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Submission to Select Committee on PFAS (per- and polyfluoroalkyl) substances

18 DECEMBER 2024

Enquiries should be directed to:

Seán Halpin

Chief Executive Officer, SciDev Limited

[redacted]

Submission authors: Seán Halpin Chief Executive Officer, SciDev Limited and Steve Becker, Technical Director – Water Technologies, SciDev

About Seán Halpin

SciDev CEO Seán Halpin is an environmental professional with nearly two decades in the remediation and water treatment industry. Seán was the co-founder and Commercial Director for Haldon Industries, which was established in 2016 to address the growing need for PFAS treatment solutions in the Australian private sector. In 2021, Haldon Industries was acquired by SciDev Ltd.

About Steven Becker

Steven Becker is the Technical Director - Water Technologies at SciDev Ltd. Steve is a Certified Environmental Professional with more than 30 years' experience in the environmental industry and has been managing the investigation, treatment, and remediation of PFAS in soil, water and wastewater applications since 2014.

In addition to providing expertise in emerging contaminant treatment for SciDev's global operations, Steve is an Affiliate Research Professor at the University of Alaska Fairbanks and serves on the PFAS Work Groups for the Interstate Technology and Regulatory Council (ITRC) in the U.S. and the Network for Industrially Co-ordinated Sustainable Land Management in Europe (NICOLE).

About SciDev

SciDev Limited is an Australian company, headquartered in Sydney and listed on the Australian Securities Exchange. We specialise in delivering tailored water treatment solutions for industries and have extensive expertise in remediating PFAS contamination. We have collaborated with the NSW Environmental Protection Authority to shape regulations, anticipate future frameworks, and define discharge criteria that safeguard the environment.

Our proprietary technologies, FluorofIX™ and RegenIX™, have set new world-leading standards for the effective treatment and safe disposal of PFAS-contaminated water to below reporting limits.

SciDev's industry-leading credentials:

- first company in NSW to receive a mobile waste processing license
- first company in Victoria to work with the regulator to treat PFAS-contaminated water and have the treated water discharged directly into the environment
- first company in WA to work with the regulator to set the discharge criteria for PFAS treated water – these remain the most stringent limits nationality

- delivered the first project in Australia to receive the Department of Water, Environment and Regulation approval to continuously discharge to the environment.

SciDev's PFAS remediation technology, FluorofIX™ and RegenIX™

Developed in 2016, SciDev's FluorofIX™ technology is currently the only commercially available solution that can treat large volumes of highly contaminated water to below a limit of reporting of 0.00023ug/l whilst generating waste volumes of <0.018%. FluorofIX™ is also effective at removing the full profile of long and short-chain PFAS molecules.

FluorofIX™ systems are mobile and modular, allowing for rapid deployment to a site. These systems can be instantly reconfigured to treat contaminated surface water, groundwater, and liquid waste, allowing highly contaminated material to be safely discharged to the environment. These factors combined make FluorofIX™ the most effective, sustainable and commercially viable treatment solution currently available.

RegenIX™, our non-solvent-based resin regeneration process, complements PFAS-selective ion-exchange resins by enabling the regeneration and reuse of treatment media. This process creates a highly concentrated, alkaline PFAS solution suitable for advanced destruction technologies, reducing waste generation, treatment costs, and environmental impacts.

To date, SciDev has remediated over 30 PFAS-impacted sites, treating more than seven billion litres of PFAS-contaminated water across various applications in Australia. A NATA-accredited laboratory has validated all waters treated as PFAS-free.

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1. Purpose of this submission

SciDev submits this document to support the Select Committee in crafting effective and sustainable PFAS management strategies.

This submission provides an overview of the regulatory environment and technological solutions driving industry response in Australia. It highlights:

- the necessity of establishing national standardised regulations across water sources, between states, and to support a national strategy for PFAS management aligned with international standards
- the importance of including industry as key partners in PFAS management, as industry brings valuable insights into the commercial and practical realities of remediation efforts and can guide economically sustainable and scalable solutions.

As Australia's foremost expert in PFAS water remediation, SciDev addresses the following two Terms of Reference criteria:

- (g) International best practices for the environmentally sound management and safe disposal of PFAS
- (i) Effectiveness of remediation works on specific sites and international best practices for remediation and management of contaminated sites

This submission provides actionable recommendations to support the Select Committee in establishing robust, consistent frameworks for PFAS management in Australia.

2. Executive Summary

2.1 Overview

PFAS (per- and polyfluoroalkyl substances) contamination poses significant environmental and public health challenge in Australia, demanding urgent and coordinated action. PFAS 'forever chemicals,' widely used across industries for their unique non-stick, water- and grease-resistant properties, are now associated with persistent contamination and serious health risks. Currently, there are over 1000 sites across Australia under investigation for elevated PFAS levels with thousands more flagged for potential contamination.

Historically, Australia has been a global leader in PFAS remediation, introducing regulations and reporting standards earlier than many other countries. However, there are significant inconsistencies when it comes to the regulation and management of PFAS in Australia today including: a) discrepancies in risk appetite regarding PFAS with environmental protection criteria currently 304 times higher than federal drinking water criteria for PFAS; and b) differences between states on both regulations and enforcement and no overall national strategy.

Since its emergence as a contaminant of concern, a range of technologies have been developed to remediate PFAS-contaminated water and soil. Every PFAS treatment project is unique and presents its own challenges and variables, including the molecular make-up of the total PFAS concentration, the presence of co-contaminants, the receiving environment, applicable regulatory compliance, the current waste disposal market, the client's budget, and site-specific constraints.

From an industry perspective, selecting the appropriate technology solution is primarily driven by the reporting standard of that jurisdiction, i.e. stricter standards require stronger solutions. Having uniform standards across Australia may allow industry to fine tune the development of technology and lead to more commercially viable, effective and scalable solutions.

Since 2016, Australian company SciDev has collaborated with industries and regulators across Australia to deliver tailored, sustainable solutions for contaminated sites. Our proprietary and homegrown remediation technologies, FluorofIX™ and RegenIX™, have set new global standards in the treatment and disposal of PFAS-contaminated water. We have, to date, treated over *seven billion litres* of PFAS-contaminated water across more than 30 sites in Australia.

FluorofIX™ is the only commercially available solution capable of treating large volumes of highly contaminated water to *below 0.23ng/L the lowest current NATA accredited limit of reporting*, while RegenIX™ extends the life span of ion-exchange resins by enabling their regeneration and reuse, reducing waste and significantly lowering treatment costs.

Today, the United States and Europe lead efforts to ban the use of the most toxic PFAS, with the US introducing the strictest regulations for PFAS in drinking water. Australia must continue to innovate and enhance its frameworks to remain at the forefront of PFAS management and bring regulation and enforcement in line with stringent international best practices.

With the global spotlight firmly on PFAS and ongoing emerging evidence in Australia and abroad of the extent and impact of PFAS contamination, Australia is at an inflection point. By aligning with international best practices and leveraging our homegrown technologies, Australia can safeguard public health, protect its environment, and position itself as a global leader in addressing PFAS contamination.

2.2 Recommendations

Adopt a national approach to PFAS regulation

- Develop a national strategy for PFAS management providing clarity for industry and government, enabling consistent application of remediation technologies.
- Facilitate data collection to support better risk assessment and targeted remediation efforts.

Implement a 'cradle-to-grave' management framework

- Develop a comprehensive PFAS management system covering manufacturing, import, use, treatment, and disposal.
- Model this system after the U.S. Resource Conservation and Recovery Act (RCRA) to ensure traceability and accountability for PFAS throughout their lifecycle.

Promote industry collaboration and innovation

- Establish an interdisciplinary joint council comprising regulators, industry experts, and researchers to evaluate PFAS treatment technologies.
- Create an Australian-focused repository of PFAS data and technology evaluations, leveraging global best practices from the U.S. ITRC and European NICOLE frameworks.

Enhance PFAS treatment capabilities

- Encourage the adoption of modular, scalable treatment systems, such as SciDev's FluorofIX™ and complementary technology RegenIX™, to address site-specific PFAS challenges efficiently.
- Support the use of treatment trains that integrate complementary technologies to achieve non-detect PFAS levels while minimising environmental impacts and costs.

Prioritise PFAS destruction over disposal

- Phase out PFAS landfill disposal as a routine practice and focus on destructive technologies like incineration, regenerable AIX, GAC reactivation, and emerging destruction methods.
- Invest in research and development of advanced PFAS destruction technologies, modelled after the U.S. Department of Defense SERDP and ESTCP programs.

Phase out non-essential PFAS uses

- Adopt an 'essential use' framework for PFAS applications, following EU regulatory approaches.
- Expand and strengthen the phase-out of non-essential PFAS applications across industries.

Foster sustainability in PFAS remediation

- Incorporate energy-efficient and waste-minimising solutions into PFAS treatment technologies.
- Promote the use of regenerable ion-exchange resins and other sustainable treatment approaches to reduce life-cycle costs and environmental impacts.

3. PFAS in Australia

3.1 Extent of contamination

PFAS contamination is a significant environmental issue in Australia. PFAS compounds have been detected in soil, water bodies, and wildlife, as well as in human populations in various regions across the country. The contamination primarily stems from historical usage of PFAS-containing firefighting foams at military bases, airports, industrial sites, and firefighting training facilities and transport infrastructure.

An estimated 1000 sites across Australia are currently under investigation for elevated levels of PFAS near sewage treatment plants, landfills, and places where fire-fighting foams have been used. Thousands more sites are flagged for potential PFAS contamination. In response to growing concern, the Australian government has initiated various measures to address PFAS contamination, including site investigations, risk assessments, and remediation efforts.

3.2 Regulatory environment

3.2.1 National Environment Management Plan

The National Environment Management Plan (NEMP) guidelines provide the baseline standards for PFAS remediation projects in Australia and serve as the foundation for licensing and compliance requirements. While the NEMP offers a critical framework for managing PFAS contamination, several regulatory inconsistencies remain that hinder the effective and cohesive management of PFAS across the country.

NEMP 3.0[1] refers to three specific regulated species of PFAS; PFOS, PFHxS and PFOA. When required to treat a water source to the 99% level of species protection under the PFAS NEMP 2.0, remediation is required to 0.00023 ug/L for PFOS.

In contrast, the Australian Drinking Water Guideline developed by the Australian Government[2] for the sum of PFOS and PFHxS is 0.07ug/L, revealing the allowable drinking water guideline is over 304 times more concentrated for these chemicals in some cases.

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[1] Department of Climate Change, Energy the Environment and Water. National Environmental Management Plan 3.0. https://consult.dcceew.gov.au/nemp-pfas

[2] Australian Government, National Health and Medical Research Council, National Water Quality Management Strategy Australian Drinking Water Guidelines 6 2011 Version 3.9 Updated December 2024 https://www.nhmrc.gov.au/about-us/publications/australian-drinking-water-guidelines

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This discrepancy can lead to confusion among stakeholders and uneven risk management. Regulatory inconsistencies create challenges for industry, regulators and communities in ensuring environmental and public health protection. Without consistent thresholds, industry face difficulties in designing remediation systems that meet both environmental discharge requirements and the stricter standards associated with drinking water safety.

3.2.2 Navigating state-based regulations

Regulations governing PFAS remediation and discharge vary significantly between Australian states, creating challenges for national consistency.

Each state and territory has its own regulatory frameworks and reporting thresholds for PFAS, leading to inconsistencies in how contamination is managed and reported. This fragmentation can delay remediation efforts, as companies working across multiple jurisdictions must navigate differing requirements.

Some states, such as Western Australia, have stringent PFAS regulations, including comprehensive discharge criteria and remediation guidelines requiring treatment of PFAS to the lowest possible limits of reporting (0.23ng/L), while other states and territories take a less stringent approach to PFAS regulation requiring less efficient treatment. This unevenness may result in slower progress in addressing PFAS contamination in certain regions and missed opportunities to adopt best practices nationwide.

In addition, industries face operational inefficiencies and higher costs when required to comply with different regulations across jurisdictions. A standardised national framework would simplify compliance and promote the adoption of commercially viable solutions.

3.3 How Australia compares with other jurisdictions

The United States of America is heavily focused on PFAS regulation. On April 10, 2024, the US Environment Protection Agency announced the final National Primary Drinking Water Regulation (NPDWR) for six PFAS compounds establishing legally enforceable Maximum Contaminant Levels (MCLs).[3] Some states, such as California[4] have adopted stricter regulations than the federal government implementing public health goals for PFOA (0.007 ng/L) and PFOS (1 ng/L). Cleanup efforts are ongoing, particularly in areas surrounding military bases and industrial sites where contamination is high.

[3] United States Environmental Protection Agency, Final PFAS National Primary Drinking Water Regulation. https://www.epa.gov/sdwa/and-polyfluoroalkyl-substances-pfas

[4] California Environmental Protection Agency's Office of Environmental Health Hazard Assessment (OEHHA) https://oehha.ca.gov/water/public-health-goal-press-release-water/california-adopts-health-protective-goals-forever

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The European Union has been proactive in restricting PFAS under its Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) Regulation[5]. The European Commission announced a phased restriction of all non-essential PFAS uses by 2030.

Some countries are leading the charge in the EU, namely Germany who is a leader in PFAS research and is currently remediating a range contaminated sites caused by legacy industrial pollution. It supports a mix of regulatory actions and remediation techniques, including soil washing and thermal treatment. The Netherlands has taken strong action against PFAS in drinking water and industry, with one of the strictest regulatory approaches in the EU. Sweden has been a strong advocate for EU-wide PFAS restrictions and has implemented local limits on PFAS in drinking water.

3.4 Challenges and complexities of PFAS remediation

The ability of PFAS to remain intact in the environment results in increasing levels of contamination in soil and water, and the remediation of PFAS-contaminated sites presents numerous challenges, making it a complex and demanding process.

PFAS compounds are known for their exceptional persistence in the environment. The strong carbon-fluorine bonds make them resistant to degradation processes, resulting in a long environmental half-life. This persistence extends the exposure duration, making removing and remediating PFAS a time-consuming process.

PFAS contamination often occurs over large areas due to the widespread use of these chemicals in various applications. High water solubility and low soil adsorption of PFAS compounds contribute to their rapid mobility, leading to the contamination of groundwater and surface water.

Conventional methods like chemical oxidation, thermal treatment, and bioremediation have shown limited success, and their application to PFAS-contaminated sites is challenging. In addition, PFAS remediation is an expensive process, and the sheer scale of contamination in some areas makes the financial burden significant.

There are also complexities to managing PFAS waste, requiring careful consideration of the type of PFAS waste, the amount of waste generated, and potential risks associated with different disposal options.

[5] European Commission, Registration, Evaluation, Authorisation and Restriction of Chemicals, https://commission.europa.eu/index_en

4. Response to Terms of Reference

4.1 (g) International best practices for the environmentally sound management and safe disposal of PFAS

For the effective and environmentally sound management of PFAS, we recommend the approach used by USEPA in the management of hazardous wastes under Subtitle C of the Resource Conservation and Recovery Act[6]. Such a 'cradle-to-grave' approach would integrate the manufacture, import and use of PFAS; the treatment of PFAS-impacted media; and the disposal or destruction of PFAS-containing wastes. Key elements of such an approach should include:

4.1.1 Manufacture and use

(i) Develop and implement a framework for the (re)evaluation of PFAS

To gain a better understanding of existing and future risks to human health and the environment, we recommend Australia develop and implement a framework for the re-evaluation of existing PFAS and the evaluation of both new PFAS and PFAS alternatives prior to manufacture or import[7]. This framework should incorporate the best aspects of, and the lessons learned from, PFAS evaluation under both the U.S. Toxic Substances Control Act (TSCA) and the European Union (EU) Registration, Evaluation, Authorization, and Restriction of Chemicals (REACH) regulations.

Evaluations under this framework should be based on all available scientific data, with a minimum threshold of data required to be provided by the manufacturer or importer sufficient to evaluate both human and ecotoxicity and the compounds' potential fate and transport of a release to the environment. These evaluations must include access to confidential business information (CBI), which would need to be available to the technical reviewers but with robust mechanisms to protect CBI from public release[8].

[6] USEPA. 2024a. *Resource Conservation and Recovery Act (RCRA) overview*. Resource Conservation and Recovery Act (RCRA) Laws and Regulations. https://www.epa.gov/rcra/resource-conservation-and-recovery-act-rcra-overview. U.S. Environmental Protection Agency. Last updated 11 September 2024.

[7] Dean, W.S., H. A. Adejumo, A. Caiati, P. M. Garay, A. S. Harmata, L. Li, E. E. Rodriguez, and S. Sundar. 2020. *A framework for regulation of new and existing PFAS by EPA*. Journal of Science Policy and Governance 16 (1).

[8] Richter, L., A. Cordner, and P. Brown. 2021. *Producing ignorance through regulatory structure: The case of per- and polyfluoroalkyl substances (PFAS)*. Sociological Perspectives 64 (4):631-656.

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(ii) Phase out non-essential uses of PFAS

Australia should develop or adopt a process to identify those uses of PFAS that are deemed "essential". The concept of essential use was defined in the Montreal Protocol, as uses which are "necessary for health, safety or is critical to the functioning of society" and for which "there are no available technically and economically feasible alternatives"[9]. The application of the essential use concept for PFAS was proposed by the Global PFAS Science Panel in 2015[10] and expanded upon in an article by Cousins et al. in 2019[11]. The concept has been promoted as a regulatory tool in the EU *Chemicals Strategy for Sustainability: Towards a Toxic Free Environment*[12]. The incorporation of the essential use concept in the EU legal framework was examined by Garnett and Van Calster in 2021[13], with the information requirements for evaluation of essential uses of PFAS being elucidated by Glüge et al. in 2022[14].

Once the current uses of PFAS have been evaluated and those essential uses have been identified, then the government should expand and strengthen the phase-out of PFAS from all non-essential uses, building on the policy statements in the *National PFAS Position Statement*[15] and the *Intergovernmental Agreement on a National Framework for Responding to PFAS Contamination*[16].

(iii) Minimise current and future releases of PFAS

To minimise the extent of PFAS released to the environment, Australia should require all manufacturers, importers, and industrial users of PFAS to have robust systems in place for the

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[9] United Nations. 1987. Montreal Protocol on substances that deplete the ozone layer. 1522 UNTS 3, 26 ILM 1541, 1550 (1987). Online at https://cil.nus.edu.sg/wp-content/uploads/2019/02/1987-Montreal-Protocol.pdf. Accessed 11 December 2024.

[10] Blum A., S.A. Balan, M. Scheringer, X. Trier, G. Goldenman, I. T. Cousins, M. Diamond, T. Fletcher, C, Higgins, A. E. Lindeman, and G. Peaslee. 2015. *The Madrid statement on poly-and perfluoroalkyl substances (PFASs)*. Environmental Health Perspectives 123(5):A107-11.

[11] Cousins, I. T., G. Goldenman, D. Herzke, R. Lohmann, M. Miller, C. A. Ng, S. Patton, M. Scheringer, X. Trier, L. Vierke, Z. Wang, and J. C. DeWitt. 2019. Environmental Science Processes and Impacts 21:1803.

[12] European Commission. 2020. Chemicals strategy for sustainability: Towards a toxic free environment. 14 Oct. 2020, COM(2020) 667. Online at: https://environment.ec.europa.eu/strategy/chemicals-strategy_en. Accessed 12 December 2024.

[13] Garnett, K., and G. Van Calster. 2021. *The concept of essential use: A novel approach to regulating chemicals in the European Union*. Transnational Environmental Law 10 (1):159-187.

[14] Glüge, J., R. London, I. T. Cousins, J. DeWitt, G. Goldenman, D. Herzke, R. Lohmann, M. Miller, C. A. Ng, S. Patton, X. Trier, Z. Wang, and M. Scheringer. 2022. *Information requirements under the essential-use concept: PFAS case studies*. Environmental Science and Technology 56 (10):6232-6242.

[15] Council of Australian Governments. 2019. National per- and polyfluoroalkyls substances (PFAS) position statement. Online at https://federation.gov.au/sites/default/files/about/agreements/appd-national-pfas-position-statement.pdf. Accessed 12 December 2024.

[16] Council of Australian Governments. 2020. Intergovernmental agreement on a national framework for responding to PFAS contamination. Online at https://federation.gov.au/sites/default/files/about/agreements/agreement-nat-framework-pfas-contamination.pdf. Accessed 12 December 2024.

handling of PFAS-containing materials and the treatment and disposal or destruction of PFAS-containing wastes generated by their processes (see the following section). In addition to risk- and performance-based discharge limits for PFAS in different media, consider implementing technology-based effluent regulations for existing and new PFAS sources, like those used by the USEPA under the Clean Air Act[17] and the Clean Water Act[18]. As those most familiar with the capabilities, requirements, and performance of treatment technologies, industry should be integral to the identification and continuing evaluation of appropriate technologies and development of technology-based effluent standards.

Further, to better identify and understand the location and scope of PFAS releases to the environment, require all major manufacturers, importers, and industrial users of PFAS to report annually on their generation and disposition of PFAS-containing wastes, similar to the USEPA Toxic Release Inventory[19].

(iv) Create an Australia-focused repository of PFAS information

Australia should establish an interdisciplinary joint council of Federal and state regulators, researchers, and industry to identify and continuously evaluate available PFAS treatment technologies, modelled after and working collaboratively with the PFAS Work Groups established by the ITRC and NICOLE. This joint council would be responsible for creating and maintaining a central repository of information on PFAS treatment technologies, like the one maintained by the ITRC[20] and the one due to be published by NICOLE in 2025. This repository should build on the work done for the US and the EU, but those works should be evaluated with an eye to availability and relevance to the PFAS situation in Australia as well as compatibility with Australian institutions and regulatory frameworks.

(v) Industry must be part of the solution

As best practice, the evaluations described above should be conducted by interdisciplinary Scientific Advisory Boards, which should be made up of representatives from industry, professional scientific bodies, and regulatory agencies. The benefits of industry involvement in

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[17] USEPA. 2024b. *Setting emissions standards for major sources of toxic air pollutants*. Clean Air Act Overview. Online at https://www.epa.gov/clean-air-act-overview/setting-emissions-standards-major-sources-toxic-air-pollutants. U.S. Environmental Protection Agency. Last updated 16 January 2024.

[18] USEPA. 2024c. *Learn about effluent guidelines.* Effluent Guidelines. Online at https://www.epa.gov/eg/learn-about-effluent-guidelines. U.S. Environmental Protection Agency. Last updated 15 August 2024.

[19] USEPA. 2024d. *Addition of certain per- and polyfluoroalkyl substances to the Toxics Release Inventory*. Toxics Release Inventory Program. U.S. Environmental Protection Agency. Online at https://www.epa.gov/toxics-release-inventory-tri-program/addition-certain-and-polyfluoroalkyl-substances-toxics-release. Last updated 8 October 2024.

[20] ITRC. 2023b. *12. Treatment technologies*. PFAS Technical and Regulatory Guidance Document. Interstate Technology and Regulatory Council. Online at https://pfas-1.itrcweb.org/12-treatment-technologies/. Last updated September 2023.

regulatory decision-making have long been recognised[21]. This is especially true in this case, where industry organisations such as the American Water Works Association have been at the forefront of evaluating and providing guidelines for implementing technologies for the treatment of PFAS. Additionally, collaboration and data-sharing among the various international advisory committees should be encouraged so that no one country or agency bears the full burden of evaluation.

4.1.2 Treatment

(vi) PFAS treatment solutions must be tailored to site-specific conditions

It must be recognised that there will be no 'silver bullet' for PFAS treatment or remediation. Whether it is technology for the removal of PFAS from soil[22] or water/wastewater[23], each treatment technology has its strengths and weaknesses. For most PFAS-impacted waste streams or sites, the effective and sustainable treatment of PFAS requires the integration of multiple complementary technologies into a treatment train[24]. While the available technologies should be vetted as described above, the process for selection and regulatory approval of appropriate treatment technologies must be flexible and allow for a wide range of treatment technologies that can be combined based on site-specific conditions.

(vii) Solutions should be flexible and adaptable

Treatment systems should be easily scalable, flexible, and adaptable to adapt to changing needs. These factors need to be considered in the design of the system, and modular treatment systems used when practical. The benefits of modular treatment systems have been recognised across a variety of technologies and industries[25], and include rapid deployment and installation,

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[21] Plumlee, L. A. 1977. *EPA's interactions with industry.* The Bulletin of the Society of Pharmacological and Environmental Pathologists 5(1):7-8.

[22] Concawe. 2024. PFAS soil treatment processes – A review of operating ranges and constraints. Concawe Special Task Force on Soil and Groundwater (WQ/STF-33). May.

[23] DiGuiSeppi, W. H., C. J. Newell, G. Carey, P. R. Kulkarni, Z. Xia, J. Stults, T. L. Maher, E. F. Houtz, R. Mora, R. Wice, P. W. Tomiczek III, S. D. Richardson, J. Xiong, J. Hale, J. P. Hnatko, R. McGregor, J. T. McDonough, A. Oka, R. Thomas, J. Fenstermacher, and J. Hatton. 2024. *Available and emerging liquid treatment technologies for PFASs*. Remediation Journal 34:21782.

[24] Wanninayake, D. M. 2021. *Comparison of currently available PFAS remediation technologies in water: A review.* Journal of Environmental Management 283:111977; Yadav, S., I. Ibrar, R. A. Al-Juboori, L. Singh, N. Ganbat, Tayma Kazwini, E. Karbassiyazdi, A. K. Samal, S. Subbiah, and A. Altaee. 2022. *Updated review on emerging technologies for PFAS contaminated water treatment*. Chemical Engineering Research and Design 182:667-700; ITRC. 2023c. *12.8 Integrated water treatment solutions*. PFAS Technical and Regulatory Guidance Document. Interstate Technology and Regulatory Council. Online at https://pfas-1.itrcweb.org/12-treatment-technologies/#12_8. Last updated September 2023.

[25] Cao, K., N. Sitapure, and J. S. Kwon. 2023. *Exploring the benefits of utilizing small modular device for sustainable and flexible shale gas water management.* Journal of Cleaner Production 384:135282; dos Santos, A.J., R. Vargas, C. Oporto, M. R. V. Lanza, A. Thiam, R. A. Torres-Palma, R. Gonzalez-Rodriguez, U. J. Jauregui-Haza, V. Sosa, P. J. Espinoza-Montero, A. Najera, Y. Cheremond, T.

portability, scalability, and the ability to easily adapt to evolving needs. Using a modular water treatment approach, SciDev was able to design, mobilise, and commission a PFAS treatment system in Western Australia capable of treating 2.5 ML/day in less than 40 days from contract award[26].

As an example of a modular treatment train approach, in 2020 SciDev deployed a modular temporary treatment plant to address comingled petroleum hydrocarbons and PFAS at the Trueagain site in Rutherford, NSW[27]. The treatment train for this project consisted of the addition of powdered activated carbon (PAC) to capture oils, hydrocarbons, and organics, coagulation/flocculation and clarification to remove the PAC and other total suspended solids, pH adjustment to optimise filtration efficiency, zeolite for physical filtration and metals removal, a granular activated carbon (GAC) pretreatment to remove residual organics, and PFAS-selective anionic ion exchange (IX) resins for the primary PFAS removal. By using a series of PFAS-selective weak base and strong base PFAS-selective IX resins with differing affinities for long-chain and short-chain PFAS, SciDev was able to treat the wastewater to non-detect levels for all tested PFAS compounds.

4.1.3 Disposal and destruction

(viii) Landfilling of PFAS wastes should be an option of last resort

Disposing of PFAS-containing waste in landfills merely relocates and concentrates the PFAS contaminant load in a new location. This creates a cyclic pattern wherein PFAS-containing wastes are deposited and subsequently leach PFAS, the PFAS-containing leachate is treated, and the PFAS-containing wastes from leachate treatment are placed back into the landfill[28]. When landfill disposal of PFAS wastes occurs, it should only be accepted at landfills with robust leachate collection and treatment systems, such as those specifically designed for hazardous wastes[29].

Perez, V. D. Quezada, G. Caballero-Manrique, V. Rojas, H. L. Barazorda-Ccahuana, A. P. Parada, and S. Garcia-Segura. 2023. *Electrochemical technologies as modular adaptive decentralized treatment systems to enact water security for Latin America: Insights and prospects*. Water Security 20:100147.

[26] SciDev Ltd. 2024. *Project Profiles*. Our Projects. Online at https://scidevltd.com/project-profiles/. Accessed 12 December 2024.

[27] Tolaymat, T., N. Robey, M. Krause, J. Larson, K. Weitz, S. Parvathikar, L. Phelps, W. Linak, S. Burden, T. Speth, and J. Krug. 2023. *A critical review or perfluoroalkyl and polyfluoroalkyl substances (PFAS) landfill disposal in the United States*. Science of the Total Environment 905:167185.

[28] USDoD. 2024. *Strategic Environmental Research and Development Program (SERDP) and Environmental Security Technology Certification Program (ESTCP)*. Office of the Assistant Secretary of Defense (Energy Resilience and Optimization. Online at https://serdp-estcp.mil/. Accessed 12 December 2024.

[29] Meegoda, J. N., B. B. de Souza, M. M. Casarini, and J. A. Kewalramani. 2022. *A review of PFAS destruction technologies*. International Journal of Environmental Research and Public Health. 19:16397.

(ix) Prioritize PFAS destruction over disposal

PFAS destruction by incineration at a hazardous waste combustion facility or through the GAC reactivation process is a viable technical alternative to disposal. Incineration is the only PFAS destruction technology identified as "field implemented" by the ITRC[30]. Likewise, incineration and GAC reactivation are the sole technologies presented as established PFAS destruction options in the USEPA 2024 guidance on PFAS destruction and disposal[36]. Each hazardous waste incineration or GAC reactivation facility should have standard operating procedures for PFAS-containing wastes. Their processes should be independently evaluated prior to authorisation to process PFAS-impacted wastes. USEPA guidance cautions that, while all hazardous waste combustion technologies can potentially achieve the temperatures and residence times required for the destruction of PFAS, many units do not normally operate at those conditions[31].

(x) Promote ongoing research, development, and evaluation of PFAS treatment and destruction technologies

Australia should consider establishing a formal centralised research funding program for applied PFAS research modelled after the US Department of Defense Strategic Environmental Research and Development Program (SERDP) and Environmental Security Technology Certification Program (ESTCP) research programs[32]. Because dealing with PFAS contamination is considered a national priority in the US, a number of emerging PFAS destruction technologies have been developed and evaluated in whole or in part through these programs. The ITRC maintains and annually updates the inventory and status of these technologies[33]. While these technologies range in their state of technological readiness, a few have been thoroughly tested at the pilot scale and are on the cusp of being commercially available and viable[34]. By promoting innovation through research and development, long-term increases in treatment options, efficiencies, and sustainability can be achieved while at the same time lowering treatment costs[35].

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[30] Lee, H. K. Sam, F. Coulon, S. de Gisi, M. Notarnicola, and C. Labianca. 2024. *Recent developments and prospects of sustainable remediation treatments for major contaminants in soil: A review.* Science of the Total Environment 912:168769.

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4.2 (i) Effectiveness of remediation works on specific sites and international best practices for remediation and management of contaminated sites

4.2.1 Treatment trains

(xi) Promote the use of treatment trains that incorporate complementary technologies for PFAS removal

The multi-barrier "treatment train" approach is well-established in the traditional water and wastewater treatment industry[36], especially for complex wastewaters. What makes the PFAS situation unique is that, in addition to the need to address co-contaminants and the physical and chemical characteristics of the media to be treated, multiple technologies may be required for PFAS removal based on the physical and chemical characteristics of the specific PFAS in the mixture[37].

For example, foam fractionation is highly effective at removing long-chain (≥ six (6) carbon) PFAS from wastewaters, it is substantially less effective at the removal of short-chain (<six (6) carbon) PFAS[42]. While short-chain PFAS removal can be increased with the use of cationic surfactants[38], many of these potential surfactants are unsuitable for release to the environment and would need to be themselves removed prior to discharge or reuse. To address this shortcoming, foam fractionation can be paired with PFAS-selective IX resins to capture residual PFAS in the effluent[39].

Another example is the use of complementary PFAS-selective IX resins for the removal of a broad spectrum of PFAS. SciDev routinely uses a combination of weak-base and strong-base IX resins in our PFAS water and wastewater treatment systems. This combination allows us to routinely treat PFAS, including oxidizable precursors, to non-detect levels. A testimony to the strength of the complementary technology approach is the treatment of more than one (1)

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billion litres of PFAS-contaminated water at a mine in Western Australia since the plant was commissioned in November 2022 with no PFAS detections above 0.2 ng/L[40].

(xii) Optimise treatment trains for the stepwise removal of PFAS from the waste stream

Not only can these complementary technologies be paired to cover a technology's shortcomings, but each technology in the treatment train can also be optimised for the removal of PFAS. As examples, advanced oxidation can be used to transform oxidizable precursors into compounds that can be captured on sorptive media[45]. Coagulants and flocculants which enhance PFAS removal can be selected or added to the clarification process[41]. Modified products that increase the PFAS removal efficiency of GAC[42] can be incorporated, even when GAC is not the primary method of PFAS removal. The synergies associated with the optimised stepwise removal of PFAS extends the life of the final treatment media, resulting in an overall reduction in waste generation from the treatment of PFAS-impacted water and wastewater.

(xiii) Incorporate measures to enhance sustainability

In the development of treatment trains, technologies should be evaluated individually and synergistically to identify combinations that would enhance sustainability through measures such as reducing energy and material use, waste minimisation, hazard minimisation, and reducing overall life cycle costs. For example, liquid treatment trains should evaluate the potential to incorporate the regeneration of PFAS-selective IX resins as part of the remedy. The ability to regenerate and reuse IX resins can substantially reduce the overall life cycle cost of PFAS treatment compared to single-use IX resin systems by reducing the volume of resin used and minimising waste requiring transport and disposal or destruction[43]. Both solvent-based and non-solvent-based options for the regeneration of certain PFAS-selective IX resins are commercially available in Australia. As with any remediation technology, each regeneration method has its strengths and limitations; however, best-fit applications for either regeneration

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process are generally the treatment of waters with higher PFAS concentrations or where the treatment goals include the removal of short and ultrashort chain PFAS. Both of these scenarios result in the need to more frequently replace single-use IX resins[50], making regeneration a more attractive alternative.

(xiv) Move toward the integration of onsite PFAS destruction into treatment trains

As more PFAS destruction technologies become commercially available, treatment trains for PFAS should ideally expand to include separation, concentration, and destruction steps[51]. Separation technologies for PFAS-contaminated water and wastewater are currently well advanced[25]. A subset of these technologies also serves to concentrate PFAS in a smaller volume of solution. primarily membrane filtration, foam fractionation, and regenerable IX resins. The concentration step is important because most of the emerging destructive technologies work best on smaller volumes of high concentration liquids[25].

As this field progresses care must be taken in the pairing of concentration and destruction technologies, as the destructive technologies may be sensitive to constituents in the liquid concentrate. For example, concentrate solutions containing methanol have been shown to hinder PFAS destruction by electrochemical oxidation[52]. High salt content liquids can exacerbate salt scaling and plugging in supercritical water oxidation (SCWO) reactors[53], potentially hindering the treatment of concentrates such as those resulting from membrane filtration or IX resin regeneration.

Alternatively, certain regeneration processes can be highly compatible. One example is SciDev's patent-pending non-solvent-based resin regeneration process, RegenIX™[34]. This process results in a PFAS-laden, strongly alkaline concentrate, making it highly compatible with technologies such as hydrothermal alkaline treatment (HALT) and certain photochemical oxidation technologies. These technologies add a strong base to raise the alkalinity of the concentrate prior to treatment. Such compatibility has the potential to enhance sustainability by reducing the overall chemical inputs to the treatment train. SciDev is currently conducting joint research and development efforts with some of these destruction technologies to evaluate and optimise these potential synergies, as well as exploring the possibility of recycling the treated alkaline solution, which would further reduce chemical inputs and associated waste generation.

5. Conclusion

PFAS contamination poses a complex and pressing challenge, requiring an integrated, national approach to protect Australia's environment and public health. While Australia has made significant strides in addressing PFAS contamination, critical gaps remain in regulatory consistency, state-based alignment, and consistency with updated international standards.

As a leading Australian company with global expertise, SciDev has demonstrated the effectiveness of innovative solutions like FluorofIX™ and RegenIX™ in tackling PFAS contamination sustainably and cost-effectively. These technologies, combined with SciDev's extensive experience working alongside regulators and industries, provide a roadmap for advancing PFAS remediation efforts across the country.

The recommendations outlined in this submission aim to address regulatory gaps, foster collaboration, and support the development of practical, scalable solutions. By harmonising standards, embracing innovation, and leveraging industry expertise, Australia can maintain its leadership in PFAS management while safeguarding the environment and public health for future generations.

SciDev remains committed to working with the government, regulators, and industry to develop and implement robust frameworks and technologies that will define the next chapter in PFAS remediation and position Australia as a global leader in solving the PFAS challenge.

6. Appendices

6.1 Appendix 1: FlurofIX™ Case Study – Treating PFAS impacted water for discharge back to the environment

FluorofIX™ Treating PFAS-Impacted Water for Discharge to the Environment

CASE STUDY

Background

Remediation of the former Country Fire Authority (CFA) Victorian Emergency Management Training Centre at Fiskville represented one of the most significant per- and poly-fluoroalkyl substances (PFAS) remediation projects to be undertaken in Australia at the time.

Historical fire-fighting training activities at the 150-hectare site involved the use of aqueous film-forming foams (AFFF), now known to be a primary source of PFAS contamination in soil and groundwater at similar sites across the world.

The first of its kind in Victoria, in partnership with Ventia, SciDev designed, constructed, commissioned, and operated an innovative water treatment plant (WTP) that received Victorian Environmental Protection Agency (EPA) approval to discharge treated water continuously back to the environment.

Approval for continuous discharge of treated water was contingent on strict ongoing sampling frequency and a comprehensive proof of performance period being completed prior to receiving discharge approval.

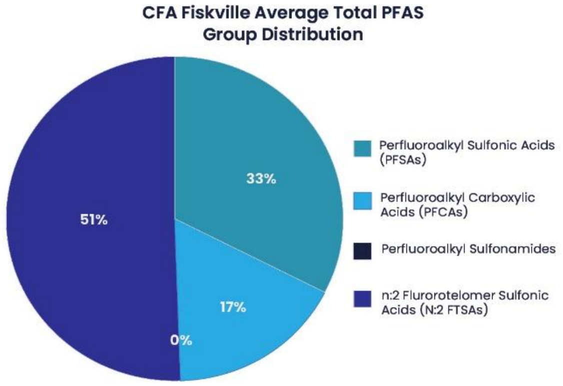
Key Challenges

During the commissioning phase, Fiskville experienced long periods of heavy rain. As a result, on-site water storage was close to maximum capacity and risked uncontrolled discharge into the adjacent creek. The WTP was run at or above its nameplate capacity for approximately one month to reduce the risk of uncontrolled discharge. The highest volume treated in a day was 684m³, representing a 37% increase in the system design flow rate.

Contaminated surface water and groundwater also required management over the course of remediation.

The project was unique for several reasons:

- Variability of water quality between the different water bodies was high.
  - Up to 600µg/L Total PFAS
  - Up to 685µg/L Total PFAS (post-TOPA)
- Water discharged needed to meet ultra-trace levels for PFAS and Oxidisable Precursors.
  - Total PFAS <0.002µg/L
  - Total PFAS (post TOPA) <0.002µg/L
- PFAS contamination profile consisted of a large portion of short-chain PFAS molecules.
- Byproduct solid wastes were to be immobilised for onsite reuse.



Our Approach

Understanding that this project involved treating a highly contaminated and variable influent to meet a challenging discharge criteria, the Victorian EPA required complete confidence in the treatment methodology and technology selection before approving continuous discharge into the environment. To achieve this, SciDev utilised its innovative FluorofIX™ ion exchange technology to effectively and efficiently remove all PFAS and oxidizable precursors from the ground and surface water at the CFA Fiskville site. SciDev's past performance using FluorofIX™ to treat a wide range of contaminated waste streams to the lowest possible Limits of Reporting (LOR) for PFAS provided the Victorian EPA with the confidence they required and SciDev was able to
provide treatment performance guarantees for PFAS removal for the duration of the project.

The WTP utilised a multi-barrier approach, adopting a range of treatment technologies including:

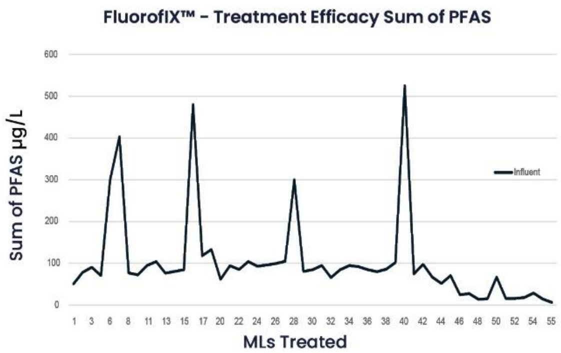
- Oxidation
- pH correction
- Coagulation & Flocculation
- Clarification and mechanical sludge dewatering
- Physical filtration and cation exchange via Zeolite
- PFAS removal via FluorofIX™
- Adsorption via Granular Activated Carbon
- Immobilisation of solid waste via SciDev propriety Powdered Activated Carbon blend

To address the high solids in the influent, a high-speed decanter centrifuge was used inline to dewater sludge and minimise waste output. The dewatered cake was then immobilised onsite using SciDev's proprietary Powdered Activated Carbon (PAC) blend prior to being, stockpiled, classified and reused onsite.

Due to the remote nature of the works and limited access, all major components of the WTP were constructed off-site and containerised, minimising onsite works and accelerating the construction programme.

Outcome

The water treatment plant was originally designed to treat an estimated total volume of between 8ML-28ML of contaminated water. By the end of the project, the WTP had successfully treated over 80ML in full compliance with the project-specific Victorian EPA licence. This additional volume was successfully processed without the need for anion ion exchange resin replacement or regeneration, demonstrating the PFAS holding capacity of FluorofIX™ and saving the project significant cost and time.



Highlights

- 80ML of contaminated water successfully treated
- Full compliance with the project's Victorian EPA licence and discharge criteria
- The highest volume treated in a day was 684m³, a 37% increase in plant nameplate capacity with no plant upgrade required.
- Maximum influent PFAS concentration of >155µg/L Sum of PFAS
- Byproduct waste requiring thermal incineration ≤0.0054% of the total volume treated.
- First project in Victoria to receive EPA approval to continuously discharge to the environment.

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6.2 Appendix 2: FlurofIX™ Case Study – Treating over one billion litres of PFAS-contaminated water at an Australian mine site

Background

A blue-chip Australian mining client had issues with surface water contaminated by per- and poly-fluoroalkyl substances (PFAS) at one of their WA operations. The source of contamination was due to the historical usage of Aqueous Film-Forming Foam (AFFF) for fire suppression and training activities. PFAS contamination was widespread across the mine site due to water reuse methods, including haul road dust suppression, that had been employed for decades. Given the site's proximity to a primary drinking water catchment and the risk of PFAS contamination impacting the drinking water supply of a densely populated urban area, a highly conservative approach was adopted by the regulator when determining the required environmental discharge criteria.

SciDev designed, constructed and is currently operating a water treatment plant capable of treating PFAS-impacted water under the most stringent controls used nationally in the treatment of PFAS. This plant was the first PFAS treatment plant to treat to these levels at full scale under the governance of the Department of Water, Environment and Regulation.

Contaminated water from around the mine site is processed through a multi-barrier water treatment plant utilising SciDev's FluorofIX™ technology. The water is processed in batches of five megalitres (ML) and is tested against 29 analytes of PFAS with a discharge limit of total PFAS below 0.00023µg/L. Once the water has been treated and validated, it is reused for haul road dust suppression on-site.

Key Challenges

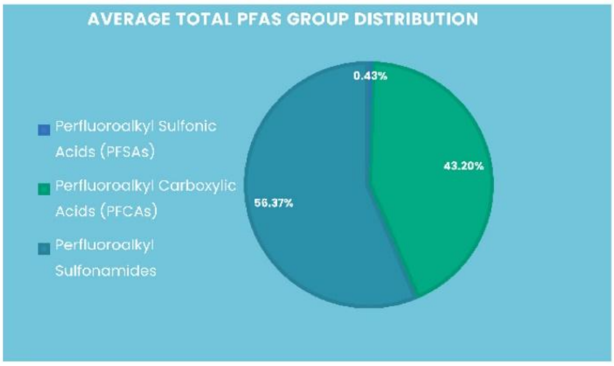
The mine's operational needs required the construction and commissioning phase of the project to be completed in 40 days from the contract award. In addition, due to the operational requirements, the water treatment plant operates continuously, 24 hours a day and processes 2.6ML/day to guarantee a consistent supply of treated water for dust suppression back to the mine site.

Due to the project's location and limited access to licenced waste disposal facilities, the minimisation of byproduct waste, especially spent ion exchange (IX) media, was a key consideration in the design of the treatment process.

Other key challenges included:

- Water quality and influent volume were extremely variable between seasons based on both mining operations and rainfall
- The discharge criteria for the system required Total PFAS removal down to <0.00023 µg/L
- 68.4% of sulfonic acids present were long-chain molecules
- 98.49% of carboxylic acids present were short-chain molecules

The water treatment plant was designed to handle water from various sources, each with different levels of contamination, including PFAS and other co-contaminants. After the first year of operation, an additional feed source was introduced, which had elevated total suspended solids. This required wholesale upgrade to the plant's capabilities to increase solids handling capacity.



Outcome

The water treatment plant was originally designed to treat an estimated total volume of 260ML of contaminated water. To date, the WTP has successfully treated over one billion litres in full compliance with the DWER licence.

The waste minimising benefits of FlourofIX™ resulted in waste generation of 0.018% of total volume treated, demonstrating the efficiency and sustainability of the technology while providing time and cost savings to the project.

Our Approach

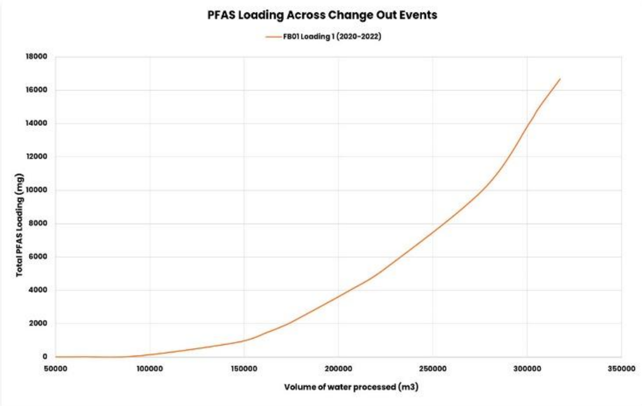
SciDevs approach to this uniquely challenging project involved the design of a bespoke multi-barrier water treatment plant (WTP) utilising SciDev's industry leading FluorofIX™ technology. The variability of influent required the implementation of a robust design that would suitably allow for periods of peak flow and elevated contaminant loading.

Several aspects of the PFAS water treatment plant contribute to its practical application, including:

- The multi-barrier treatment approach
- Specialised filtration media
- PFAS removal using FluorofIX™
- Configuration of FluorofIX™ to suit specific influent contamination profile
- Plant controlled using Programmable Logic Controller (PLC)
- Remote alarming, access and operation

The continuous operation requirements of the treatment plant played an additional role in the design and automation of the plant. The system is controlled via a Programmable Logic Controller with an integrated Human Machine Interface, designed to minimise operator input and reduce OPEX cost.

Due to the remote nature of the works and limited access, all major components of the WTP were constructed off-site and containerised, minimising onsite works and accelerating the construction programme.



Highlights

- More than one billion litres of contaminated water successfully treated to date
- Construction and commissioning of the water treatment plant was completed in less than 40 days from contract award due to on-site operational requirements
- First treatment plant to treat to below 0.0002µg/L sum of PFAS at commercial scale
- First project to receive the Department of Water, Environment and Regulation approval to continuously discharge to the environment.
- The system flow rate was designed to achieve 21L/s, and was subsequently upgraded to treat 38L/s
- By product waste generated 0.018%, all of which was able to be disposed of as general landfill.

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6.3 Appendix 3: RegenIX™ Case Study – IX Resin Regneraiton Technology

79% ↓ Reduction in OPEX

82% ↓ In resin replacement costs

93% ↓ In waste generation

67% ↓ In system footprint

- Treats short/long chain and precursor compounds to below limits of reporting
- Built-in regeneration capabilities
- No additional CAPEX
- Destruction-compatible waste stream
- Solvent-free process
- 67% reduction in system footprint over carbon alone

What is RegenIX™?

Regenerable ion exchange (IX) resins can have a significantly positive impact on reducing treatment system operational costs and the associated waste generation by minimising the IX resin replacement frequency.

RegenIX™ is SciDev's IX resin regeneration technology, which is integrated into all SciDev's treatment system designs without significant additional CAPEX costs. In addition, RegenIX™ reduces your ongoing OPEX by up to 79% and delivers treated water with per- and poly-fluoroalkyl substances (PFAS) levels below the lowest limits of reporting. Our proprietary regenerant solution is non-flammable and produces a liquid waste stream ideally suited for PFAS destruction technologies.

At SciDev, we embrace a technology-agnostic approach with customised PFAS treatment designs, creating highly efficient and effective co-contaminant pre-treatment removal. This approach allows our FluorofIX™ high holding capacity resins to deliver extraordinary PFAS removal performance while optimising RegenIX's™ ability to restore the resin's holding capacity and minimising costly IX resin replacement.

What is Regenerable Ion Exchange Resin?

Resin "selection" is a critical step in the design process in determining the overall performance of a PFAS treatment system. Historically, IX resins have been deployed in water treatment applications to remove a variety of contaminants, including nitrate, perchlorate, and arsenic. More recently, as the demand for alternative PFAS removal technologies has increased, some IX resins have been found to be highly effective at removing PFAS compounds, including short and ultra-short-chain compounds. There are a wide variety of commercially available resins with various performance characteristics and limitations, including their regeneration compatibility to restore the resin's contaminant holding capacity.

Typically, single-use resins are kept in service until a breakthrough of the targeted PFAS compounds is observed. The vessel is taken offline, where the spent resin is removed and disposed of. The vessel is then refilled with virgin resin and returned to service.

Regenerable resin follows a similar process; however, when a breakthrough of the targeted PFAS compounds is observed, the vessel is taken offline, and a regenerant solution is applied to the resin to remove the PFAS and restore the resin's contaminant holding capacity before it is returned to service. The spent regenerant solution can be stored, disposed of, or destroyed. This results in added benefit of not incurring costly resin replacement and disposal costs.