# Toxic Convenience:
## The hidden costs of forever chemicals in stain- and water-resistant products

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Toxic-Free FUTURE

## Acknowledgments

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# Executive Summary

For decades, makers of textiles including apparel and home furnishings have turned to the persistent toxic chemicals known as per- and polyfluoroalkyl substances (PFAS) to make their products resist water and stains. But their choice to use these "forever chemicals" has contributed to contamination of drinking water, homes, people, fish, and wildlife with chemicals that can cause cancer, suppress the immune system, increase cholesterol, and lead to other serious health problems.

Even though PFAS are in many of the items we use every day, we know shockingly little about which products contain this harmful chemical class—with almost no product labels disclosing their presence. To uncover this hidden information, we investigated three kinds of commonly used products, purchased from 10 major retailers. We tested for the presence of PFAS in the three categories of products: outdoor apparel, bedding, and tablecloths and napkins. To our knowledge, this testing provides the first brand-specific information on the presence of PFAS in key home furnishings such as mattress pads, comforters, and tablecloths.

We selected 20 items from each of the three categories, choosing mainly items advertised as stain- or water-resistant. We purchased the items from the following retailers: Amazon, Bed Bath & Beyond, Costco, Dick's Sporting Goods, Kohl's, Macy's, REI, Target, TJX, and Walmart. We screened the 60 items for total fluorine, as fluorine may indicate the presence of PFAS, then commissioned PFAS testing of items with fluorine above our screening level. Analysis for total fluorine and PFAS was conducted at independent laboratories.

**We found that PFAS are still in wide use in apparel and home furnishings, despite availability of alternatives:**

1. **PFAS are commonly used for stain and water resistance.** The majority (72%) of items marketed as stain- or water-resistant contained PFAS. On the other hand, none of the items without stain or water resistance marketing appeared to contain PFAS.

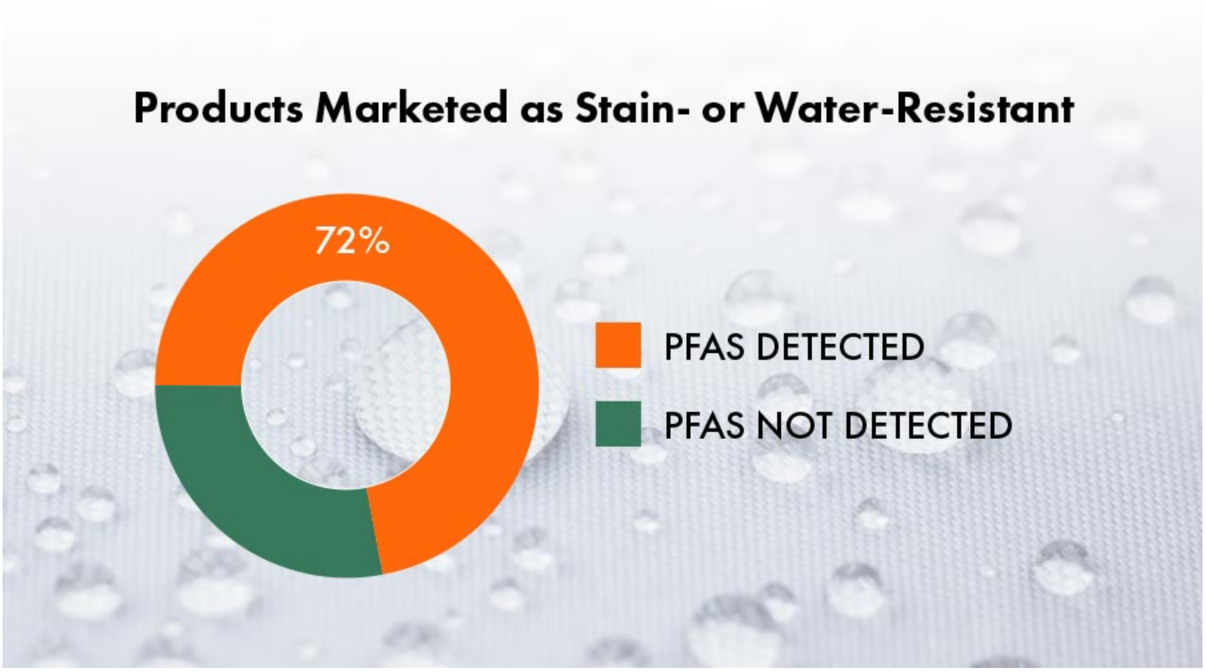
2. **Multiple types of consumer products contain PFAS.** We detected PFAS in a wide variety of products that included rain jackets, hiking pants, shirts, mattress pads, comforters, tablecloths, and napkins.

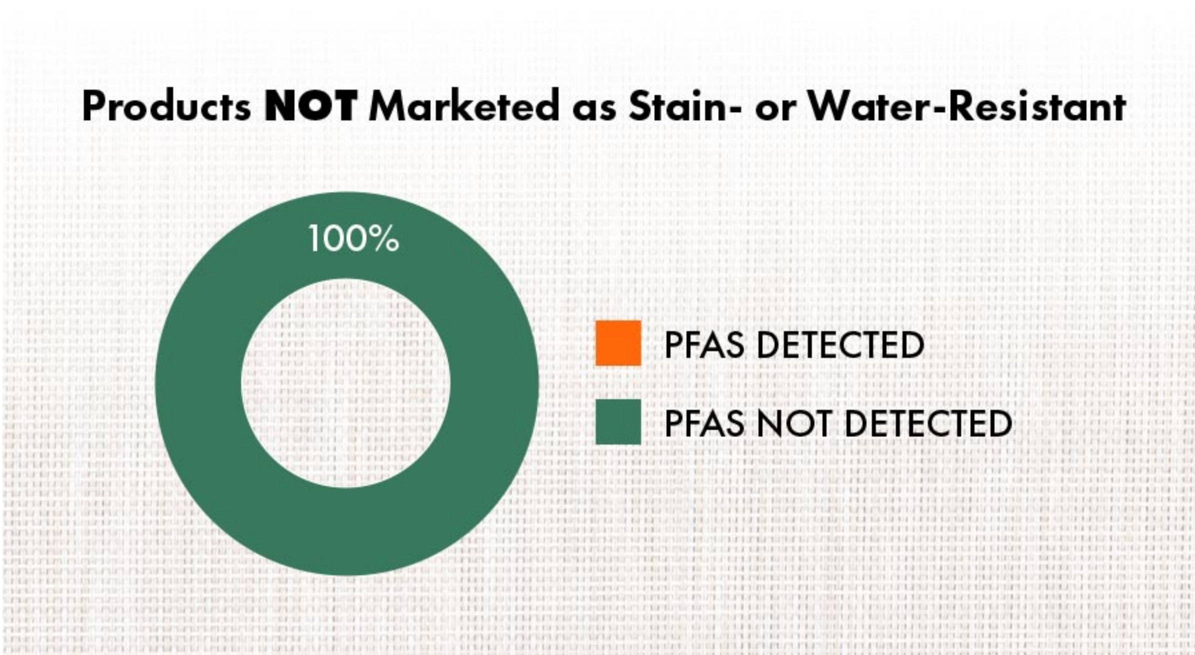
3. **No retailer's product line was totally PFAS-free.** At least one product from each of the 10 retailers contained PFAS.

4. **Manufacturers have been using a mixture of PFAS that includes compounds banned in other countries.** Our testing found not just the newer compounds believed to be the most commonly used, but also the older PFAS banned in the European Union and

phased out by major U.S. manufacturers. Most PFAS-containing items (74%) tested positive for these older PFAS.

5. **Alternatives to PFAS for stain and water resistance are in use.** We found items in each category that were marketed as stain- and/or water-resistant yet appeared to be free of PFAS-based treatments.



The widespread application of PFAS to textiles bears significant responsibility for a toxic trail of pollution that begins with the manufacture of the chemicals, continues as they are applied to fabric and made into products, enters homes, schools, and workplaces as finished items are sold and used, and ends with widespread contamination of air and water after disposal of the products.

Safer alternatives can be used to prevent the contamination of homes, bodies, wildlife, food, and drinking water with PFAS. Retailers, manufacturers, and state and federal leaders each have a role to play to bring a swift end to this unnecessary use of PFAS.

**We recommend the following:**

*Companies that make home furnishings and apparel* should adopt public corporate chemicals policies to phase out PFAS use and move to safer methods, disclose all product ingredients, and keep the public updated on progress.

*Retailers* should "mind the store" by adopting public corporate chemical policies to ensure all textile products available for sale are free of PFAS and contain only safer substitutes, requiring suppliers to provide full ingredient information, and reporting progress to the public.

*State and federal leaders* should pass polices to end the use of PFAS in all textiles, establish comprehensive chemicals policies to replace harmful chemicals with safer alternatives, ensure cleanup of contaminated communities, and wield government purchasing power to avoid PFAS.

We can envision a future in which the clothes we wear and all products in our homes, schools, and workplaces are free of toxic chemicals. PFAS—incredibly persistent, and so mobile that they have contaminated drinking water for millions of people—clearly don't belong. To work towards this future, we need to phase out the "forever chemicals" that jeopardize it.

# Introduction

The harms from PFAS, the extremely large class of fluorinated chemicals found in drinking water, indoor and outdoor air, household dust, breast milk, and the blood of nearly every U.S. resident, are well known.[1] They include reduced immune response, cancer, damage to the liver and kidney, and other serious impacts to health.[1] Less well known are the many kinds of products—items we use in our everyday lives—that continue to contain these chemicals, despite the abundance of evidence that they are harmful.

For this study, we sampled three categories of textile products to learn more about the extent of PFAS use: outdoor apparel, tablecloths and napkins, and bedding. This research updates previous studies that have analyzed outerwear for PFAS and provides new information on the presence of PFAS in home furnishings. In these types of products, PFAS may be used as surface treatments and/or as membranes laminated to fabric, providing stain and water resistance. For example, outerwear may contain a PFAS-based membrane, a surface treatment on the outer surface of the garment (often termed a durable water repellent), or both. Other products, such as tablecloths, are likely treated only with a surface treatment to provide stain repellency.

Unfortunately, these uses of PFAS leave a toxic trail of pollution that begins with manufacturing of the PFAS membrane and surface treatments, continues as treatments are applied to fabric and made into garments and indoor furnishings, enters homes and workplaces as finished products are sold and used, and ends with widespread environmental contamination from landfills and incinerators after disposal.

## PFAS manufacture

Manufacturing plants that make PFAS are well-known creators of PFAS pollution hot spots.[2, 3] When it comes to textiles, that means the manufacture of the surface treatments applied to fabric. But in addition to the PFAS surface treatments used on many textiles, some outdoor apparel also contains a PFAS-based membrane, a layer that makers laminate to the inside of the jacket fabric to help create a waterproof yet breathable garment. With its many tiny holes, the microporous membrane serves to keep rain droplets from crossing the fabric from the outside while allowing water vapor to escape from the inside[4]. Sadly, the manufacture of the type of PFAS used for these membranes, as well as of the surface treatments for textiles and other products, has contaminated drinking water for communities around the globe. These include at least 69,000 residents of the Ohio Valley in Ohio and West Virginia who drank water contaminated by DuPont's Washington Works plant in Parkersburg, West Virginia (now operated by the DuPont spinoff Chemours. People who lived in water districts closest to the plant had the highest blood levels of PFOA, a PFAS used as a processing aid to manufacture

[1] In this report, we define PFAS using the Organization for Economic Cooperation and Development definition, found at https://www.oecd.org/chemicalsafety/portal-perfluorinated-chemicals/

Teflon® and found in diverse products made at the plant such as surface treatments for textiles and paper.[5] PFOA emissions to air and to the Ohio River during decades of PFAS manufacture in Parkersburg contaminated groundwater used for public and private drinking water wells.

Beginning in 2006, the eight primary U.S. makers of PFAS entered into an agreement with the U.S. Environmental Protection Agency (EPA) to reduce PFOA emissions.[1] Some have since switched to other fluorinated processing aids such as GenX to make Teflon® and related plastics, creating new contamination problems. For example, in 2016, EPA and university scientists from North Carolina found GenX in high concentrations in a drinking water intake from the Cape Fear River downstream of the Chemours manufacturing plant in Fayetteville, North Carolina.[6] This part of the Cape Fear River provides drinking water for more than 250,000 North Carolina residents.[7]

## Factories that apply PFAS to textiles

Textile mills typically apply finishing chemicals including PFAS water- and stain-resistance treatments by immersing the fabric in a solution, using rollers to remove excess liquid, then curing with heat.[8] This process provides opportunities for PFAS to pollute water and air, as the excess liquid becomes contaminated wastewater and the application process results in air emissions of volatile PFAS. Thus, textile mills can also serve as local sources to create contamination hotspots: one in-depth study of a textile mill in China found elevated levels of PFAS in the factory effluent, as well as in the indoor air, indicating pollution of surface water as well as workers' exposure to PFAS.[8] Exposure of workers at this mill to volatile PFAS was estimated at about 100,000 times that of the general Western population.

## PFAS-treated products

Once treated, textiles emit PFAS over the course of their lifetimes. PFAS are applied to the surface of textiles in a form known as side-chain polymers, which degrade over time to releases volatile PFAS into the environment. As a result, indoor air in homes has been found to have PFAS concentrations tens to hundreds of times higher than outdoor air.[9-12] These volatile PFAS have been found at even higher concentrations in retail stores that sell outerwear, and laboratory studies have measured significant ongoing emissions of PFAS from outdoor apparel.[13, 14] People are also exposed to PFAS when they accumulate in indoor dust, and potentially from touching treated items. Research using artificial saliva and sweat indicates that persistent PFAS, especially the newer, more water-soluble compounds, can move directly from products to the user.[15, 16] Limited information is available on absorption of PFAS through the skin, but preliminary information indicates persistent PFAS such as PFOA can move through the skin.[17] This exposure route would be especially relevant for textiles like bedding, apparel, napkins, and car seats.

Researchers studying textiles have found strong evidence that the PFAS surface treatments break down over time and that they are a source of PFAS to water after laundering and to landfill leachate after disposal. For example, researchers artificially weathered outdoor apparel and tested fabric for the concentrations of volatile and persistent PFAS before and after the weathering. [18] They found that the surface treatments appeared to degrade in the weathering process, as volatile and persistent PFAS increased in concentration up to 100-fold. Similarly, when researchers subjected treated fabric from car seats to ultraviolet radiation to simulate the effects of sun exposure, fabric concentrations of persistent PFAS such as PFHxA and PFOA increased.[15]

When PFAS are present in apparel and washable home furnishings, they leave our homes in our laundry water. In an experiment simulating laundering of treated jackets and pants, PFAS were detected in laundry water at relatively high concentrations.[16] PFAS in laundry water from households are thus likely to constitute a significant source of persistent PFAS to wastewater treatment plants and to waterways, since they do not fully degrade in the wastewater treatment process.[19] Another experiment measured the amount of PFAS-based surface treatment in microplastic fibers released from outdoor jackets during washing.[20] After simulating home laundering (2 to 15 washes) of outdoor jackets treated with PFAS-containing durable water repellent, the researchers measured the amount of fibers released and estimated the amount of PFAS released along with them at up to 2,064 pounds per year in the European Union.

## End of Life

Disposal of used PFAS-treated apparel and home textiles in landfills creates a long-term source of PFAS to the environment as the surface treatments break down over time into persistent, mobile PFAS. These PFAS can then leach from the landfill, contaminating the approximately 16 billion gallons of water leaching from U.S. landfills each year.[21] A yearly total of about 1,300 pounds of PFAS has been estimated to contaminate landfill leachate in the U.S.[21] In Michigan, the U.S. state that has done the most extensive testing for PFAS in groundwater, landfills are by far the most common source of contamination and are associated with 58 contaminated sites.[22] Washington state has estimated that 2,066 metric tons, or 4.5 million pounds, of PFAS in treated textiles are disposed of in landfills in the state every year.[23]

As a result of PFAS emissions from chemical and product manufacturing, during product use, and after disposal, the extremely persistent PFAS have become ubiquitous global contaminants. PFAS have been detected in rivers, oceans, air near cities as well as in remote areas, and even on Mt. Everest.[9, 24, 25] PFAS contaminate fish and wildlife and their food web around the world, from beluga whales to sea otters, orcas and polar bears.[26-31] And this extensive environmental pollution has reached people, with PFAS contaminating blood and breast milk in people around the globe.[32-36]

# Methods

A total of 60 items were selected from three product categories: 20 each of bedding, outdoor apparel, and tablecloths and napkins. Products were purchased new in the fall of 2020 from 10 major retailers: Amazon, Bed Bath & Beyond, Costco, Dick's Sporting Goods, Kohl's, Macy's, REI, Target, TJX, and Walmart. All labeled items were manufactured in Asia, with home furnishings made primarily in China as well as in India and Pakistan, and outdoor apparel made in Vietnam, Bangladesh, China, the Philippines, and Indonesia.

The bedding, tablecloths, and napkins selected included items marketed as stain- or water-resistant, as well as items that were not. All outdoor apparel was marketed as water- or stain-resistant.

We used two methods to investigate the presence of PFAS in these items. The first is total fluorine testing, which captures all PFAS and provides information about the total PFAS concentration. The second is compound-specific testing using mass spectrometry, which can detect a limited number of PFAS but provides information about the type of PFAS used. Concentrations of total fluorine are generally much higher than those of PFAS measured using compound-specific testing; the primary reason is likely that much of the PFAS content is in a polymeric form that is not measured. Since PFAS are a very large class of chemicals, non-polymeric PFAS that we are currently unable to measure may also be present.

Textiles were cut into samples by Toxic-Free Future using instruments cleaned with isopropyl alcohol and shipped to Galbraith Laboratories (Tennessee, USA) for measurement of total fluorine content using combustion with ion selective electrode; for most items this analysis had a detection limit of 10 parts per million (ppm). Besides the 60 original samples, we submitted six duplicate samples to Galbraith. Differences in all cases were minimal with the exception of a 47% difference in measurements in one item that had extremely high total fluorine measurements. Items with total fluorine content greater than 100 ppm were selected for analysis of specific PFAS analytes. Concentrations of a total of 51 PFAS were measured by Eurofins (Sweden) using ultra-performance liquid chromatography-tandem mass spectrometry (UPLC/MS/MS) after methanol extraction; the detection limit for these analytes ranged from one to 10 µg/kg.

# Results

## Key Findings

1. **PFAS are commonly used for stain and water resistance.** The majority (72%) of items marketed as stain- or water-resistant, or 34 of 47 with this type of labeling, contained PFAS. On the other hand, none of the 13 items without stain or water resistance marketing appeared to contain PFAS.

2. **Multiple types of consumer products contain PFAS.** We detected PFAS in a wide variety of products that included rain jackets, hiking pants, shirts, mattress pads, comforters, tablecloths, and napkins.

3. **No retailer's product line was totally PFAS-free.** At least one product from each of the 10 retailers—Amazon, Bed Bath & Beyond, Costco, Dick's Sporting Goods, Kohl's, Macy's, REI, Target, TJX, and Walmart—contained PFAS.

4. **Manufacturers have been using a mixture of PFAS that includes compounds banned in other countries.** Our testing found not just the newer compounds believed to be the most commonly used, but also the older PFAS banned in the European Union and phased out by major U.S. manufacturers. Most PFAS-containing items (74%) tested positive for these older PFAS and in some cases, they were the most abundant or only PFAS detected.

5. **Alternatives to PFAS for stain and water resistance are in use.** We found items in each category that were marketed as stain- and/or water-resistant yet appeared to be free of PFAS.

Our screening for total fluorine identified 35 products containing fluorine at levels above 100 ppm, which we used as a screening level. These 35 products underwent compound-specific testing that included testing for the fluorotelomer alcohols (FTOHs), building blocks used to make PFAS-containing surface treatments known as side-chain fluorinated polymers. The laboratory testing we commissioned also included compounds such as PFOA and PFHxA that are the well-known persistent degradation products of PFAS-containing surface treatments.

Among those 35 products that underwent compound-specific testing, PFAS were detected in 34. Nearly three quarters (25 of 34) of these products contained a PFAS mixture that included or contained only older PFAS banned in the European Union and phased out by major U.S. manufacturers. Older (also known as long-chain) PFAS are defined here as perfluorocarboxylic acids with carbon chain lengths of eight or more and perfluoroalkane sulfonic acids with carbon chain lengths of six or more. USEPA regulations that went into effect in September

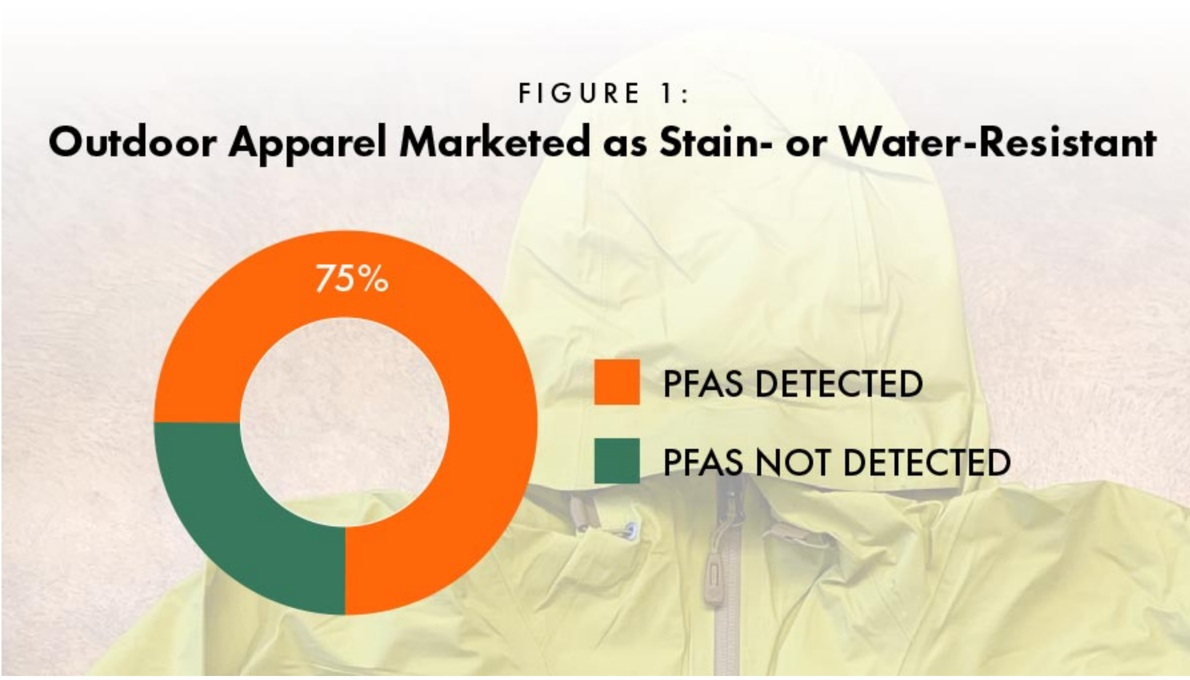
2020 prohibit the import of articles containing some of the older PFAS without prior approval; since we purchased these items in the fall of 2020, they may have been imported before the new regulations went into effect.[37]

The widespread presence of PFAS in household textiles and outdoor apparel for stain and water resistance raises concerns about the contribution of these products to human exposures via indoor and outdoor air, house dust, drinking water, food, and breast milk.

## Outdoor Apparel

The 20 outdoor apparel items tested included 13 jackets, three shirts/pullovers, and four pairs of pants. All were labeled as stain-or water-resistant. We found the following:

- Among 20 items tested, we detected PFAS in 15. Eight contained the older PFAS banned in Europe and phased out by major U.S. manufacturers.
- Most jackets (9 of 13) were treated with PFAS. In five of the jackets, we detected only newer PFAS; four jackets, including three under the REI brand, contained a mixture of older and newer PFAS, also known as long-chain and short-chain compounds, respectively.
- Two name-brand rain jackets, made by Mammut and The North Face, tested below our screening level for fluorine and appear to be made with alternatives to PFAS.
- We detected PFAS in most (6 of 7) other apparel labeled as water- or stain-resistant. Four of these items, purchased at Walmart and Dick's Sporting Goods, contained mainly or only older PFAS.



*We detected PFAS in 15 of 20 jackets, shirts/pullovers, and pants, all of which were marketed as stain- or water-resistant.*

## *Table 1: PFAS in Outdoor Apparel*

◉ = older PFAS detected ▲ = newer PFAS detected

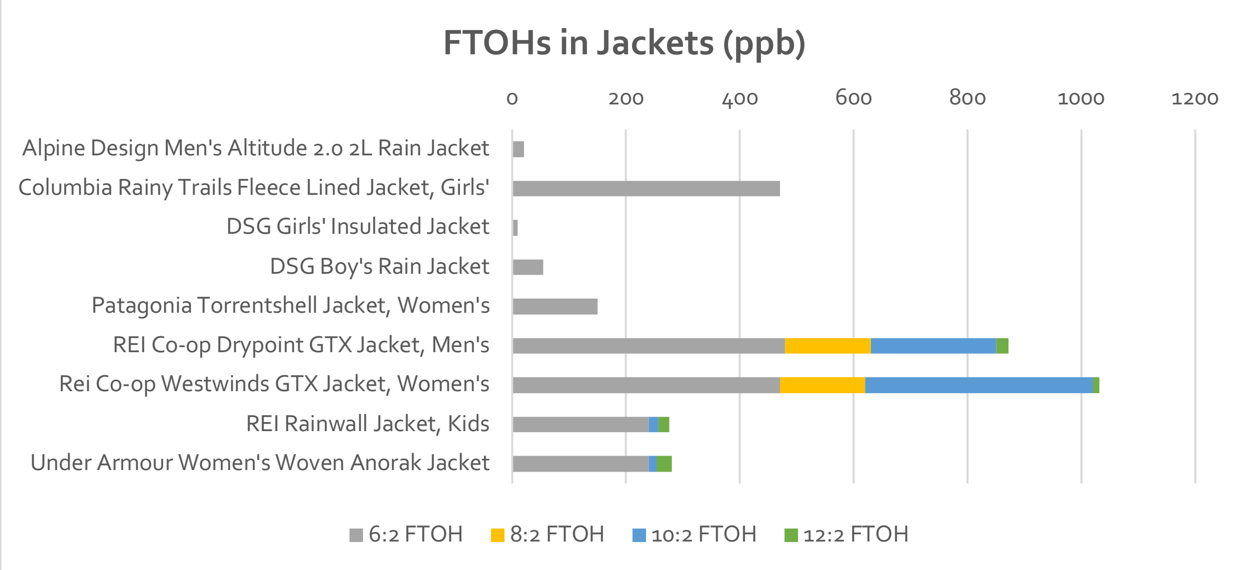
| Retailer | Product | PFAS Detected |
|---|---|---|
| All Items Labeled Stain- or Water-Resistant | | |
| DICK'S SPORTING GOODS | Alpine Design Men's Altitude 2.0 2L Rain Jacket | ▲ |
| DICK'S SPORTING GOODS | Dakine Women's Noella Tech Flannel Button Down Shirt | ◉ |
| DICK'S SPORTING GOODS | DSG Girls' Insulated Jacket | ▲ |
| DICK'S SPORTING GOODS | DSG Boy's Rain Jacket | ▲ |
| DICK'S SPORTING GOODS | DSG Men's Wind Jacket | |
| DICK'S SPORTING GOODS | The North Face Women's Resolve 2 Rain Jacket | |
| DICK'S SPORTING GOODS | Under Armour Men's Storm Windstrike 1/2 Zip Golf Pullover | ▲ |
| DICK'S SPORTING GOODS | Under Armour Women's Woven Anorak Jacket | ◉ ▲ |
| REI co-op | Columbia Rainy Trails Fleece Lined Jacket, Girls' | ▲ |

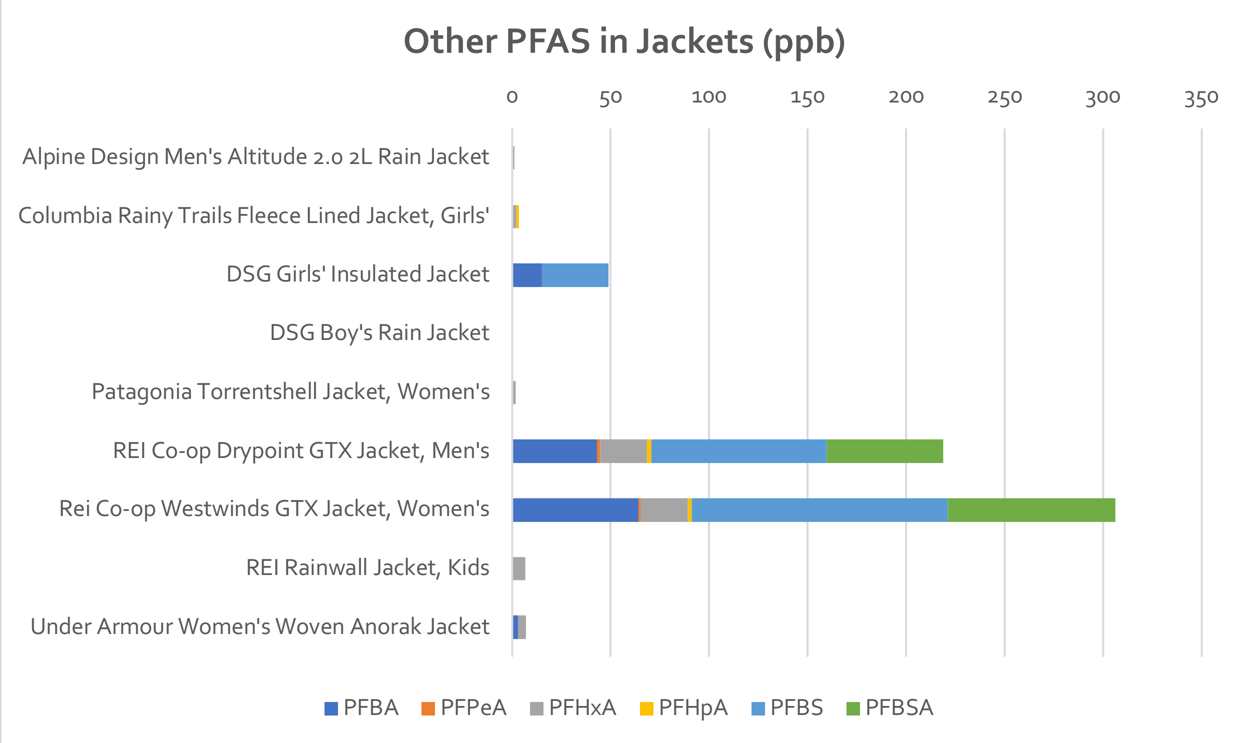
| | | |
|---|---|---|
| REI co-op | Mammut Kento HS Hooded Jacket, Men's | |
| REI co-op | Patagonia Torrentshell Jacket, Women's | ▲ |
| REI co-op | REI Co-op Drypoint GTX Jacket, Men's | ◉ ▲ |
| REI co-op | REI Co-op Westwinds GTX Jacket, Women's | ◉ ▲ |
| REI co-op | REI Rainwall Jacket, Kids | ◉ ▲ |
| REI co-op | REI Co-op Sahara Convertible Pant, Women's | |
| REI co-op | REI Co-op Savanna Trails Pant, Men's | ▲ |
| Walmart | Canis Cute Kids Girls' New Flowers Hooded Raincoat | |
| Walmart | 5.11 Tactical Women's Stain Resistant Shirt | ◉ ▲ |
| Walmart | Lelinta Men's Casual Trousers | ◉ |
| Walmart | Rothco Tactical Duty Pants | ◉ ▲ |

## Jackets

We tested 13 jackets, including 11 rain jackets, one insulated jacket, and one wind jacket. We purchased the majority of these items from two major retailers, REI and Dick's Sporting Goods. In many cases, total fluorine testing revealed high fluorine content, up to 8%, indicating the likely presence of heavy PFAS surface treatments, PFAS membranes, or both. While the Alpine Design, Dick's Sporting Goods, and Patagonia Torrentshell jackets contained exclusively newer

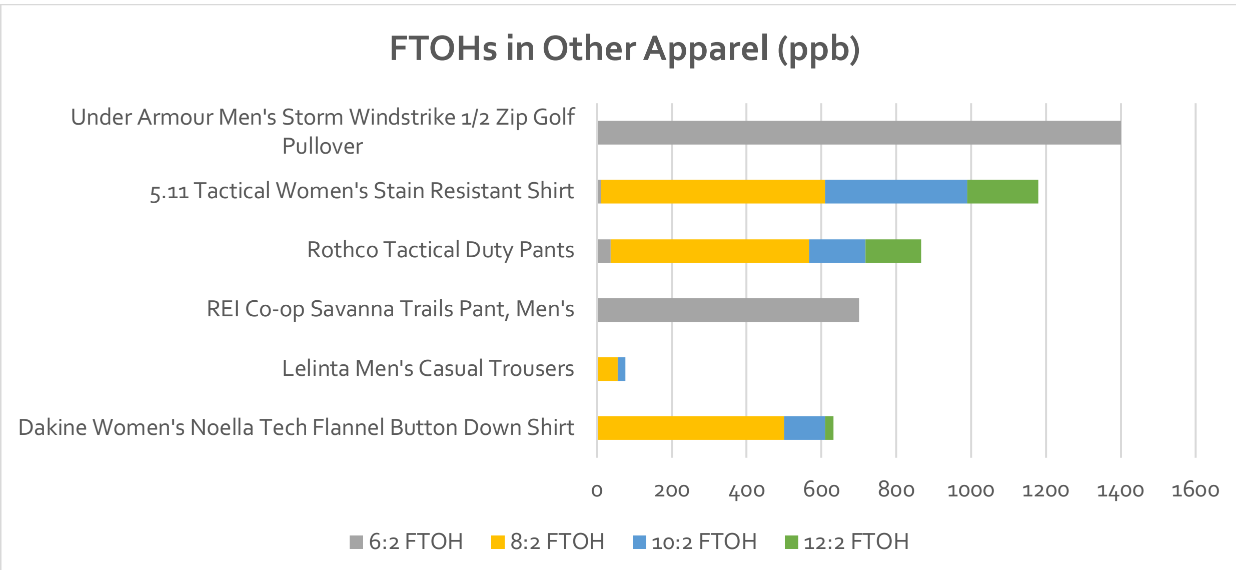
PFAS, all three REI-branded items, including two made with Gore-Tex, contained a mixture of older and newer compounds. Based on label information and the very high total fluorine content in the Gore-Tex jackets (4 to 8%), the two Gore-Tex jackets likely contain a PFAS membrane known as ePTFE as well as a PFAS-based surface treatment, or durable water repellent (DWR). Surprisingly, we detected all four fluorotelomer alcohols we analyzed for in the Gore-Tex jackets, including six-, eight-, ten-, and twelve-carbon, despite Gore's claim that it phased out eight-carbon PFAS in 2013[38]. Older PFAS were also detected in the REI-brand Rainwall Jacket for kids.

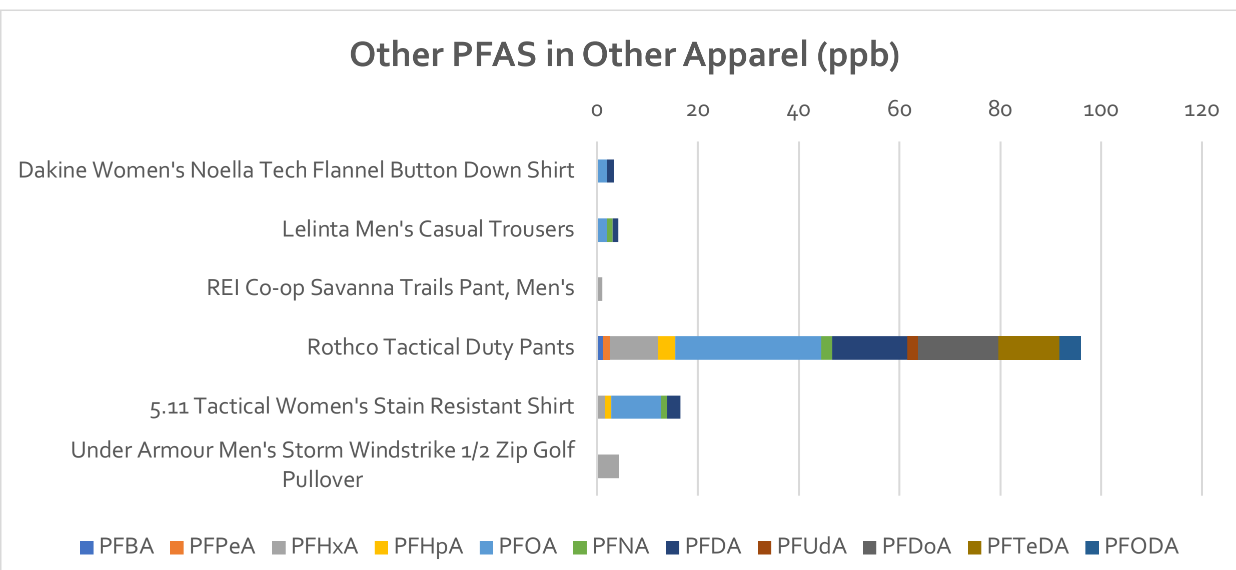


## Other Apparel

We tested two pairs of hiking pants from REI, a shirt and two pairs of pants purchased at Walmart, and a golf pullover and flannel shirt from Dick's Sporting Goods. Although the REI hiking pants were labeled similarly as having a durable water repellent finish, one pair contained PFAS but we did not detect fluorine in the other pair. Three items from Walmart contained PFAS, and in all cases the older compounds were most abundant. We detected PFAS in both items from Dick's Sporting Goods, including older PFAS in the flannel shirt and newer compounds in the golf pullover.

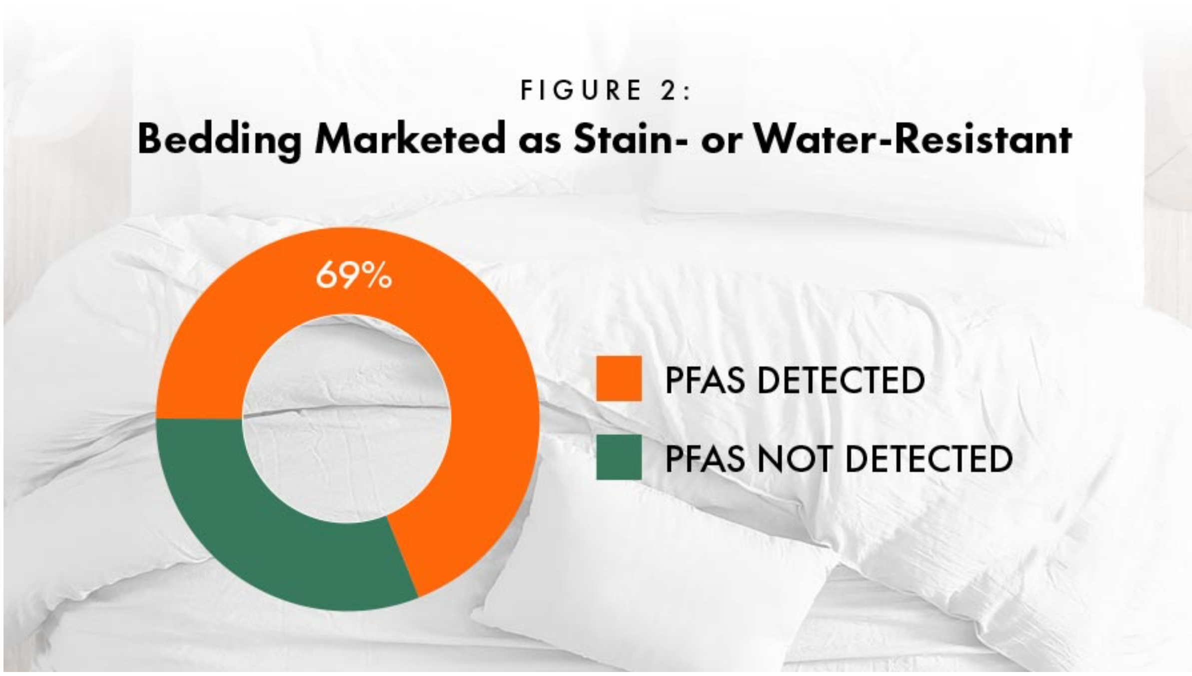


# Bedding

The 20 bedding items tested included four comforters, seven mattress pads or covers, and nine sheets or pillowcases. Thirteen of these items were labeled as stain- or water-resistant. Our testing found the following:

- We detected PFAS in nine of the 13 bedding items marketed as stain- or water-resistant. None of the items without such claims tested above our screening level for fluorine.
- All four comforters contained PFAS; all were labeled as stain- or water-resistant.
- Three of the four comforters contained a mixture of older and newer PFAS.
- Four of the seven mattress pads or protectors tested contained PFAS; six were labeled as stain- or water-resistant.
- Only one of eight tested sheet sets—pillow protectors marketed as Teflon®-treated, waterproof and stain-resistant—tested positive for fluorine and contained PFAS. Three of the eight sheet sets were marketed as stain- or water-resistant.




*Nine out of the 13 bedding items marketed as stain- or water-resistant contained PFAS.*

*Table 2: PFAS in Bedding*

◉ = older PFAS detected ▲ = newer PFAS detected

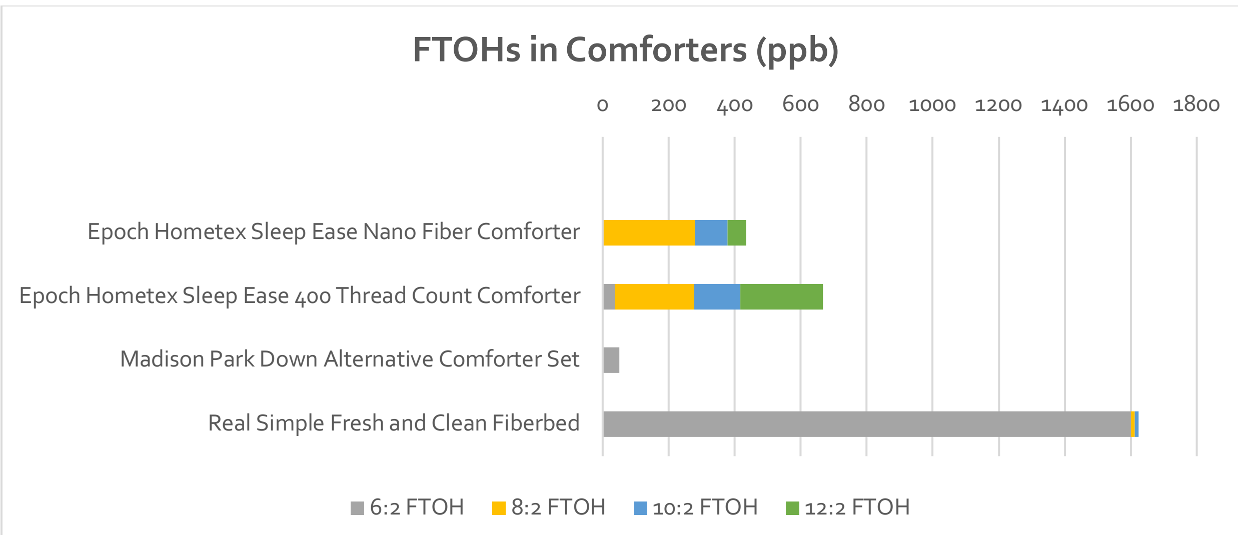
| Retailer | Product | PFAS Detected |
|---|---|---|
| Items Labeled Stain- or Water-Resistant | | |
| amazon | Fresh Ideas Cotton Rich Pillow Protectors Treated With Teflon | ◉ ▲ |
| BED BATH & BEYOND | Peak Performance Knitted Microfleece Sheet Set | |
| BED BATH & BEYOND | Real Simple Fresh and Clean Fiberbed | ◉ ▲ |
| BED BATH & BEYOND | Therapedic Mattress Pad | |
| COSTCO WHOLESALE | Beautyrest Black® Total Protection Mattress Pad | ◉ ▲ |
| KOHL'S | The Big One Essential Mattress Pad | |
| KOHL'S | Down Home DuPont™ Sorona® Mattress Pad | ◉ ▲ |
| KOHL'S | Epoch Hometex Sleep Ease 400 Thread Count Comforter | ◉ ▲ |
| macy's | Cottonloft StayClean Cotton Water and Stain Resistant Fiberbed Protector Set | ◉ ▲ |

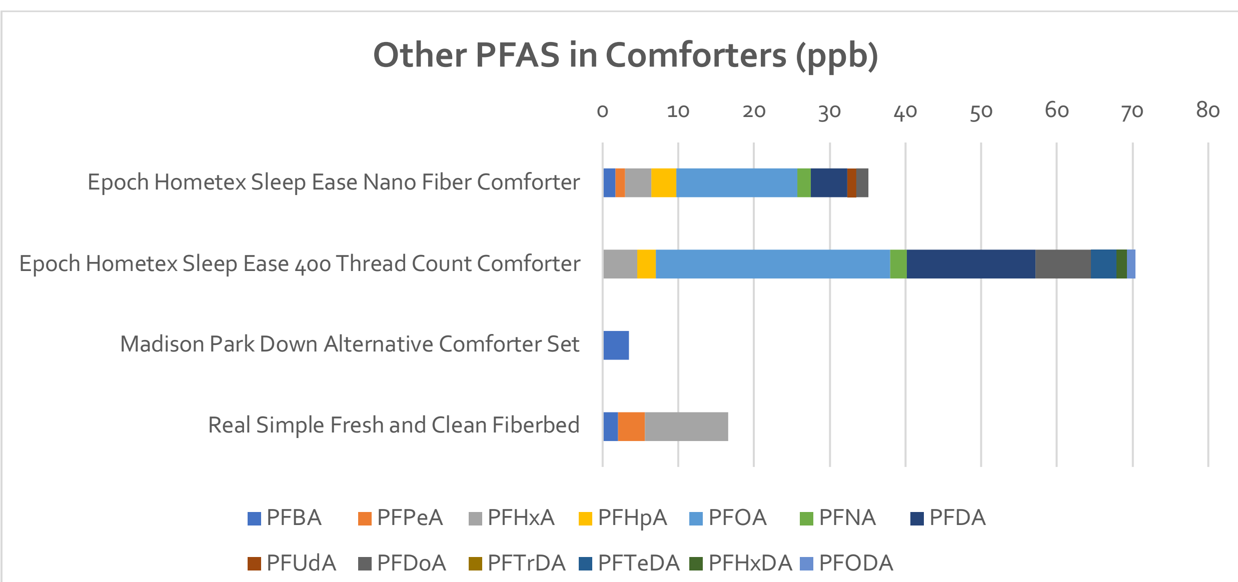
| | | |
|---|---|---|
| TARGET | Madison Park Down Alternative Comforter Set | ▲ |
| TJX | Sealy Cool & Clean Sheet Set | |
| Walmart | Epoch Hometex Sleep Ease Nano Fiber Comforter | ◉ ▲ |
| Walmart | Sertapedic Crib Mattress Pad Cover | ◉ ▲ |
| Items Not Labeled Stain- or Water-Resistant | | |
| amazon | AmazonBasics Lightweight Super Soft Easy Care Microfiber Bed Sheet Set | |
| BED BATH & BEYOND | Joovy Room 2 Waterproof Fitted Sheet | |
| BED BATH & BEYOND | Madison Park Sheet Set | |
| BED BATH & BEYOND | Panda Baby Rayon Viscose Crib Sheet | |
| macy's | Martha Stewart Collection Solid Open Stock 400 Thread Count Sheet Collection | |
| macy's | Sleep Philosophy Sofabed Mattress Pad | |

| | | |
|---|---|---|
| TARGET | Bed Gear Hyper-Cotton Sheet Set | |

## Comforters

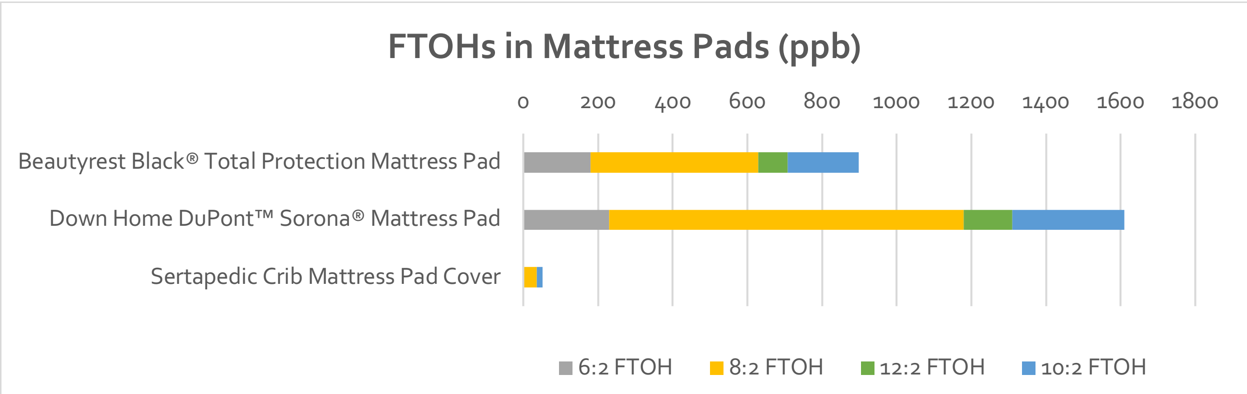
We tested four comforters, all of which were labeled as stain- or water-resistant. Because they all contained fluorine levels greater than our screening level of 100 ppm, they all underwent compound-specific testing for PFAS. Three of the four comforters contained the older PFAS phased out in some countries; in two of the comforters, these older compounds were the most abundant and both contained the well-known toxic compound PFOA.

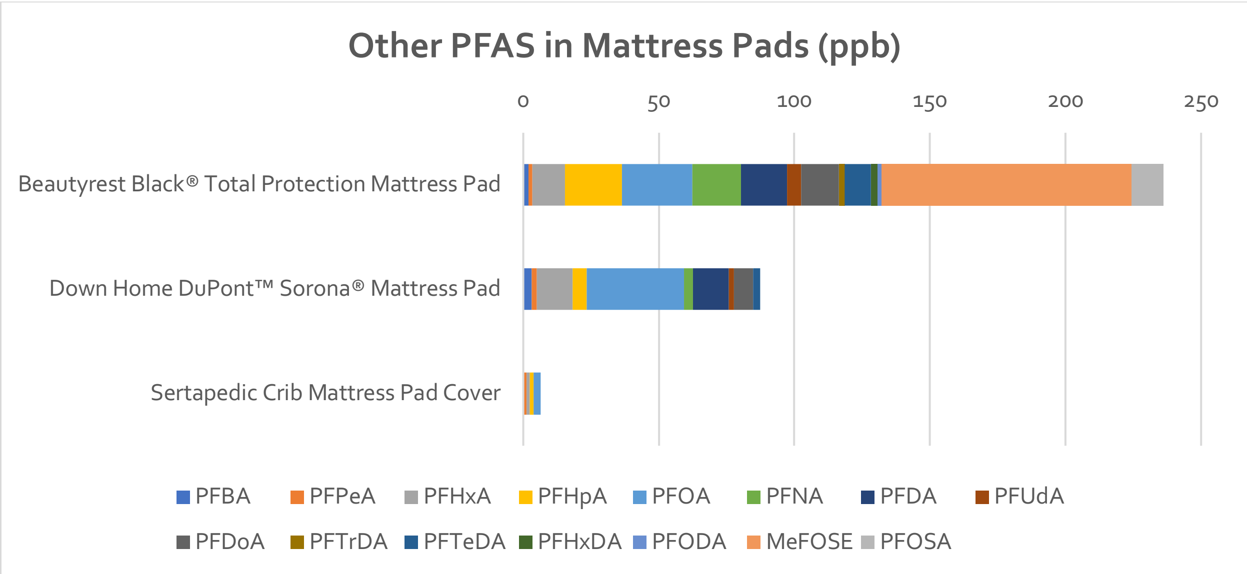


# Mattress Pads

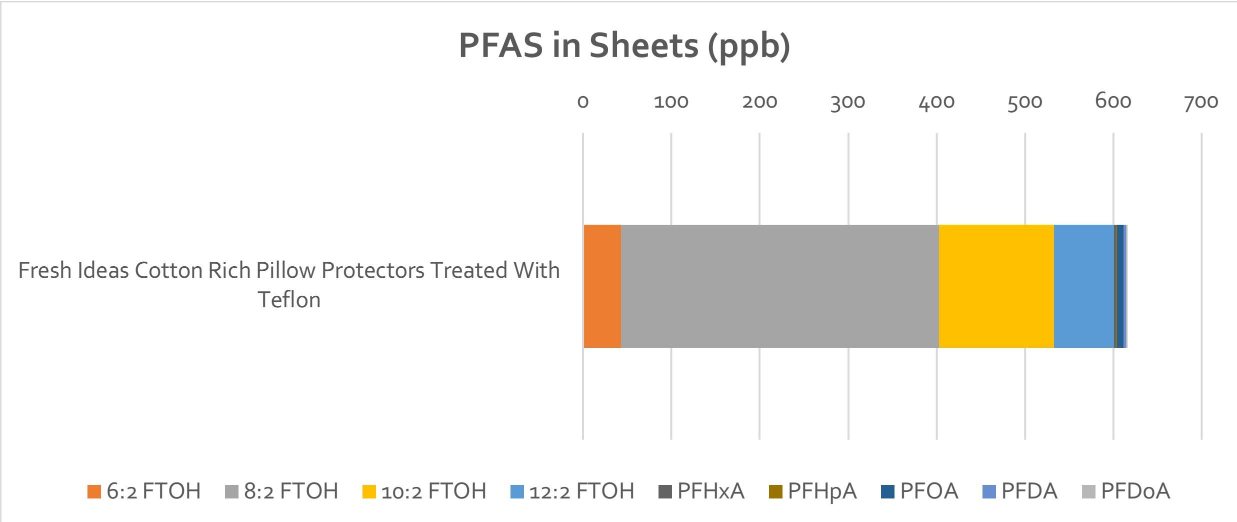
We tested seven mattress pads or protectors, six of which were labeled as stain- or water-resistant or waterproof. Four contained fluorine above the screening level and contained a mixture of older and newer PFAS, some at high concentrations. Total fluorine testing detected no fluorine in three mattress pads; two of these claimed stain resistance and/or waterproofing, indicating that their makers use alternatives to PFAS to achieve those functions.



## Sheets

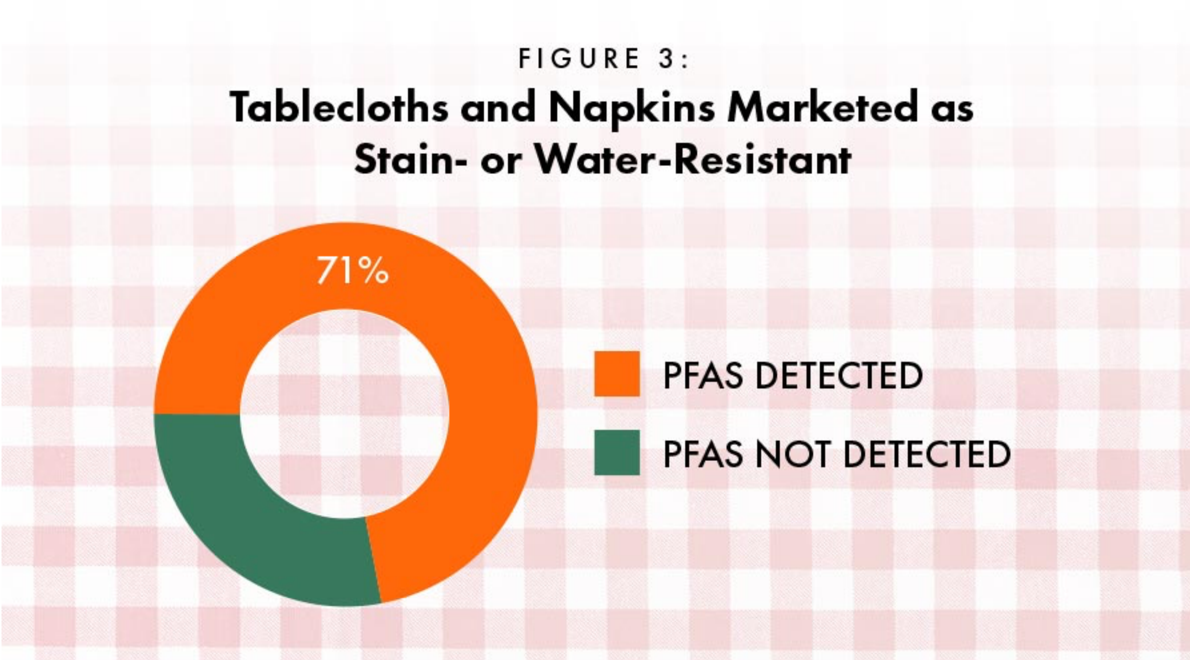
We tested eight sheet sets, including one crib sheet and one set of pillow protectors. Only the pillow protectors tested positive for fluorine above the screening level and underwent further testing. The pillow protectors—"Fresh Ideas Cotton Rich Pillow Protectors Treated with Teflon®"—contained both older and newer PFAS.




# Tablecloths and Napkins

We tested 14 tablecloths and six napkins, and found the following:

- We detected PFAS in 10 of the 20 tablecloths and napkins tested; 14 were labeled as stain- or water-resistant.
- Most (8 of 11) of the tablecloths labeled as stain-or water-resistant contained PFAS.
- None of the tablecloths or napkins that were not marketed as stain- or water-resistant tested above our screening level for fluorine.
- In four of the eight PFAS-treated tablecloths, we detected exclusively older PFAS.
- Two of the six napkin sets tested contained PFAS; three were marketed as stain-resistant.




*We detected PFAS in 10 of 14 tablecloths and napkins with stain or water resistance claims.*

## *Table 3: PFAS in Tablecloths and Napkins*

◉ = older PFAS detected ▲ = newer PFAS detected

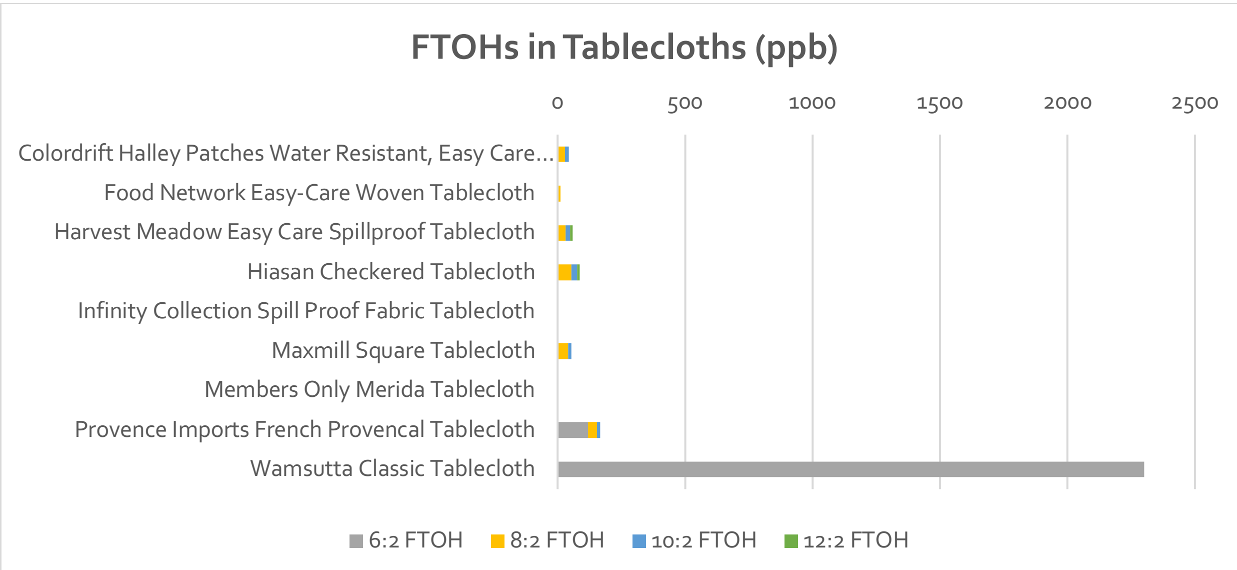
| Retailer | Product | PFAS Detected |
|---|---|---|
| Items Labeled Stain- or Water-Resistant | | |
| amazon | Hiasan Checkered Tablecloth | ◉ ▲ |
| amazon | Maxmill Square Tablecloth | ◉ |
| amazon | Provence Imports French Provencal Tablecloth | ◉ ▲ |

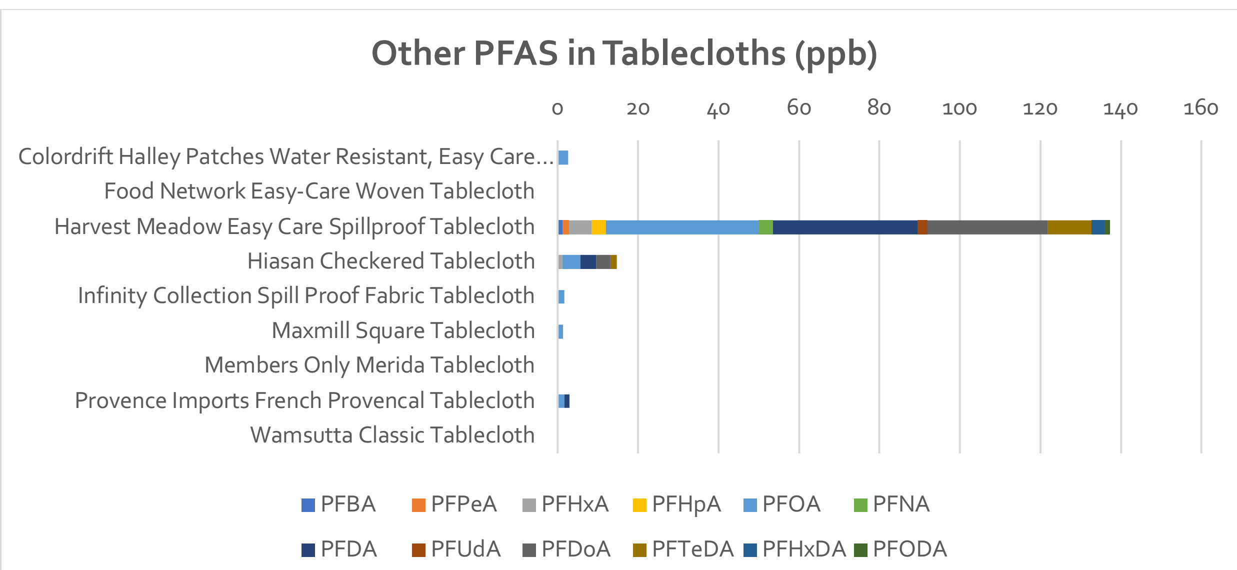
| | | |
|---|---|---|
| BED BATH & BEYOND | Wamsutta Classic Tablecloth | ▲ |
| KOHL'S | Cuisinart Basketware Stain-Resistant Microfiber Napkin | ◉ |
| KOHL'S | Food Network Easy-Care Woven Tablecloth | ◉ |
| TARGET | Elrene Barcelona Damask Stain Resistant Napkin | |
| TARGET | Town and Country Living Tablecloth | |
| TJX | Harvest Meadow Easy Care Spillproof Tablecloth | ◉ ▲ |
| TJX | Colordrift Halley Patches Water Resistant, Easy Care Tablecloth | ◉ |
| Walmart | Daily Chef Table Napkin | ◉ ▲ |
| Walmart | Efavormart Round Polyester Tablecloth | |
| Walmart | Infinity Collection Spill Proof Fabric Tablecloth | ◉ |
| Walmart | Members Only Merida Tablecloth | |

| Items Not Labeled Stain- or Water-Resistant | | |
|---|---|---|
| KOHL'S | St Nicholas Square Warm & Cozy Napkin | |
| macy's | Elrene Farmhouse Living Buffalo Check Tablecloth | |
| TARGET | C & F Berkeley Yellow Cotton Reversible Napkin | |
| TJX | 34th & Pine Napkin | |
| TJX | Newbridge Fabric Tablecloth | |
| Walmart | Mainstays Fraser Tablecloth | |

## Tablecloths

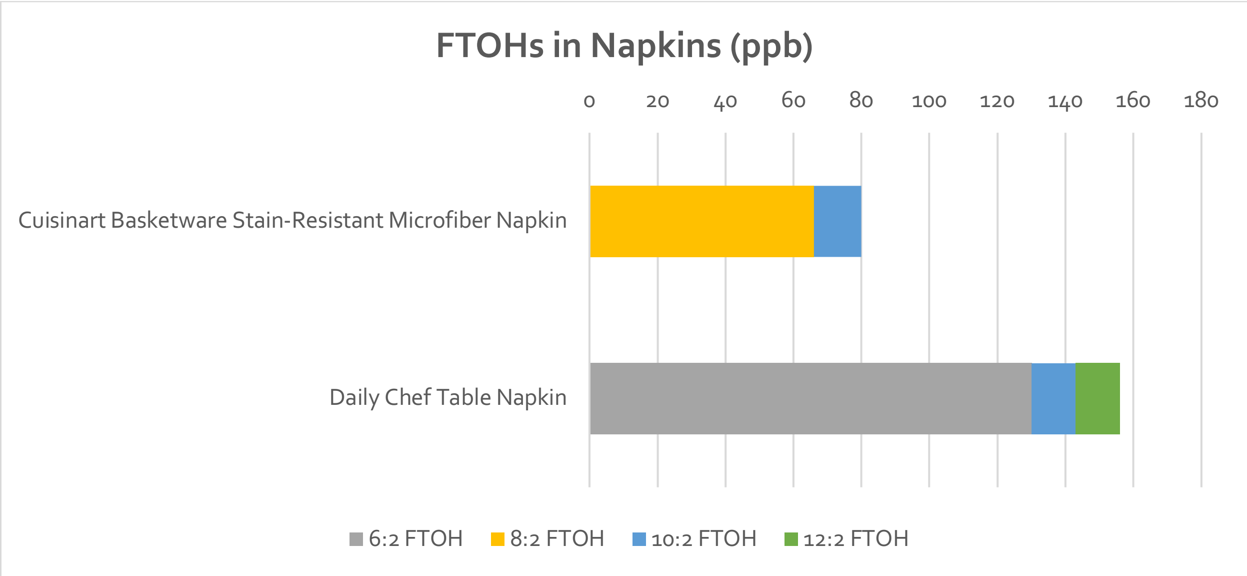
Of the 14 tablecloths we tested, 11 were labeled as stain- or water-resistant, with varying language including phrases such as "spills bead up and wipe away quickly." Nine tested above the screening level of 100 ppm for total fluorine and underwent further testing. We found PFAS in eight of those tablecloths, all labeled as stain- or water-resistant. In one tablecloth, we did not detect PFAS although it tested above the screening level for total fluorine. This was possibly due to use of a PFAS treatment we were unable to detect as there are more than 9,000 PFAS and our testing could capture just 51 of them. We did not detect fluorine in two tablecloths labeled as stain- or water-resistant; neither disclosed a separate treatment so it is unclear whether the fabric or weave is inherently resistant or a PFAS-free treatment was used.

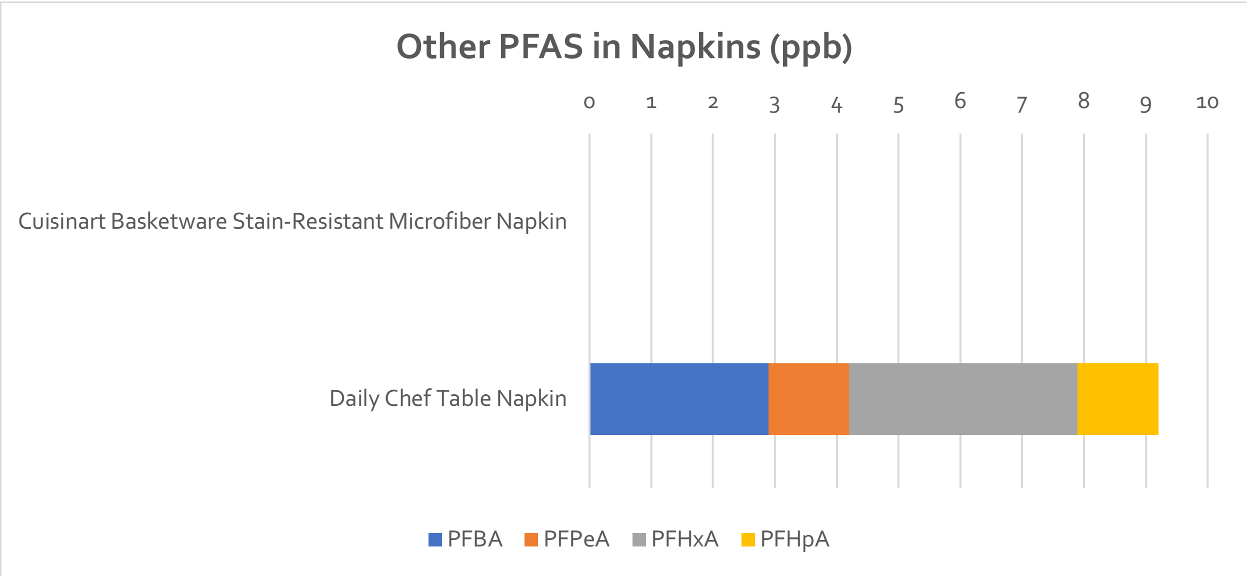


## Napkins

Just two of the six napkin sets tested above our screening level for fluorine, and they both contained PFAS: Daily Chef Table Napkins, purchased at Walmart, and Cuisinart Basketweave Microfiber Napkins, purchased at Kohl's. PFAS detected in both items included older PFAS.



# Results by Retailer

**We detected PFAS in at least one item from each of the 10 retailers.**

## Amazon

Four of five products from Amazon contained PFAS, including the older PFAS banned in the European Union and phased out by major U.S. manufacturers.

## Bed Bath & Beyond

Of the seven products purchased at Bed Bath & Beyond, two contained PFAS. One of these items included both older and newer PFAS; the other contained only newer PFAS. Apparently PFAS-free items included several sheet sets and a mattress pad advertised as stain-resistant.

## Costco

The Beautyrest® mattress pad we tested contained both older and newer PFAS, including all of the fluorotelomer alcohols we tested for; two precursors of the toxic, persistent, and bioaccumulative PFOS; and persistent PFAS including PFHxA and PFOA.

## Dick's Sporting Goods

Six of eight products purchased at Dick's Sporting Goods tested above our screening level for total fluorine, and we detected PFAS in each of these. The DSG (Dick's Sporting Goods' store brand) jackets contained only newer PFAS, while others, including an Under Armour® jacket and Dakine flannel shirt, also contained or were dominated by older PFAS.

## Kohl's

Four of the six products purchased at Kohl's contained PFAS: a mattress pad, a comforter, a tablecloth, and napkins. All four contained older PFAS, and the mattress pad and comforter also contained newer PFAS.

## Macy's

Of the four items purchased at Macy's, including a tablecloth, mattress pad, mattress protector set, and sheets, only the mattress protector set tested above our screening level for fluorine and contained PFAS.

## REI

Six of the eight products purchased at REI contained PFAS. Three items contained only newer PFAS, and three contained a mixture of older and newer PFAS. Two REI-branded jackets made with Gore-Tex tested particularly high for total fluorine, likely due to the use of a PFAS-membrane in addition to a surface treatment. All three REI-branded jackets contained older PFAS.

## Target

One of the five products purchased at Target, a comforter, contained PFAS. Sheets, two sets of napkins, and a tablecloth purchased at Target tested below our screening level for total fluorine.

## TJX

Two of five items purchased at TJX stores (including TJ Maxx and HomeGoods) contained PFAS: two tablecloths marketed as stain-resistant. A sheet set, tablecloth, and napkins tested below our screening level for total fluorine.

## Walmart

Eight of 11 products purchased at Walmart tested above our screening level for fluorine, and we detected PFAS in seven of those: a shirt and two pairs of pants labeled as water- or stain-resistant, a tablecloth, a crib mattress cover, a comforter, and a napkin set. We found older PFAS in all of those seven items, and newer PFAS in five.

# Implications—PFAS in Our Lives

Our tests have found that manufacturers continue to use PFAS widely in apparel and home furnishings. At the same time, we found similar products made without the use of PFAS in each product category.

Surprisingly, the tests revealed widespread use not only of the newer PFAS whose use the chemical industry acknowledges, but also the older PFAS banned in some countries.

This continued use of PFAS has unfortunate implications for communities where PFAS are manufactured and/or applied to textiles, for children and adults living, learning, or working where PFAS-treated items are present, and for communities whose drinking water may be contaminated by landfills leaching PFAS from textiles.

## How the Chemicals We Found May Harm Us

### 6:2 FTOH

6:2 FTOH is the chemical we detected with the highest overall abundance (nearly 50% of detected PFAS) and was present in 37% of the products we sampled, at concentrations up to 2,300 parts per billion (ppb). This chemical is an expected breakdown product of the side-chain fluorinated polymers typically used as surface treatments and together with the detection of fluorine is an indication of the use of this type of polymer. After 6:2 FTOH detaches from the polymer, it in turn breaks down to form persistent PFAS including PFHxA and PFHpA.[39] In 2020, U.S. Food and Drug Administration (FDA) scientists reviewed the toxicity of 6:2 FTOH.[40] They described evidence from laboratory studies that 6:2 FTOH exposure results in effects including kidney and liver degeneration; impacts on thymus and spleen, key immune system organs; developmental effects including decreased survival of young and reduced growth during lactation; and indications of possible carcinogenicity. Shortly after the publication of this review, FDA announced industry's voluntary withdrawal of food packaging treatments containing this chemical. As our testing shows, however, 6:2 FTOH is still widely present in surface treatments used on textiles.

### 8:2 FTOH

Surprisingly, this older PFAS was also highly abundant, second only to 6:2 FTOH and detected in 33% of products and at concentrations up to 950 ppb. Its abundance indicates that many textile manufacturers have continued to rely on older PFAS banned in other countries and phased out by U.S. manufacturers. As a result, U.S. residents have continued exposure to 8:2 FTOH and its breakdown products, which include PFOA and PFNA.[41] These compounds are well-established as toxic and bioaccumulative, with estimated half-lives in people of two to 10 years for PFOA and 2.5 to 4.3 years for PFNA.[1] Potential toxic effects of PFOA include harm to the immune system, increased cholesterol, and cancer; and for PFNA, they include increased cholesterol and decreased antibody response to vaccines.[1]

## PFOA, PFHxA, PFBA and other persistent PFAS

PFOA, PFHxA, PFBA and other persistent PFAS were found in 48% of the products. Detected in 28% of the products, PFOA was the most abundant persistent PFAS overall in terms of concentrations, followed by PFBA (12% of products) and PFHxA (37% of products). PFOA was present at a relatively high concentration in the pants we purchased at Walmart (29 ppb) and a tablecloth purchased at TJX (HomeGoods) (38 ppb). The new-generation compounds such as PFHxA and PFBA have not been as well-studied as PFOA, but laboratory studies found effects including developmental delays and litter loss (PFBA), stillborn offspring (PFHxA), kidney degeneration (PFHxA), damage to liver function (PFHxA), and effects on lipid metabolism (PFBA, PFHxA, and others).[42-48]

# Moving Past PFAS—Other Technologies in Use

As our testing shows, PFAS are a common way for companies to achieve water and stain resistance on garments and home furnishings, but alternatives to PFAS are also in wide use.

## Water-Repellent Membranes And Finishes

As described earlier, waterproofing is typically achieved using a microporous membrane, a water-repellent finish, or both. While PFAS-based membranes and PFAS-containing finishes are now in common use, PFAS-free waterproofing has a long history and is also widely available. Back in the 1930s, tightly woven cotton fabric, forming a microporous structure, was developed for use by the British Air Force.[49] Today, polyurethane is commonly used to create a microporous membrane, such as in Marmot's MemBrain laminated fabrics and Jack Wolfskin's Texapore.[50, 51] Sympatex® manufactures a membrane using polyester for use in apparel.[50] To our knowledge, these alternatives have not been independently assessed for hazard.

Several kinds of PFAS-free water-repellent finishes are in common use. These include hydrocarbons, silicone, melamine, and highly branched molecules called dendrimers.[52] Hydrocarbons and waxes are available and have increasingly been adopted by outdoor brands. Schoeller's ecorepel® is a paraffin wax treatment used by Mammut, and Green Theme Technologies manufactures a hydrocarbon-based treatment, known as Empel™, now used by Black Diamond.[53, 54] Rudolf Group's Bionic Finish® Eco, used by companies including H&M, is an example of a dendrimer-based treatment.[55] Melamine is used in conjunction with stearic acid, reacted with formaldehyde, as a surface treatment.[52] Melamine compounds were recently detected in a high proportion of infant clothing items tested with the highest levels in outerwear.[56] Silicone treatments have been introduced by major companies such as Dow.[57]

While the composition of these treatments is generally guarded by producers as proprietary, researchers conducted a general hazard assessment of durable water repellents that included PFAS, hydrocarbons, and silicone.[58] This assessment scored paraffin wax, representing hydrocarbon treatments, as GreenScreen Benchmark 3, or recommended for use. In contrast, the assessment of chemicals likely found in silicone-based treatments identified hazards including repeated-dose toxicity, aquatic toxicity, persistence, and bioaccumulation.

# Cleanability

Many companies successfully produce products that are easily cleanable without the use of PFAS-containing surface treatments. For home furnishings such as tablecloths and napkins, this may be as simple as machine washability. For larger items such as furniture and carpet, this may involve the use of more specialized cleaners, which can be selected from items designated safer under the USEPA's Safer Choice program.

# Recommendations

We can't continue to accept the tradeoff of polluting our homes, bodies, air, soil, water, and breast milk with persistent, toxic PFAS so that companies can market products as stain- and water-resistant. With the tremendous progress companies have made in the last several years bringing PFAS-free items to market, the time is now for textile manufacturers, retailers, and policymakers to lead the way to PFAS-free products made with safer alternatives.

## Textile Manufacturers

Companies that make home furnishings and apparel should do the following:

- *Policy*: Immediately adopt public policies that quickly phase out use of all PFAS with quantifiable goals and timelines.
- *Choose safer methods*: Implement known safer methods, such as making items with washable fabrics rather than treating fabric with stain-repellent chemicals.
- *Avoid regrettable substitution*: Assess any substitute chemicals for hazard using tools such as GreenScreen for Safer Chemicals® or ChemFORWARD to ensure that any replacement chemicals are the safest possible, excluding at a minimum GreenScreen Benchmark 1 chemicals.
- *Embrace transparency*: Disclose all product ingredients.
- *Update the public*: Provide progress reports to the public on at least an annual basis.

## Retailers

Retailers should do the following:

- *Policy*: Adopt ambitious public safer chemicals policies that get ahead of the curve and ensure all textile products available for sale are free of PFAS.
- *Goals and metrics*: Set clear, ambitious public goals with timelines and quantifiable metrics to reduce and eliminate PFAS.
- *Transparency*: Require suppliers to provide full disclosure of product ingredients.
- *Avoid regrettable substitution*: Assess any substitute chemicals for hazard using a method such as GreenScreen for Safer Chemicals® or ChemFORWARD to ensure that any replacement chemicals are the safest possible, excluding at a minimum GreenScreen Benchmark 1 chemicals.
- *Disclose progress*: Provide progress reports to the public on at least an annual basis.
- *Stay ahead of and support government regulation*: As policies addressing toxic chemicals gain traction in more states and from the Biden administration, retailers must act. Retailers should support state and federal policy reform to advance ingredient

transparency, eliminate PFAS, and incentivize the development of green-chemistry solutions.

# Policymakers

Leaders at the state and federal levels should enact policies as follows:

- End the use of PFAS in all textiles.
- Adopt comprehensive chemicals policies that require ingredient disclosure, restrict the most dangerous chemicals, and identify safer alternatives using tools such as GreenScreen for Safer Chemicals® and ChemFORWARD.
- Ensure cleanup of contaminated communities, holding polluters financially responsible.
- Use governmental purchasing power to avoid products containing PFAS and spur movement toward the safest substitutes.

# Consumers

Our results indicate that even though PFAS aren't listed on product labels, we can in many cases avoid buying apparel and home furnishings with PFAS by staying away from stain-resistant products. Ultimately, store shelves will be free of products with PFAS when policymakers and companies do their part, so everyone can also help by advocating for change.

Here are five actions you can take to protect your family from PFAS in apparel and home furnishings:

1. Call on your favorite retailers to "mind the store." When retailers like REI continue to sell PFAS-containing products, they contribute to the contamination of our communities and drinking water. Take action today and sign our petition to REI at MindTheStore.org.

2. Contact your elected officials. Write to your state and federal representatives and let them know you would like them to ban PFAS in apparel and other products in your home.

3. *Avoid buying apparel and home furnishings that advertise stain resistance.* Our tests found that many items marketed as stain-resistant, from apparel to bedding, tablecloths, and napkins, are treated with PFAS. Instead, choose items that are washable. Buyer beware: third-party standards like OEKO-TEX®, bluesign®, and ZDHC don't currently restrict the entire PFAS class, so you can't rely on these standards when shopping for PFAS-free.

4. *If you need apparel or home furnishings that are waterproof or water-resistant, find items that are PFAS-free.* We found rain jackets and mattress pads that are marketed as water-resistant or waterproof yet did not appear to contain PFAS. Contact companies and search for items listed as PFAS-free to ensure they are free of the entire class of compounds. Avoid items with labeling such as "PFOA-free" that indicates it is free of some but not all PFAS.

5. *Get engaged for change.* Sign up for our email list at ToxicFreeFuture.org and follow us on Instagram, Facebook, and Twitter for opportunities to move company and public policies towards a toxic-free future.

# References

1. Agency for Toxic Substances & Disease Registry,*Toxicological Profile for Perfluoroalkyls*; U.S. Department of Health and Human Services, Public Health Service: **2021**; https://www.atsdr.cdc.gov/toxprofiles/tp200.pdf
2. Ecology Center, Supply chains of nonstick PTFE pan coatings: Case studies; https://www.ecocenter.org/healthy-stuff/pages/supply-chains-nonstick-ptfe-pan-coatings-case-studies.
3. Schreder, E.; Kemler, B.,*Path of Toxic Pollution: How making "forever chemicals" for food packaging threatens people and the climate*; Toxic-Free Future: **2021**; https://toxicfreefuture.org/research/daikin-path-of-toxic-pollution/.
4. Özek, H., Development of waterproof breathable coatings and laminates. In *Waterproof and Water Repellent Textiles and Clothing*, Williams, J. T., Ed. Elsevier, Woodhead Publishing: Cambridge, US, **2018**.
5. Steenland, K.; Jin, C.; MacNeil, J.; Lally, C.; Ducatman, A.; Vieira, V.; Fletcher, T., Predictors of PFOA Levels in a Community Surrounding a Chemical Plant. *Environmental Health Perspectives* **2009,** *117*, (7), 1083-1088.
6. Sun, M.; Arevalo, E.; Strynar, M.; Lindstrom, A.; Richardson, M.; Kearns, B.; Pickett, A.; Smith, C.; Knappe, D. R. U., Legacy and Emerging Perfluoroalkyl Substances Are Important Drinking Water Contaminants in the Cape Fear River Watershed of North Carolina. *Environmental Science & Technology Letters* **2016,** *3*, (12), 415-419.
7. Hogue, C., What's GenX still doing in the water downstream of a Chemours plant?; https://cen.acs.org/articles/96/i7/whats-genx-still-doing-in-the-water-downstream-of-a-chemours-plant.html.
8. Heydebreck, F.; Tang, J.; Xie, Z.; Ebinghaus, R., Emissions of Per- and Polyfluoroalkyl Substances in a Textile Manufacturing Plant in China and Their Relevance for Workers' Exposure. *Environmental Science & Technology* **2016,** *50*, (19), 10386-10396.
9. Rauert, C.; Shoieb, M.; Schuster, J. K.; Eng, A.; Harner, T., Atmospheric concentrations and trends of poly- and perfluoroalkyl substances (PFAS) and volatile methyl siloxanes (VMS) over 7 years of sampling in the Global Atmospheric Passive Sampling (GAPS) network. *Environmental Pollution* **2018,** *238*, 94-102.
10. Fromme, H.; Dreyer, A.; Dietrich, S.; Fembacher, L.; Lahrz, T.; Völkel, W., Neutral polyfluorinated compounds in indoor air in Germany - the LUPE 4 study. *Chemosphere* **2015,** *139*, 572-578.
11. Winkens, K.; Koponen, J.; Schuster, J.; Shoeib, M.; Vestergren, R.; Berger, U.; Karvonen, A. M.; Pekkanen, J.; Kiviranta, H.; Cousins, I. T., Perfluoroalkyl acids and their precursors in indoor air sampled in children's bedrooms. *Environmental Pollution* **2017,** *222*, 423-432.
12. Morales-McDevitt, M. E.; Becanova, J.; Blum, A.; Bruton, T. A.; Vojta, S.; Woodward, M.; Lohmann, R., The Air That We Breathe: Neutral and Volatile PFAS in Indoor Air. *Environmental Science & Technology Letters* **2021**.

13. Schlummer, M.; Gruber, L.; Fiedler, D.; Kizlauskas, M.; Müller, J., Detection of fluorotelomer alcohols in indoor environments and their relevance for human exposure. *Environ Int* **2013,** *57-58*, (42-49).
14. Langer, V.; Dreyer, A.; Ebinghaus, R., Polyfluorinated compounds in residential and nonresidential indoor air. *Environ Sci Technol* **2010,** *44*, 8075-8081.
15. Wu, Y.; Miller, G. Z.; Gearhart, J.; Peaslee, G.; Venier, M., Side-chain fluorotelomer-based polymers in children car seats. *Environmental Pollution* **2021,** *268*, 115477.
16. CEC, Furthering the Understanding of the Migration of Chemicals from Consumer Products - A Study of Per- and Polyfluoroalkyl Substances (PFASs) in Clothing, Apparel, and Children's Items.; http://www3.cec.org/islandora/en/item/11777-furthering-understanding-migration-chemicals-from-consumer-products-en.pdf.
17. Franko, J.; Meade, B. J.; Frasch, H. F.; Barbero, A. M.; Anderson, S. E., Dermal Penetration Potential of Perfluorooctanoic Acid (PFOA) in Human and Mouse Skin. *Journal of Toxicology and Environmental Health, Part A* **2012,** *75*, (1), 50-62.
18. van der Veen, I.; Hanning, A.-C.; Stare, A.; Leonards, P. E. G.; de Boer, J.; Weiss, J. M., The effect of weathering on per- and polyfluoroalkyl substances (PFASs) from durable water repellent (DWR) clothing. *Chemosphere* **2020,** *249*, 126100.
19. Guerra, P.; Kim, M.; Kinsman, L.; Ng, T.; Alaee, M.; Smyth, S. A., Parameters affecting the formation of perfluoroalkyl acids during wastewater treatment. *Journal of Hazardous Materials* **2014,** *272*, 148-154.
20. Schellenberger, S.; Jönsson, C.; Mellin, P.; Levenstam, O. A.; Liagkouridis, I.; Ribbenstedt, A.; Hanning, A.-C.; Schultes, L.; Plassmann, M. M.; Persson, C.; Cousins, I. T.; Benskin, J. P., Release of Side-Chain Fluorinated Polymer-Containing Microplastic Fibers from Functional Textiles During Washing and First Estimates of Perfluoroalkyl Acid Emissions. *Environmental Science & Technology* **2019,** *53*, (24), 14329-14338.
21. Lang, J.; Allred, B.; Field, J.; Levis, J.; Barlaz, M., National estimate of per- and polyfluoroalkyl substance (PFAS) release to U.S. municipal landfill leachate. *Environ Sci Technol* **2017,** *51*, (4), 2197-2205.
22. Michigan PFAS Action Response Team, PFAS Sites and Areas of Interest Interactive Map; https://data.michigan.gov/d/c7kk-ngqy/visualization.
23. Washington Department of Ecology, Per- and Polyfluoroalkyl Substances Chemical Action Plan; https://apps.ecology.wa.gov/publications/summarypages/2104048.html.
24. Miner, K. R.; Clifford, H.; Taruscio, T.; Potocki, M.; Solomon, G.; Ritari, M.; Napper, I. E.; Gajurel, A. P.; Mayewski, P. A., Deposition of PFAS 'forever chemicals' on Mt. Everest. *Sci Total Environ* **2021,** *759*, 144421.
25. Casal, P.; González-Gaya, B.; Zhang, Y.; Reardon, A. J.; Martin, J. W.; Jiménez, B.; Dachs, J., Accumulation of Perfluoroalkylated Substances in Oceanic Plankton. *Environ Sci Technol* **2017,** *51*, (5), 2766-2775.
26. Smithwick, M.; Norstrom, R. J.; Mabury, S. A.; Solomon, K.; Evans, T. J.; Stirling, I.; Taylor, M. K.; Muir, D. C. G., Temporal Trends of Perfluoroalkyl Contaminants in Polar Bears (Ursus maritimus) from Two Locations in the North American Arctic, 1972−2002. *Environmental Science & Technology* **2006,** *40*, (4), 1139-1143.

27. Reiner, J. L.; O'Connell, S. G.; Moors, A. J.; Kucklick, J. R.; Becker, P. R.; Keller, J. M., Spatial and Temporal Trends of Perfluorinated Compounds in Beluga Whales (Delphinapterus leucas) from Alaska. *Environmental Science & Technology* **2011,** *45*, (19), 8129-8136.
28. Kannan, K., E Perrotta, and NJ Thomas, Association between perfluorinated compounds and pathological conditions in southern sea otters. *Environmental Science and Technology* **2006,** *40*, (16), 4943-4948.
29. Smithwick, M.; Muir, D. C.; Mabury, S. A.; Solomon, K. R.; Martin, J. W.; Sonne, C.; Born, E. W.; Letcher, R. J.; Dietz, R., Perflouroalkyl contaminants in liver tissue from East Greenland polar bears (Ursus maritimus). *Environ Toxicol Chem* **2005,** *24*, (4), 981-6.
30. Gebbink, W. A.; Bossi, R.; Rigét, F. F.; Rosing-Asvid, A.; Sonne, C.; Dietz, R., Observation of emerging per- and polyfluoroalkyl substances (PFASs) in Greenland marine mammals. *Chemosphere* **2016,** *144*, 2384-91.
31. Gebbink, W. A.; Bignert, A.; Berger, U., Perfluoroalkyl Acids (PFAAs) and Selected Precursors in the Baltic Sea Environment: Do Precursors Play a Role in Food Web Accumulation of PFAAs? *Environmental Science & Technology* **2016,** *50*, (12), 6354-6362.
32. Yeung, L. W. Y.; Mabury, S. A., Are humans exposed to increasing amounts of unidentified organofluorine? *Environmental Chemistry* **2016,** *13*, (1), 102-110.
33. Lau, C., K Anitole, C Lodes, D Lai, A Pfahles-Hutchens, and J Seed, Perfluoroalkyl acids: a review of monitoring and toxicological findings. *Toxicological Sciences* **2007,** *99*, (2), 366-394.
34. Centers for Disease Control and Prevention, Early Release: Per- and Polyfluorinated Substances (PFAS) Tables, NHANES 2011-2018; https://www.cdc.gov/exposurereport/pfas_early_release.html.
35. Fiedler, H.; Sadia, M., Regional occurrence of perfluoroalkane substances in human milk for the global monitoring plan under the Stockholm Convention on Persistent Organic Pollutants during 2016–2019. *Chemosphere* **2021,** *277*, 130287.
36. Zheng, G.; Schreder, E.; Dempsey, J. C.; Uding, N.; Chu, V.; Andres, G.; Sathyanarayana, S.; Salamova, A., Per- and Polyfluoroalkyl Substances (PFAS) in Breast Milk: Concerning Trends for Current-Use PFAS. *Environmental Science & Technology* **2021,** *55*, (11), 7510-7520.
37. Significant New Use Rule: Long-Chain Perfluoroalkyl Carboxylate and Perfluoroalkyl Sulfonate Chemical Substances.40 CFR Part 721. **2020**. https://www.regulations.gov/document/EPA-HQ-OPPT-2013-0225-0232.
38. *Life Cycle Assessment of DWR treatments on waterproof, windproof and breathable jacket. Summary report.*; **2015**; https://www.gore-tex.com/sites/default/files/assets/Gore-DWR-LCA-summary-report-151215-2.pdf.
39. Russell, M. H.; Himmelstein, M. W.; Buck, R. C., Inhalation and oral toxicokinetics of 6:2 FTOH and its metabolites in mammals. *Chemosphere* **2015,** *120*, 328-335.
40. Rice, P. A.; Aungst, J.; Cooper, J.; Bandele, O.; Kabadi, S. V., Comparative analysis of the toxicological databases for 6:2 fluorotelomer alcohol (6:2 FTOH) and perfluorohexanoic acid (PFHxA). *Food and Chemical Toxicology* **2020,** *138*, 111210.
41. Butt, C.; Muir, D.; Mabury, S., Biotransformation pathways of fluorotelomer-based polyfluoroalkyl substances: a review. *Env Tox and Chem* **2013,** *33*, (2), 243-267.
42. Das, K.; Grey, B.; Zehr, R.; Wood, C.; Butenhoff, J.; Chang, S.-C.; Ehresman, D.; Tan, Y.-M.; Lau, C., Effects of perfluorobutyrate exposure during pregnancy in the mouse. *Toxicol Sci* **2008,** *105*, (1), 173-181.

43. Iwai, H.; Hoberman, A., Oral (gavage) combined developmental and perinatal/postnatal reproduction toxicity study of ammonium salt of perfluorinated hexanoic acid in mice. *Int J Toxicol* **2014,** *33*, (3), 219-237.
44. Loveless, S.; Slezak, B.; Serex, T.; Lewis, J.; Mukerji, P.; O'Connor, J.; Donner, E.; Frame, S.; Korzeiowski, S.; Buck, R., Toxicological evaluation of sodium perfluorohexanoate. *Toxicology* **2009,** *264*, 32-44.
45. Mukerji, P.; Rae, J.; Buck, R.; O'Connor, J., Oral repeated-dose systemic and reproductive toxicity of 6:2 fluorotelomer alcohol in mice. *Toxicology Reports* **2015,** *2*, 130-143.
46. Chengelis, C.; Kirkpatrick, J.; Rodovsky, A.; Shinohara, M., A 90-day repeated dose oral (gavage) toxicity study of perfluorohexanoic acid (PFHxA) in rats (with functional observational battery and motor activity determinations). *Reproductive Toxicology* **2009,** *27*, 342-351.
47. Rosenmai, A.; Ahrens, L.; le Godec, T.; Lundqvist, J., Relationship between peroxisome proliferator-activated receptor alpha activity and cellular concentration of 14 perfluoroalkyl substance in HepG2 cells. *J Appl tox* **2017,** *38*, (2), 219-226.
48. Wolf, C.; Schmid, J.; Lau, C.; Abbott, B., Activation of mouse and human peroxisome proliferator-activated receptor-alpha (PPARα) by perfluoroalkyl acids (PFAAs): further investigation of C4-C12 compounds. *Reproductive Toxicology* **2012,** *33*, 546-551.
49. Stotz & Co. AG, Ventile® Our History; https://ventile.co.uk/the-history-of-ventile/.
50. Sympatex, Product and Technology; https://www.sympatex.com/en/about-us/product-and-technology/.
51. Jack Wolfskin, Goal Achieved: Our Clothes and All Items of Equipment are Entirely PFC-Free; https://www.jack-wolfskin.com/information-pfc/.
52. ZDHC,*Durable Water and Soil Repellent Chemistry in the Textile Industry - a Research Report*; **2012**; file:///Users/erikashome/Downloads/FINAL_ZDHC_P05_DWR-Research_Nov20121-1.pdf.
53. Green Theme Technologies, Technology: Clean Chemistry, Polymer Science, and a Patented Process, Create the Empel™ Advantage; https://greenthemetek.com/technology/.
54. Schoeller, Environmentally Friendly Water and Dirt Repellence; https://www.schoeller-textiles.com/en/technologies/ecorepel.
55. Rudolf Group, Bionic-Finish® Eco; https://www.rudolf.de/en/technology/bionic-finish-eco/.
56. Zheng, G.; Salamova, A., Are Melamine and Its Derivatives the Alternatives for Per- and Polyfluoroalkyl Substance (PFAS) Fabric Treatments in Infant Clothes? *Environmental Science & Technology* **2020,** *54*, (16), 10207-10216.
57. Dow, Dowsil™ IE-8749 Emulsion; https://www.dow.com/en-us/pdp.dowsil-ie-8749-emulsion.04128934z.html.
58. Holmquist, H.; Schellenberger, S.; van der Veen, I.; Peters, G. M.; Leonards, P. E. G.; Cousins, I. T., Properties, performance and associated hazards of state-of-the-art durable water repellent (DWR) chemistry for textile finishing. *Environment International* **2016,** *91*, 251-264.

# Appendix: Total Fluorine in Outdoor Apparel, Bedding, and Tablecloths & Napkins

*Table 4: Total Fluorine in Outdoor Apparel*

| Item | Total Fluorine |
|---|---|
| Alpine Design Men's Altitute 2.0 2L Rain Jacket ppm | 424 ppm |
| Canis Cute Kids Girls' New Flowers Hooded Raincoat | 11 ppm |
| Columbia Rainy Trails Fleece Lined Jacket, Girls' | 760 ppm |
| Dakine Women's Noella Tech Flannel Button Down Shirt | 288 ppm |
| DSG Girls' Insulated Jacket | 330 ppm |
| DSG Boy's Rain Jacket | 743 ppm |
| DSG Men's Wind Jacket | <10 ppm |
| Lelinta Men's Casual Trousers | 441 ppm |
| Mammut Kento HS Hooded Jacket, Men's | 61 ppm |
| The North Face Women's Resolve 2 Rain Jacket | 13 ppm |
| Patagonia Torrentshell Jacket, Women's | 956 ppm |
| REI Co-op Drypoint GTX Jacket, Men's | 82,000 ppm |
| Rei Co-op Westwinds GTX Jacket, Women's | 83,300 ppm |
| REI Rainwall Jacket, Kids | 1486 ppm |
| REI Co-op Sahara Convertible Pant, Women's | <9 ppm |
| REI Co-op Savanna Trails Pant, Men's | 698 ppm |
| Rothco Tactical Duty Pants | 1337 ppm |
| 5.11 Tactical Women's Stain Resistant Shirt | 1832 ppm |
| Under Armour Men's Storm Windstrike 1/2 Zip Golf Pullover | 938 ppm |
| Under Armour Women's Woven Anorak Jacket | 6465 ppm |

*Table 5: Total Fluorine in Bedding*

| Item | Total Fluorine |
| --- | --- |
| AmazonBasics Lightweight Super Soft Easy Care Microfiber Bed Sheet Set | <10 ppm |
| Bed Gear Hyper-Cotton Sheet Set | 17 ppm |
| Beautyrest Black® Total Protection Mattress Pad | 807 ppm |
| The Big One Essential Mattress Pad | <9 ppm |
| Cottonloft StayClean Cotton Water and Stain Resistant Fiberbed Protector Set | 1314 ppm |
| Down Home DuPont™ Sorona® Mattress Pad | 537 ppm |
| Epoch Hometex Sleep Ease Nano Fiber Comforter | 183 ppm |
| Epoch Hometex Sleep Ease 400 Thread Count Comforter | 361 ppm |
| Fresh Ideas Cotton Rich Pillow Protectors Treated With Teflon | 393 ppm |
| Joovy Room 2 Waterproof Fitted Sheet | 11 ppm |
| Madison Park Down Alternative Comforter Set | 109 ppm |
| Madison Park Sheet Set | 42 ppm |
| Martha Stewart Collection Solid Open Stock 400 Thread Count Sheet Collection | <9 ppm |
| Panda Baby Rayon Viscose Crib Sheet | <10 ppm |
| Peak Performance Knitted Microfleece Sheet Set | <10 ppm |
| Real Simple Fresh and Clean Fiberbed | 1221 ppm |
| Sealy Cool & Clean Sheet Set | <10 ppm |
| Sertapedic Crib Mattress Pad Cover | 120 ppm |
| Sleep Philosophy Sofabed Mattress Pad | <10 ppm |
| Therapedic Mattress Pad | <10 ppm |

*Table 6: Total Fluorine in Tablecloths and Napkins*

| Item | Total Fluorine |
|---|---|
| AmazonBasics Lightweight Super Soft Easy Care Microfiber Bed Sheet Set | <10 ppm |
| Bed Gear Hyper-Cotton Sheet Set | 17 ppm |
| Beautyrest Black® Total Protection Mattress Pad | 807 ppm |
| The Big One Essential Mattress Pad | <9 ppm |
| Cottonloft StayClean Cotton Water and Stain Resistant Fiberbed Protector Set | 1314 ppm |
| Down Home DuPont™ Sorona® Mattress Pad | 537 ppm |
| Epoch Hometex Sleep Ease Nano Fiber Comforter | 183 ppm |
| Epoch Hometex Sleep Ease 400 Thread Count Comforter | 361 ppm |
| Fresh Ideas Cotton Rich Pillow Protectors Treated With Teflon | 393 ppm |
| Joovy Room 2 Waterproof Fitted Sheet | 11 ppm |
| Madison Park Down Alternative Comforter Set | 109 ppm |
| Madison Park Sheet Set | 42 ppm |
| Martha Stewart Collection Solid Open Stock 400 Thread Count Sheet Collection | <9 ppm |
| Panda Baby Rayon Viscose Crib Sheet | <10 ppm |
| Peak Performance Knitted Microfleece Sheet Set | <10 ppm |
| Real Simple Fresh and Clean Fiberbed | 1221 ppm |
| Sealy Cool & Clean Sheet Set | <10 ppm |
| Sertapedic Crib Mattress Pad Cover | 120 ppm |
| Sleep Philosophy Sofabed Mattress Pad | <10 ppm |
| Therapedic Mattress Pad | <10 ppm |