BACWA BAY AREA CLEAN WATER AGENCIES

FEBRUARY 2024

PFAS STUDY SUMMARY

Bay Area Clean Water Agencies and San Francisco Estuary Institute

Study of PFAS in Bay Area Wastewater

KEY POINTS

PFAS are ubiquitous in numerous everyday products and in the environment.

As long as PFAS continues to be produced and used in consumer products, PFAS will be present in wastewater influent, effluent, and biosolids.

WHAT MAKES THIS STUDY UNIQUE?

This study quantified PFAS in wastewater using a comprehensive lab method called the Total Oxidizable Precursors (TOP) assay. This method quantifies more of the PFAS than other typical lab methods, which means this study was able to better track PFAS through the treatment process. Sampling of residential areas was another unique study feature.

WHERE IS THE PFAS IN WASTEWATER COMING FROM?

Residential users appear to be a significant source of PFAS to Bay Area wastewater treatment plants. Among industrial and commercial facilities included in this study, industrial laundries showed the highest concentrations, followed by car washes.

HOW MUCH PFAS IS IN BAY AREA WASTEWATER?

PFAS concentrations in Bay Area wastewater (see Figure 1 on page 3) were similar to levels seen in other communities in California. There are currently no PFAS standards directly applicable to biosolids or San Francisco Bay wastewater discharges. Most biosolids samples were below the “action levels” for land application recently adopted in other states.

What are PFAS?

Per- and polyfluoroalkyl substances (PFAS) are a large group of human-made compounds that are resistant to heat, water, and oil. Common PFAS-containing products include non-stick cookware, cardboard/paper food packaging, water-resistant clothing, carpets, personal care products, and fire-fighting foam. PFAS do not break down in the environment, can accumulate within the human body, and can be toxic at relatively low concentrations.

Publicly Owned Treatment Works (POTWs) receive PFAS from residential, commercial, and industrial customers in their service areas. Some PFAS transform to other PFAS compounds during the treatment process, but are not destroyed. PFAS received in POTW influent ultimately partition into effluent, air, or biosolids depending on the individual compound’s chemical characteristics.

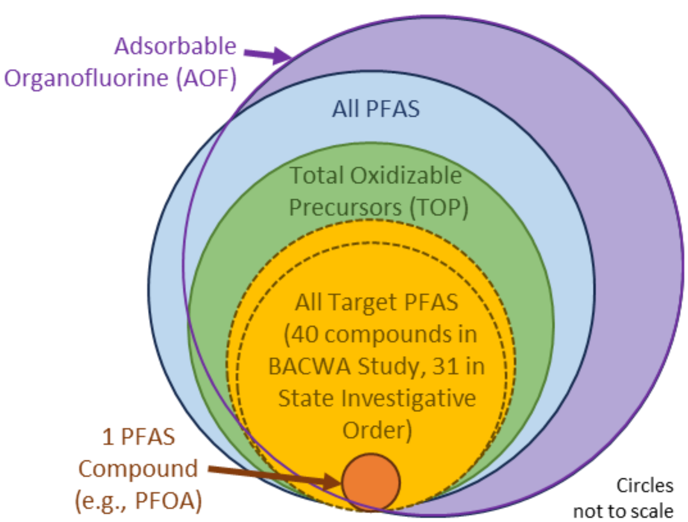
Why did BACWA Complete this Study?

In 2019, the State Water Board started requiring testing of drinking water systems and other high-risk locations for PFAS such as landfills, airports, industrial chrome-platers, refineries & bulk terminals, and POTWs[a]. The Bay Area Clean Water Agencies (BACWA) worked with State and Regional Water Board staff to respond to the need for testing at POTWs. BACWA worked with scientists at San Francisco Estuary Institute (SFEI) to design and complete a two-phase study[b,c]:

- **Phase 1** (Fall 2020). Fourteen representative facilities collected influent, effluent, and biosolids samples to test for PFAS. Facilities were selected based on their size, location, level of industry in their service area, treatment technology, and whether they had participated in previous SFEI PFAS studies, so that trends in individual PFAS compounds could be tracked over time. The final report for Phase 1 was released in October 2021[d].

- **Phase 2** (Mid-2022). Seven facilities collected influent and effluent samples, and five of the seven also collected biosolids samples for PFAS analysis. Samples were also collected upstream of POTWs in residential areas and at select industrial and commercial facilities. Industrial facilities were selected that had not already been included in the State Water Board's investigative orders. Phase 2 was completed by larger agencies that volunteered to participate. Results from Phase 2 were shared at the Regional Monitoring Program Annual Meeting in October 2023[e], and the final report for Phase 2 was completed in December 2023. The report is available from BACWA staff upon request.

While the State Water Board required wastewater samples (influent, effluent, biosolids) to be measured for a specified 31 individual PFAS analytes, the BACWA-SFEI study went beyond this list and used a target method that included 40 individual analytes. Additionally, this study included another method called the Total Oxidizable Precursors (TOP) assay. The TOP assay involves oxidizing the sample to convert PFAS to terminal transformation products, then analyzed with the Target method. The total PFAS quantified with the TOP method includes not only the 40 analytes in the Target method, but additionally includes PFAS precursors that can transform to those 40 analytes. The advantage of the TOP analysis is that it gives a better estimate of all PFAS in a sample, and not just the 40 individual analytes included in the analytical method (see conceptual schematic at left). Both the target and TOP assay quantified PFAS using USEPA Method 1633. Phase 2 also included analysis of Adsorbable Organofluorine (AOF) via USEPA Draft Method 1621.



What did the Study Find?

KEY FINDING

In Phase 2, TOP analysis was completed for influent, effluent, and biosolids from 5 facilities.

On average, about half of the mass of total quantified PFAS contained in POTW influent was partitioned to biosolids.

Phase 1 of the study demonstrated that sampling a representative selection of POTWs (rather than all POTWs) was an appropriate strategy for characterizing PFAS. PFAS levels were similar across the 14 participating facilities, as summarized in the Phase 1 report[d]. Both phases of this BACWA-SFEI study showed similar results to the State Water Board's Investigative Order[f] for the targeted analysis. This study also showed that the targeted analysis only captures a fraction of total PFAS compounds. In Phase 2 influent samples, for example, the median for sum of PFAS via the TOP method was 5 times greater than the median for sum of PFAS via target analysis, while the ratio was about 2 for effluent.

Phase 2 showed that PFAS in influent is both transformed and partitioned to biosolids before leaving as treated effluent, as shown below in **Figure 1.** This finding may seem self-evident, but the results of the Phase 1 study and the statewide Investigative Order were not conclusive on this point. Based on targeted analysis, the total quantified PFAS concentration is often *higher* in effluent than influent, potentially leading to the false conclusion that PFAS are added or created within treatment plants. As expected, total quantified PFAS based on Phase 2 TOP analysis conclusively showed substantial removal from influent to effluent at each of the seven facilities sampled (*see orange bars for influent and effluent, Figure 1*). AOF data showed a similar trend.

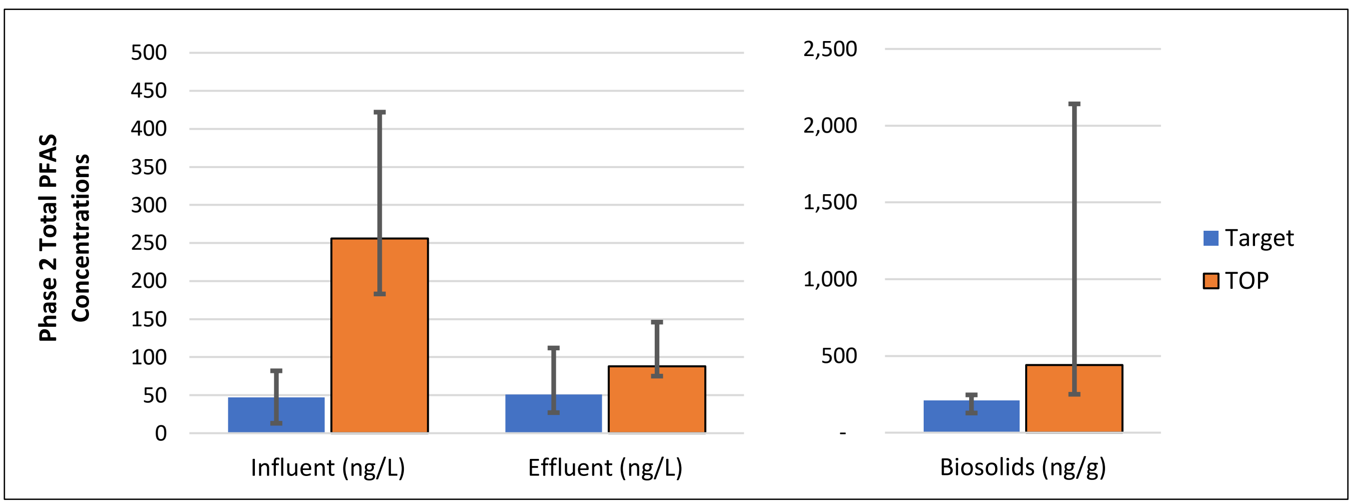


Figure 1. *Phase 2 Total Quantified PFAS based on a sum of targeted analysis of 40 compounds ("Target") and Total Oxidizable Precursors analysis ("TOP"). Note TOP results includes 40 compounds included in Target method, plus PFAS precursors that are converted to one of the 40 Target compounds. Influent and effluent data are in units ng/L and Biosolids are in ng/g (dry weight). The height of each bar chart indicates the median, while the error bars show the minimum and maximum. Phase 1 data are excluded because the TOP analysis was not performed.*

How do PFAS Levels in Bay Area Wastewater Compare to Regulatory Thresholds?

There are currently no water quality criteria for PFAS directly applicable to San Francisco Bay. USEPA has developed draft aquatic life criteria[g], and plans to develop human health criteria based on fish consumption (see side bar). Although surface water quality criteria are still in development, both the State Water Board and USEPA have developed regulatory thresholds for drinking water. Drinking water criteria are not applicable to most Bay Area POTWs, since the Bay is not used as a drinking water supply. They are included here for informational purposes only.

The State Water Board has adopted notification levels of 6.5 ng/L for perfluorooctane sulfonic acid (PFOS), 5.1 ng/L for perfluorooctanoic acid (PFOA), and 3 ng/L for perfluorohexane sulfonic acid (PFHxS)[h]. The USEPA's proposed drinking water Maximum Contaminant Level (MCL) is 4 ng/L for PFOS and PFOA[i]. The proposed MCL for PFHxS is included as part of a unitless "Hazard Index." Effluent concentrations observed from Phase 1 and 2 are compared to these thresholds in **Figure 2**. Although production of both PFOS and PFOA has been phased out in the United States, these compounds were detected in all but one of the study's effluent samples. Some PFOS and PFOA may come from the transformation of other PFAS compounds. Typical concentrations were near or above the proposed federal MCLs.

PFAS IN THE BAY

Through the Regional Monitoring Program, SFEI scientists are monitoring PFAS in San Francisco Bay water, sediment, and sport fish. PFOS is the predominant compound in sport fish, and fish caught in the South Bay have the highest concentrations. Stormwater and wastewater are both possible sources of PFAS in sport fish.

As part of its PFAS Strategic Roadmap, USEPA is planning to publish water quality criteria based on fish consumption in Fall 2024. In the future, the levels of PFAS in sport fish may cause San Francisco Bay to be listed as an impaired water body per section 303(d) of the federal Clean Water Act.

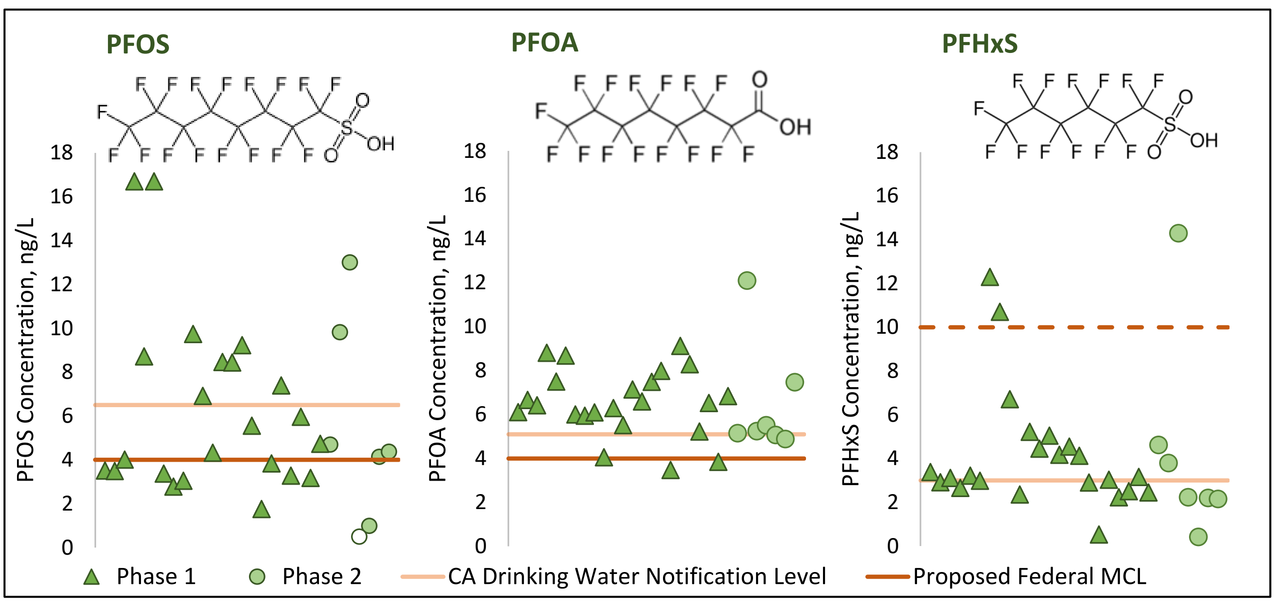


Figure 2. *Phase 1 and 2 effluent concentrations of PFOA, PFOS, and PFHxS compared to California notification levels and proposed USEPA Maximum Contaminant Levels (MCLs) for drinking water. For PFHxS, the proposed MCL is illustrated with a dashed line at 10 ng/L; the unitless Hazard Index of 1.0 is calculated by dividing PFHxS concentrations by 10. The 3 other compounds included in the Hazard Index were primarily non-detects. The open circle for PFOS indicates a non-detected value; all filled shapes indicate a detected result.*

How do PFAS Levels in Bay Area Biosolids Compare to Regulatory Thresholds?

PFAS is a potential concern for biosolids end uses, particularly land application or other uses where PFAS could migrate to food crops or drinking water. There are currently no federal or state standards for PFAS in biosolids. However, several other states have established "action levels" for biosolids that may be "industrially impacted." When PFOA or PFOS concentrations in biosolids exceed the action level of 20 ng/g (µg/kg or ppb), utilities in Michigan[j] and New York[k] are subject to restrictions on biosolids recycling. In this BACWA-SFEI study, the only biosolids samples that exceeded these thresholds were from agencies that have exceptionally long storage times in lagoons and storage beds, which may allow more time for PFAS transformations to occur or allow PFAS to become more concentrated on a dry weight basis.

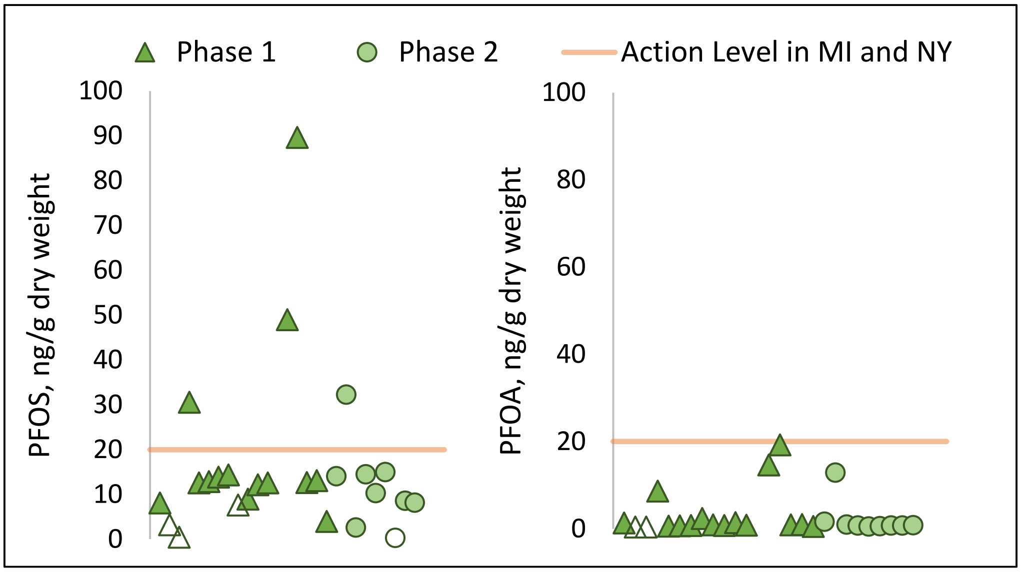


Figure 3. *Phase 1 and 2 biosolids concentrations of PFOA and PFOS (ng/g dry weight) compared to action levels in Michigan and New York. Filled shapes indicate detected values. Unfilled shapes indicate non-detects.*

Where is PFAS in Bay Area Wastewater Coming From?

To identify potential sources of PFAS, Phase 2 of the BACWA-SFEI study focused on sampling in residential areas and at commercial and industrial facilities. Samples were collected from residential areas (n=14), industrial laundries (n=5), hospitals (n=4), facilities with chrome plating onsite (n=3), semiconductor manufacturing (n=2), car washes (n=3), a military site, and a pulp paperboard manufacturing facility. Landfill leachate is also a known source of PFAS in wastewater that was previously sampled under a State Water Board investigative order[a]. Results of this study's collection system monitoring are shown in **Figure 4** and indicate that:

- **Residential** samples showed a large range of total quantified PFAS concentrations. The median sum of TOP and target analytes were only slightly lower than those found in plant influent.
- **Industrial Laundries.** Concentrations of total quantified PFAS measured as TOP were significantly higher than median influent concentrations at several (but not all) industrial

laundries. These facilities typically launder uniforms, linens, floor mats, and similar items. Some laundered textiles could contain intentionally added PFAS (e.g., for stain resistance).

- **Car Washes** showed total PFAS measured as TOP at moderately higher concentrations than plant influent. Unlike industrial laundries, however, there were not any extremely high values at the car washes, and discharge flow rates tend to be lower at the car washes.

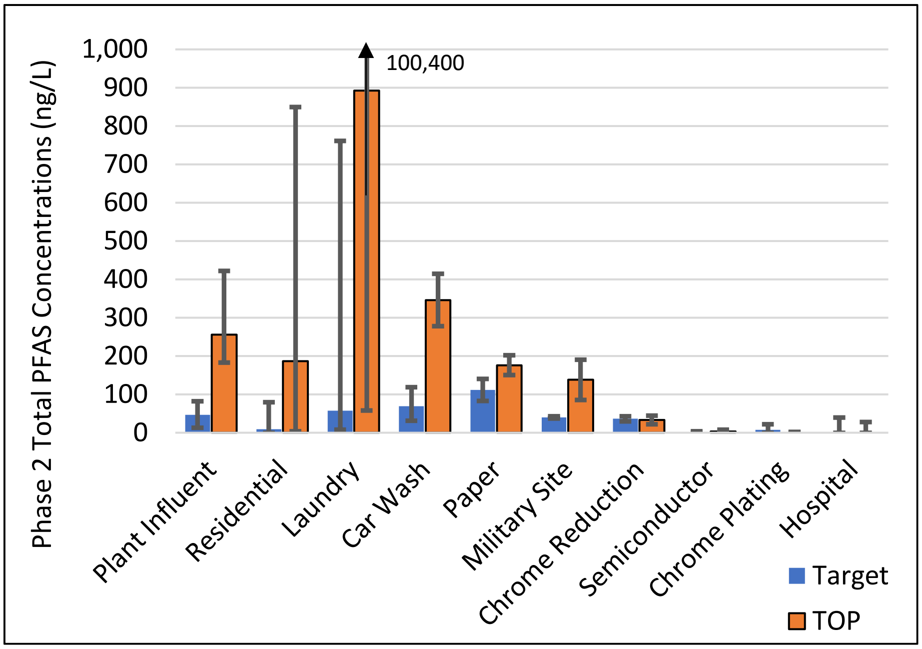


Figure 4. *Comparison of Phase 2 plant influent results with residential, commercial, and industrial wastewater (ng/L). Total PFAS is based on a sum of targeted analysis of 40 compounds("Target") and Total Oxidizable Precursor analysis ("TOP"). The height of each bar chart indicates the median, while the error bars show the minimum and maximum.*

At most Bay Area treatment plants, more than 95% of flows are from residential and commercial customers. Phase 2 results indicate that residential areas may contribute PFAS at concentrations similar to plant influent, which means that residential users may be the dominant source of PFAS to many treatment facilities. PFAS is found in many consumer products, including textiles, household chemicals, cosmetics, and food packaging, at concentrations several orders of magnitude higher than those found in this study, as shown in **Figure 5**. This source of PFAS can only be controlled by removing or reducing the amount of PFAS found in consumer products.

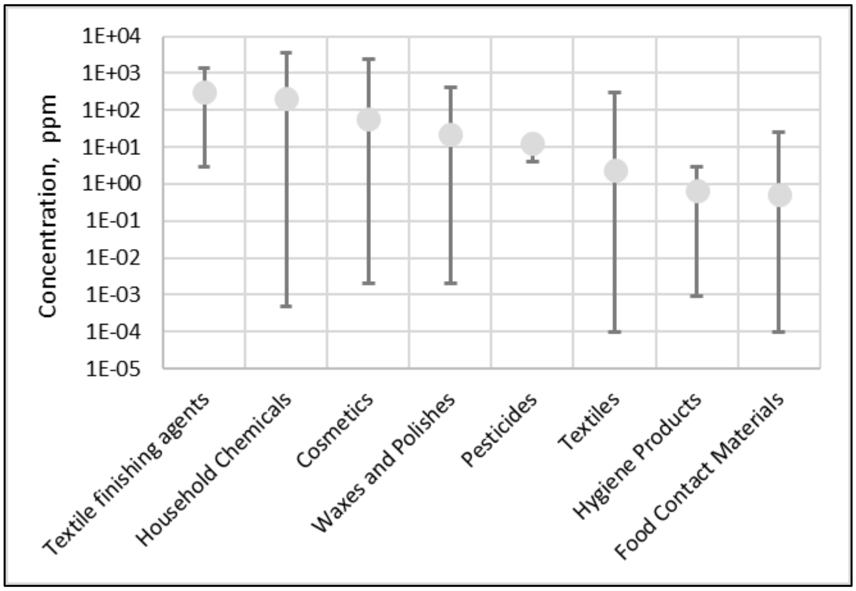


Figure 5. *PFAS concentrations in select categories of consumer products. Figure adapted from Dewapriya et al., 2023[i]. The round marker indicates the average, while the error bars show the minimum and maximum values. The units (ppm) are equivalent to ng/L x 1,000,000.*

What is BACWA Doing Next?

BACWA and its members are interested in developing actionable data that will inform future source control or other management efforts. To start, BACWA and its members plan to continue working with SFEI, the Water Board, and the California Department of Toxic Substances Control to identify consumer products with PFAS that have a potential nexus to wastewater, stormwater, and surface waters like San Francisco Bay. In the coming years, SFEI plans to continue studying PFAS in stormwater and the Bay, while BACWA will continue to focus on identifying controllable sources within sewer service areas.

Where Can I Find More Information?

USEPA PFAS Strategic Roadmap:
https://www.epa.gov/pfas/pfas-strategic-roadmap-epas-commitments-action-2021-2024

[a] SWRCB Investigative Order for POTWs:
https://www.waterboards.ca.gov/board_decisions/adopted_orders/water_quality/2020/wqo2020_0015_dwq.pdf

[b] Study of PFAS in Bay Area POTWs: Phase 1 Sampling and Analysis Plan:
https://bacwa.org/wp-content/uploads/2020/12/SFEI-Final-PFAS-SAP-Phase-1-2020-11-23.pdf

[c] Study of PFAS in Bay Area POTWs: Phase 2 Sampling and Analysis Plan: https://bacwa.org/wp-content/uploads/2022/03/Final-PFAS-Phase-2-SAP-2022-03-28.pdf

[d] Study of PFAS in Bay Area POTWs, Phase 1 Memo:
https://bacwa.org/wp-content/uploads/2023/03/Memo_BACWA-PFAS-Phase-1.pdf

[e] Lin, D. and Fono, L. Investigation of PFAS Sources to Municipal Wastewater. Presentation to 2023 Regional Monitoring Program Annual Meeting, October 2023. Video and slides available at https://www.sfei.org/projects/rmp-annual-meeting

[f] Aflaki, R. "What can we learn from the GeoTracker PFAS data?" Presentation to CASA; Available at https://casaweb.org/wp-content/uploads/2023/10/Aflaki-Roshan.pdf

[g] USEPA, 2022. "Fact Sheet: Draft 2022 Aquatic Life Ambient Water Quality Criteria for PFOA and PFOS. "Available at https://www.epa.gov/system/files/documents/2022-04/pfoa-pfos-draft-factsheet-2022.pdf

[h] SWRCB. "PFAS Regulations for California Drinking Water." Available at https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/pfas.html

[i] USEPA. Proposed PFAS National Drinking Water Regulation. Available at https://www.epa.gov/sdwa/and-polyfluoroalkyl-substances-pfas

[j] Michigan Department of Environment, Great Lakes, and Energy. "Interim Strategy – Land Application of Biosolids Containing PFAS (2024)." Available at https://www.michigan.gov/egle/about/organization/water-resources/biosolids/pfas-related

[k] New York State Department of Environmental Conservation. "Biosolids Recycling in New York State – Interim Strategy for the Control of PFAS Compounds." September 7, 2023. Available at https://extapps.dec.ny.gov/docs/materials_minerals_pdf/dmm7.pdf

[l] Dewapriya, P., et al. "Per- and polyfluoroalkyl substances (PFAS) in consumer products: Current knowledge and research gaps." Journal of Hazardous Materials Letters, Volume 4, November 2023, 100086. https://doi.org/10.1016/j.hazl.2023.100086