
Plastic plates	PLA plastic	7.5" Black Compostable Plate[142]	Eco-Products	No—plastic	No—plastic	None specific to OGR/leak resistance
Plastic tray	PLA plastic	Jaya Sushi Food Tray with Lid Combo[143]	Stalk Market	No—plastic	No—plastic	None specific to OGR/leak resistance
Plastic tray	PLA, Clear top and Black bottom	NatureWorks Ingeo™ PLA Sushi Tray[144]	World Centric	No—plastic	No—plastic	None specific to OGR/leak resistance

Table 51. A sample performance inventory for Category 2: Dinnerware, PLA coated dinnerware.

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Bowl	Paper - PLA Lined	White Disposable Bowl with Green Patterns on Outside[145]	PrimeWare	N	N	None specific to OGR/leak resistance

[141] http://www.dyneapak.com/en/nature.html
[142] https://www.ecoproducts.com/black_compostable_plates.html
[143] https://www.stalkmarketproducts.com/take-out-tray-with-lid-combo-9-x4-x1.html
[144] https://store.worldcentric.com/7x5x2-black-sushi-box-with-pla-clear-lid
[145] https://totalsupply1.com/Disposables/Take-out-Packaging/To-Go-Bowls/Primeware-FC-8-Food-Container%2C-8oz-1000%2Ccs-/i/RJEFC8E

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Bowl	Paper - PLA Lined	PLA-lined soup container[146]	Vegware	Y	Y	Perfect for everything from hot soups and stews to ice cream sundaes; Paper Coating Alternatives Ingeo™ functions well… with good moisture, grease and oil resistance. (Ingeo Brochure[147])
Bowl	Paper - PLA Lined	World Art Soup Container[148]	Eco-Products	Y	Y	Without leaking; Paper coating alternatives Ingeo™ functions well… with good moisture, grease and oil resistance. (Ingeo Brochure)
Bowl	Paper - PLA Lined	Greenstripe Soup Container[149]	Eco-Products	Y	Y	Without leaking; Paper coating alternatives Ingeo™ functions well… with good moisture, grease and oil resistance. (Ingeo Brochure)
Trays	Molded sugarcane fiber, PLA lined (No added PFAS)	Fiber tray PLA lined[150]	WorldCentric	Y	Y	Moisture and grease resistance, but not grease proof

[146] https://www.vegwareus.com/us/catalogue/bon_appetit_bowls/32oz_plalined_paper_food_bowl_185series/
[147] https://www.natureworksllc.com/~/media/News_and_Events/NatureWorks_TheIngeoJourney_pdf.pdf
[148] https://www.ecoproducts.com/world_art.html
[149] https://www.ecoproducts.com/greenstripe-paper-containers.html
[150] https://assets.brandfolder.com/q6sdrm-8dqtq8-a6ikdy/v/11751614/original/WC-NoAdded-PFAS-Products-2020(secure).pdf

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Catering pan	Molded Sugarcane Fiber, PLA lined (No added PFAS)	Fiber catering pan PLA lined	WorldCentric	Y	Y	Moisture and grease resistance, but not grease proof
Bowls	Molded Sugarcane Fiber, PLA lined (No added PFAS)	Fiber bowl PLA lined	WorldCentric	Y	Y	Moisture and grease resistance, but not grease proof
Bowls	Paper, PLA-Coated	EarthChoice Ingeo PLA-Lined Soup Cups[151]	EarthChoice	Y	Y	Paper Coating Alternatives Ingeo™ functions well… with good moisture, grease and oil resistance. (Ingeo Brochure);
Bowls	Paper, PLA-Coated	Ecotainer food containers (soup bowls)[152]	Graphic Packaging International	Y	Y	Paper Coating Alternatives Ingeo™ functions well… with good moisture, grease and oil resistance. (Ingeo Brochure)
Bowl	Compostable paper coated on the inside with polylactic acid (PLA)	Emerald Compostable Paper Soup Cups and lids[153]	Emerald	N	Y	Excellent for frozen yogurt, cereal, and more

[151] https://earthchoicepackaging.com/brochures/EC-0135.pdf
[152] https://www.graphicpkg.com/products/ecotainer-food-containers/
[153] https://www.emeraldbrand.com/1-000-Emerald-Commercially-Compostable-8oz.-Soup-Containers-.13-cents-Container

Table 52. A sample performance inventory for Category 2: Dinnerware, poly-coated and uncoated dinnerware.

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance ?	Promotional language
Poly-coated food trays, food boats	Paper, poly-coated	Dixie® Kant Leek® by Georgia Pacific[154]	Dixie	Y	Y	Excellent grease and moisture barrier
Poly-coated plates	Paper, poly-coated	Dixie Pathways Paper Plates with Soak-Proof Shield[155]	Dixie	Y	Y	Soak Proof Shield™ moisture-resistant and grease-resistant
Poly-coated plates	Paper, poly-coated	Dixie Ultra® plates with Soak-Proof Shield[156]	Dixie	Y	Y	Soak Proof Shield™ that can handle anything from salad dressing to burger grease[157]
Poly-coated bowls	Paper, poly-coated	Dixie Ultra® bowls with Soak-Proof Shield[158]	Dixie	Y	Y	Soak Proof Shield™ that can handle anything from salad dressing to burger grease
Uncoated plates	Paper, uncoated	Dixie® 9" Uncoated paper plates by GP PRO[159]	Dixie	N	N	None specific to OGR/leak resistance

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154 https://www.gppro.com/gp/gppro/USD/GP-PRO-Categories/Food-Packaging-Products/DIXIE%C2%AE-2-5%23-POLY-COATED-PAPER-FOOD-TRAYS-BY-GP-PRO-%28GEORGIA-PACIFIC%29%2C-RED-PLAID%2C-500-TRAYS-PER-CASE/p/RP2508
155 https://www.walmart.com/ip/Dixie-Pathways-Heavyweight-Paper-Plates-125-Count/23138664
156 https://www.dixie.com/food packaging categories/dixieshop?query=%3Arelevance%3Abrand%3ADIXIE%2BULTRA&searchText=
157 https://www.dixie.com/GP-Family-of-Brands/DIXIE-ULTRA%C2%AE-HEAVY-DUTY-6-7-8%22-DISPOSABLE-PAPER-PLATES%2C-528-COUNT/p/15734/30
158 https://www.dixie.com/GP-Family-of-Brands/DIXIE-ULTRA%C2%AE-HEAVY-DUTY-20OZ-DISPOSABLE-PAPER-BOWLS%2C-156-COUNT/p/15259/31
159 https://www.gppro.com/gp/gppro/USD/GP-PRO-Categories/Dixie%C2%AE-Paper-Plates%2C-Platters%2C-Bowls/DIXIE%C2%AE-9%22-UNCOATED-PAPER-PLATES-BY-GP-PRO-%28GEORGIA-PACIFIC%29%2C-WHITE%2C-1%2C000-PLATES-PER-CASE/p/709902WNP9

Table 53. A sample performance inventory for Category 2: Dinnerware, clay-coated dinnerware.

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Trays, Boats	Clay-coated Kraft (CCK)	Food trays,[160] Food boats, Food Tray Sleeves, Lunch Trays, Start the Day Breakfast Tray, Low Profile Food Trays	Southern Champion Tray	N	N	None specific to OGR/leak resistance
Plates & bowls	Paper, clay-coated (Kaolin clay)	Solo® Eco-Forward™[161]	DART	Y	Y	Solo® paper plates,[162] platters and bowls have excellent moisture resistance, grease resistance and strength to keep you serving in style.
Food boat	Clay-coated paperboard food tray/boat	Compostable Food trays;[163] Brown Disposable Boat[164]	Eco-Products	Y	N	Resilient to grease
Food boat	Clay-coated Kraft food trays	Food trays/boats[165]	Specialty Quality Packaging	N	N	None specific to OGR/leak resistance
Food trays	Clay-coated Kraft board	Food trays[166]	Vegware	Y	N	Serve street food in sustainable style with our new grease resistant kraft food trays!

[160] https://www.sctray.com/images/uploads/files/Catalog_2019_Print_sm.pdf
[161] https://www.dartcontainer.com/products/foodservice-catalog/dinnerware-containers/dinnerware/paper/solo-paper-dinnerware/mp9r-j8001/
[162] https://www.dartcontainer.com/products/foodservice-catalog/dinnerware-containers/dinnerware/paper/solo-paper-dinnerware/hb12-j8001/
[163] https://www.ecoproducts.com/food_trays.html
[164] https://www.ecoproductsstore.com/renewable-and-compostable-1lb-food-trays-kraft-green-leaf-print-design.html
[165] https://web.archive.org/web/20190507042841/http:/lancasales.com/LancaSales/Vendor%20Brochures/SQP/SQP%20Catalog%20-%202015.pdf
[166] https://docs.vegware.com/vegware_productlist_ed24.pdf

Table 54. A sample performance inventory for Category 2: Dinnerware, PVOH- and EVOH copolymer-coated dinnerware.

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Paperboard coating	PVOH or EVOH Food packaging coating	KURARAY[167] POVAL and EXCEVAL;[168] wide range of coating grades and versatility	Kuraray	Y	Y	Excellent barrier against oxygen and grease; FDA certified product and can be used in paper coating formulas and will be the best candidate of non-fluoro chemical barrier agents in the next generation of grease proof papers. High water resistance.
Food boat	PVOH-coated paperboard	EcoSBS - food boat[169]	Sustainable Fiber Solutions	Y	Y	Wrap paper - OGR, low MVTR; oil and grease resistance; canola oil: no penetration in 20 mins; peanut oil: no penetration in 16 mins; MVTR*: standard conditions (50% RH; 73 F): 75 – 100 gms/sq m/24 hrs. moisture resistance

[167] https://www.kuraray-poval.com/fileadmin/user_upload/KURARAY_POVAL/technical_information/brochures/poval/Kuraray_ApplicationFlyer_Paper.pdf
[168] https://www.kuraray-poval.com/fileadmin/user_upload/KURARAY_POVAL/technical_information/brochures/elvanol/kuraray_poval_barrier_coatings_for_packaging.pdf
[169] https://sustainablefibersolutions.com/applications/

Table 55. A sample performance inventory for Category 2: Dinnerware, unknown coated dinnerware.

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Plates, bowls	Coated bagasse (molded sugarcane fiber)	Vanguard by Eco-Products Plates, 3-Compt plates, bowls, Noodle bowls[170]	EcoProducts	Y	Y	Water- and grease-resistance; Grease will soak through our VanguardTM products after prolonged exposure faster than the existing chemistries that provide grease resistance, measured in days.
Plates	Coated bagasse (molded sugarcane fiber)	Vanguard by Eco-Products[171]	EcoProducts	Y	Y	Water- and grease-resistance;[172] Grease will soak through our VanguardTM products after prolonged exposure faster than the existing chemistries that provide grease resistance, measured in days.

[170] https://www.ecoproducts.com/vanguard_1.html; https://brandfolder.com/s/q1n3vg-enj6vc-84o2gh
[171] https://www.ecoproducts.com/vanguard_1.html
[172] https://brandfolder.com/s/q1n3vg-enj6vc-84o2gh

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Bowls	Coated bagasse (molded sugarcane fiber)	Vanguard by Eco-Products Bowls	EcoProducts	Y	Y	Water- and grease-resistance; Grease will soak through our VanguardTM products after prolonged exposure faster than the existing chemistries that provide grease resistance, measured in days.
Plates, bowls, trays	Molded fiber	ecoSentials [173]	Footprint	Y	Y	Oil and water leak proof

[173] https://footprintus.com/technology/

Appendix K. Food Packaging Category 3 – Sample Performance Inventory

We developed this is an inventory of PFAS-free products to support the Performance Evaluation Module. The products in these tables all fall within Category 3 (take-out containers). (The product type listed may differ slightly from the name used to define food packaging application.)

Table 56. A sample performance inventory for Category 3: Take-out containers, PLA foam containers.

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Clamshells	PLA, Foam	Brown 8" 3 Compartment Clamshell; 9”, 8”, 6” clamshells[174]	Earth Maize (Earth-To-Go)	Y	Y	Moisture resistant; grease resistant

Table 57. A sample performance inventory for Category 3: Take-out containers, PLA plastic containers.

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Plastic take-out container with lid	PLA	Biodegradable 8 oz. Rectangular To Go Container[175]	Green Paper Products, LLC	No—plastic	No—plastic	None specific to OGR/leak resistance
Take-out container lid	PLA	Clear 8 oz. Take Out Container Lid[176]	World Centric	No—plastic	No—plastic	None specific to OGR/leak resistance
Take-out bowl	PLA	Clear Salad Bowls[177]	World Centric	No—plastic	No—plastic	None specific to OGR/leak resistance[178]
Take-out containers, Deli	PLA	World Centric Ingeo Round Deli Containers[179]	World Centric	No—plastic	No—plastic	None specific to OGR/leak resistance

[174] http://earth-to-go.org/earth-maize/earth-maize
[175] https://greenpaperproducts.com/biodegradable-compostable-container-rd-cs-8.aspx
[176] https://store.worldcentric.com/lid-pla-8-32-oz-round-delis-clear
[177] https://store.worldcentric.com/16-oz-salad-bowl-clear
[178] http://www.worldcentric.org/biocompostables/bowls/salad
[179] https://store.worldcentric.com/store/take-out-containers/round-deli-containers

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Take-out Containers, Clamshells	PLA, Clear	World Centric Clear to Go Ingeo™ Hinged Clamshells[180]	World Centric	No—plastic	No—plastic	None specific to OGR/leak resistance
Take-out containers, Deli	PLA, Clear	World Centric Ingeo Rectangular Deli Containers[181]	World Centric	No—plastic	No—plastic	None specific to OGR/leak resistance
Take-out containers	PLA	Jaya Bowls, lids, hinged containers, deli containers, all various sizes[182]	Stalk Market	No—plastic	No—plastic	None specific to OGR/leak resistance
Take-out containers	PLA	PLA salad bowls[183]/Deli containers[184]	Vegware	No—plastic	No—plastic	None specific to OGR/leak resistance[185]
Take-out containers	PLA	Vegware PLA Portion Pots[186]	Vegware	No—plastic	No—plastic	None specific to OGR/leak resistance
Clamshells	PLA	Hinged PLA Deli Containers[187]	Vegware	No—plastic	No—plastic	None specific to OGR/leak resistance
Clamshells	PLA, Clear	Pactiv EarthChoice Clear Hinged Container[188]	Pactiv	No—plastic	No—plastic	None specific to OGR/leak resistance
Clamshells	PLA, clear	Ingeo Clamshell[189]	Green Safe Products	No—plastic	No—plastic	None specific to OGR/leak resistance[190]

[180] https://store.worldcentric.com/store/take-out-containers/hinged-containers/custitem_facet_product_material/Compostable-Bio~Plastic/?
[181] https://store.worldcentric.com/store/take-out-containers/rectangular-deli-containers/?
[182] https://www.stalkmarketproducts.com/brands/jaya.html
[183] https://www.vegwareus.com/us/catalogue/bon_appetit_bowls/24oz_pla_salad_bowl_185series/
[184] https://www.vegwareus.com/us/catalogue/bon_appetit_bowls/
[185] https://docs.vegware.com/vegware_productlist_ed24.pdf
[186] https://www.vegwareus.com/us/catalogue/portion_pots/
[187] https://www.vegwareus.com/us/catalogue/deli_containers/
[188] https://earthchoicepackaging.com/brochures/EC-0135.pdf
[189] https://greensafeproducts.com/shop/12-oz-ingeo-round-deli-container-600-per-case/
[190] https://greensafeproducts.com/product-category/clamshell-containers/compostable-plastic-clamshell/

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Take-out Containers, portion cups	PLA, clear	Ingeo Portion Cup[191]	Green Safe Products	No—plastic	No—plastic	None specific to OGR/leak resistance
Take-out Bowls	PLA, clear	Eco-Products Clear PLA Salad Bowls[192]	Eco-Products	No—plastic	No—plastic	None specific to OGR/leak resistance
Clamshells	PLA	Hinged Clamshell[193]	Eco-Products	No—plastic	No—plastic	None specific to OGR/leak resistance
Take-out Deli Container	PLA	Rectangular Deli Container[194]	Eco-Products	No—plastic	No—plastic	None specific to OGR/leak resistance
Take-out Deli Container	PLA	Round Deli Container[195]	Eco-Products	No—plastic	No—plastic	None specific to OGR/leak resistance
Take-out containers	PLA	Eco-Products Portion Cups[196]	Eco-Products	No—plastic	No—plastic	None specific to OGR/leak resistance
Take-out containers, Sandwich Boxes	PLA	Eco-Products PLA Sandwich Wedge Container[197]	Eco-Products	No—plastic	No—plastic	None specific to OGR/leak resistance

[191] https://greensafeproducts.com/shop/2-oz-ingeo-portion-cup-2000-per-case/
[192] https://www.ecoproducts.com/salad_bowls.html
[193] https://www.ecoproductsstore.com/6_inch_x_6_inch_x_3_inch_clear_hinged_clamshell.html
[194] https://www.ecoproductsstore.com/18oz-renewable-and-compostable-salad-bowl-base-only.html
[195] https://www.ecoproductsstore.com/16_oz_round_deli_container.html
[196] https://www.ecoproductsstore.com/round_deli_and_portion_cups.html
[197] https://www.ecoproductsstore.com/3_in_sandwich_wedge_container.html?size=Pack+125&gclid=CjwKCAjw7anqBRALEiwAgvGgm99WLygvmgXSNildhisw7fJzHyuRN90UsLPesh-k7EIhmg7jzfRzBRoCvYwQAvD_BwE

Table 58. A sample performance inventory for Category 3: Take-out containers, PLA coated containers.

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Hoagie box	Unbleached compostable plant fiber with a PLA bio-lining	Hoagie box - PLA lined[198]	World Centric	Y	Y	These fiber items with no added PFAS provide moisture and grease resistance[199] but are not grease proof and may not work with very oily and greasy foods.
Burger box	Unbleached compostable plant fiber with a PLA bio-lining	Fiber burger box	World Centric	Y	Y	These fiber items with no added PFAS provide moisture and grease resistance but are not grease proof and may not work with very oily and greasy foods.
Clamshells	Unbleached compostable plant fiber with a PLA bio-lining	Fiber clamshell - PLA lined	World Centric	Y	Y	These fiber items with no added PFAS provide moisture and grease resistance but are not grease proof and may not work with very oily and greasy foods.

[198] https://www.worldcentric.com/leaf/

[199] https://assets.brandfolder.com/q6sdrm-8dqtq8-a6ikdy/v/11751614/original/WC-NoAdded-PFAS-Products-2020(secure).pdf

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Clamshells, Hoagie box,	Molded sugarcane fiber, PLA lined (No added PFAS)	Fiber clamshell - 3 compt - PLA lined	World Centric	Y	Y	These fiber items with no added PFAS provide moisture and grease resistance but are not grease proof and may not work with very oily and greasy foods.
Take-out containers, Bowls	Paper, PLA-coated	Hot Paper Ingeo Lined Soup Bowls[200]	World Centric	Y	Y	Suitable for liquids; Paper Coating Alternatives Ingeo™ functions well… with good moisture, grease and oil resistance. (Ingeo Brochure[201])
Food container and lid	Paper, PLA-coated	Planet+ Food container and lid[202]	StalkMarket Compostable Products	Y	Y	Paper Coating Alternatives Ingeo™ functions well… with good moisture, grease and oil resistance. (Ingeo Brochure)

[200] https://store.worldcentric.com/store/bowls-and-lids/soup-bowls
[201] https://www.natureworksllc.com/~/media/News_and_Events/NatureWorks_TheIngeoJourney_pdf.pdf
[202] https://www.stalkmarketproducts.com/brands/planet.html

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Boxes and wedges	Paper, PLA-coated	Vegware Sandwich/ Wrap Boxes and Wedges[203]	Vegware	Y	Y	Grease-resistant coating; Paper Coating Alternatives Ingeo™ functions well… with good moisture, grease and oil resistance. (Ingeo Brochure)
Take-out Containers, Other, French fry scoops	Paper, PLA-coated	Eco-Products Compostable French Fry Scoop[204]	Eco-Products	Y	Y	Grease resistant; Paper Coating Alternatives Ingeo™ functions well… with good moisture, grease and oil resistance. (Ingeo Brochure)
Take-out container, interlocking folded container	Paper, PLA-coated	Compostable Innobox Edge[205]	Inno-Pak	Y	Y	Great leak protection; Hot food friendly; Cold food friendly; Ingeo™ functions well… with good moisture, grease and oil resistance. (Ingeo Brochure)

[203] https://www.vegwareus.com/us/catalogue/sandwich_wrap_boxes/
[204] https://www.ecoproducts.com/food_trays.html
[205] https://www.innopak.com/products/compostable_innobox_edge/

Table 59. A sample performance inventory for Category 3: Take-out containers, Poly-coated containers.

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Take-out containers, Clamshells	Paper, poly-coated	Dixie Pathways Paper Small Sandwich Clamshells with Soak-Proof Shield[206]	Dixie	Y	Y	Excellent grease and moisture barrier
Take-out containers, Boxes	Paper, poly-coated	Dixie Pathways Take-out Box with Soak-Proof Shield[207]	Dixie	Y	Y	Excellent grease and moisture barrier
Take-out containers, Folded boxes	Paper, poly-coated	EconoPaxx™ food-service cartons[208]	Graphic Packaging International, LLC	Y	Y	Maximum grease and moisture barrier
Take-out containers, Bowls/food cup	Paper, polyethylene-coated	Evolution World™ Hot & Cold Food container[209]	Eco-Products Evolution Soup Bowls	N	N	Outer coating protects against condensation
Take-out containers, Folded boxes	Paper, polyethylene-coated	Pactiv EarthChoice One Box[210]	EarthChoice	N	N	None specific to OGR/leak resistance

[206] https://www.gppro.com/gp/gppro/USD/Products/Food-Wrap%2C-Containers-%26-Trays/DIXIE%C2%AE-SMALL-SANDWICH-CLAMSHELL-CONTAINERS-BY-GP-PRO-%28GEORGIA-PACIFIC%29%2C-PATHWAYS%C2%AE%2C-200-CONTAINERS-PER-CASE/p/4021PATH; GP5136 Cartons and Trays Brochure.pdf
[207] https://www.gppro.com/gp/gppro/USD/GP-PRO-Categories/Food-Packaging-Products/DIXIE%C2%AE-10%23-TAKE-OUT-BARNS-BY-GP-PRO-%28GEORGIA-PACIFIC%29%2C-PATHWAYS%C2%AE%2C-200-BARN-CARTONS-PER-CASE/p/966PATH; GP5136 Cartons and Trays Brochure.pdf
[208] https://www.graphicpkg.com/products/econopaxx/
[209] https://www.ecoproducts.com/evolution_world.html
[210] https://earthchoicepackaging.com/brochures/EC-0135.pdf

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Take-out containers, Folded boxes	Paper, poly-coated	Bio-Pak® and Bio-Plus Earth® Interlocking folded containers[211]	WestRock	Y	Y	Leak resistant, withstands sauces and gravies; suitable for all food types from hot to cold, wet to dry
Take-out containers, Folded boxes	SBS paperboard, poly-coated	Black 8.5"x 6" x2" Folded Take Out Container[212]	Choice	Y	Y	Poly-coated interior that makes it leak- and grease-resistant
Take-out containers, Folded pails	SBS coated with half mil poly	Take-out Pails[213]	Graphic Packaging International	Y	Y	Prevent liquid and grease soak-through. Though not leak-proof at the opening, the one piece web design prevents leakage through the bottom and sides.
Take-out Boxes	Poly-coated natural Kraft and white paperboard	Boxes[214]	EcoSource	Y	Y	Leak and grease resistant

[211] https://www.westrock.com/-/media/pdf/folding-carton/fold-pak/biopak-product-brochure-2019.pdf?modified=20191219030919
[212] https://www.webstaurantstore.com/choice-8-1-2-x-6-x-2-black-microwavable-folded-paper-2-take-out-container-pack/999PTOBK2.html
[213] https://www.graphicpkg.com/documents/2018/12/away-from-home-products-brochure.pdf/
[214] http://www.ecosourcepaper.com/products#boxes

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Take-out Container	SBS paperboard, poly-coated interior	Folded Take Out Containers[215]	Choice	Y	Y	Poly-coated interior that makes it leak- and grease-resistant
Take-out containers, Folded boxes	"Poly coated" inside; Kraft paper from 97% renewable resources	ChampPak Retro - Kraft[216]	Southern Champion Tray	Y	Y	Leak and grease resistant

Table 60. A sample performance inventory for Category 3: Take-out containers, uncoated containers.

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Hamburger packaging; sandwich clamshell; pizza delivery boxes	Grease-Gard® FluoroFree® (uncoated)	Grease-Gard® FluoroFree® [217]	Ahlstrom-Munksjo	Y	N	Outstanding grease-resistance
Pizza boxes	Uncoated, uncoated corrugated	U.S. Foods Monogram Pizza Box[218]	U.S. Foods	N	Y	Built to be sturdy, prevent leakage

[215] https://www.webstaurantstore.com/choice-8-1-2-x-6-x-2-black-microwavable-folded-paper-2-take-out-container-pack/999PTOBK2.html
[216] https://www.sctray.com/catalog/product/0762
[217] https://www.ahlstrom-munksjo.com/products/food-packaging-baking-and-cooking-solutions/food-packaging-papers/QSR-Food-Service-Papers/
[218] https://www.usfoods.com/content/dam/usf/pdf/National_Sales/catersource/USF_Monogram_Pizza_Box_Brochure.pdf

Table 61. A sample performance inventory for Category 3: Take-out containers, clay-coated containers.

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Take-out containers, Folded boxes	Clay-coated Kraft board	Food cartons[219]	Vegware	Y	Y	Versatile kraft board cartons with a compostable grease-resistant lining. Leak-proof webbed corners and fold in flaps give a secure closure.
Clamshells, French fry scoop, sausage boxes, pizza boxes & wedges, carryout barns, bakery boxes	Clay-coated Kraft (CCK)	Foodservice Packaging[220]	Southern Champion Tray	N	N	N/A
Barn box; bakery boxes	Clay-coated Recycle Board (CCRB)	Take-out boxes and bakery boxes	Southern Champion Tray	N	N	N/A

[219] https://docs.vegware.com/vegware_productlist_ed24.pdf
[220] https://www.sctray.com/catalog/foodservice

Table 62. A sample performance inventory for Category 3: Take-out containers, PVOH- and EVOH Copolymer-coated containers.

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
PVOH- or EVOH-coated: paperboard coating	PVOH or EVOH food packaging coating	KURARAY[221] POVAL and EXCEVAL;[222] wide range of coating grades and versatility	Kuraray	Y	Y	Excellent barrier against oxygen and grease; FDA certified product and can be used in paper coating formulas and will be the best candidate of non-fluoro chemical barrier agents in the next generation of grease proof papers. High water resistance.[223]

[221] https://www.kuraray-poval.com/fileadmin/user_upload/KURARAY_POVAL/technical_information/brochures/poval/Kuraray_Application Flyer_Paper.pdf
[222] https://www.kuraray-poval.com/products/excevaltm/
[223] https://www.kuraray-poval.com/fileadmin/user_upload/KURARAY_POVAL/technical_information/brochures/poval/Flyer-Poval-Exceval-Paper-Kuraray.pdf

Table 63. A sample performance inventory for Category 3: Take-out containers, unknown coated containers.

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Take-out container	SBS paperboard; environmentally friendly Kraft paper	Kraft Microwavable Folded Paper #1 Take-Out Container[224]	Choice	N	N	None specific to OGR/leak resistance
Take-out container	SBS paperboard, unknown coating	Brown 4.375" x 4.125" x2.5" Kraft Folded Take-out Container	Choice	N	N	None specific to OGR/leak resistance
Paperboard coating	EnShield (Non-poly or fluorocarbon alternative)	Take-out Packaging[225]	WestRock	Y	Y	Superior oil and grease resistance, barrier protection
Paperboard coating	EnShield (Non-poly or fluorocarbon alternative)	Bakery boxes	WestRock	Y	Y	Superior oil and grease resistance, barrier protection
Clamshell	Coated bagasse (molded sugarcane fiber)	Vanguard by Eco-Products Clamshell,[226] White; 2 compt clamshell; 3-compt clamshell	Eco-Products	Y	Y	Water- and grease-resistance; grease will soak through after prolonged exposure faster than the existing chemistries that provide grease resistance, measured in days.
Clamshells, to go containers	Molded fiber, unknown coating	ecoSentials™[227]	Footprint	Y	Y	Oil and water leak proof

[224] https://www.webstaurantstore.com/choice-4-3-8-x-4-1-8-x-2-1-2-kraft-microwavable-folded-paper-1-take-out-container-pack/999PTOKFT1.html
[225] https://www.westrock.com/-/media/pdf/paperboard/product-guide/enshield-product-guide-revnov17-pdf.pdf?modified=20191219211252
[226] https://brandfolder.com/s/q1n3vg-enj6vc-84o2gh
[227] https://footprintus.com/technology/

Product type	Alternative	Product name/ application	Company name	OGR?	Leak resistance?	Promotional language
Clamshells, folding cartons, French fry containers, Wholesale doughnuts	Treated paperboard	EcoSBS; EcoLInerboard [228]	Sustainable Fiber Solutions	Y	Y	Wrap paper - OGR, low MVTR; oil and grease resistance; canola oil: no penetration in 20 mins; peanut oil: no penetration in 16 mins; MVTR*: standard conditions (50% RH; 73 F): 75 – 100 gms/sq m/24 hrs. moisture resistance

[228] https://sustainablefibersolutions.com/applications/