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# IMPROVEMENTS IN CONTAMINATED GROUNDWATER TREATMENT ON INFRASTRUCTURE PROJECTS IN SYDNEY: TOWARDS HARMLESS DISCHARGES

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# Improvements in contaminated groundwater treatment on infrastructure projects in Sydney: towards harmless discharges

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## ABSTRACT

Groundwater treatment plants are vital for protecting the environment and human health during the construction and operation of Sydney's rail and road tunnels. As network construction has expanded, groundwater containing a wide range of contaminants has been intercepted by tunnelling posing a risk to Sydney's waterways.

Proactive collaboration between the NSW EPA and industry ensured contaminant risks were identified early and treatment plants designed, constructed and operated to effectively treat groundwater contaminated with legacy pollutants.

This paper examines how early engagement and communication of the EPA's regulatory requirements with proponents and their consultants worked to enable the protection of Sydney's waterways. Coupled with an innovative, pragmatic approach to regulating advanced technologies, it played a critical role in the adoption of advanced groundwater treatment plant technology to produce high-quality effluent. This paper also quantifies some of the improvements in effluent quality, highlighting the contribution to restoring and maintaining the community's uses and values of Sydney's waterways.

## INTRODUCTION

Groundwater treatment plants (GWTPs) are playing a critical role in the ongoing management of contaminated groundwater inflows which result from the construction and ongoing operation of major rail and road tunnelling construction projects across Sydney. Initially these plants employed basic physiochemical treatment processes, using a standard treatment train that included, for example:

- Raw water screening
- pH correction
- Coagulant/polymer dosing
- Clarification/settling
- Solids handling and disposal.

These processes reduced coarse screenings and suspended solids, turbidity, and oil and grease, while also likely decreasing the concentration of certain metals. However, they were not designed to address nutrients such as ammonia or phosphorus and specific toxicants that might be present, nor did they include treatment to significantly reduce metals.

As Sydney's network of road and rail tunnels expanded—encompassing projects like the Sydney Metro Northwest, WestConnex, NorthConnex, and Sydney Metro City and Southwest—the number of GWTPs grew significantly to meet the demands of these large-scale infrastructure developments.

In parallel to this was an increasing awareness and understanding of the pollutants in the contaminated groundwater intercepted by these tunnels which meant that many more pollutants of concern were identified than had been in earlier projects. This was related to improved analytical techniques, but also the tunnel locations which now intercepted groundwater contaminated with legacy pollutants from previous industrial land uses including gaslight plants, chemical production and storage facilities, and landfills. The pollutants often included perfluoroalkyl and polyfluoroalkyl substances (PFAS)/ perfluorooctane sulfonic acid (PFOS), heavy metals, petroleum hydrocarbons, ammonia and nitrate/nitrite.

Photo by Florina Ene, Vecteezy

While the initial emphasis was on the treatment of groundwater intercepted during construction, there was also growing recognition that many of these tunnels would also require GWTPs for their operational life.

The NSW EPA is NSW's primary environmental regulator and takes an environmental stewardship approach to its role. The NSW EPA also plays an important role during planning approval processes, providing its requirements for protection of the environment and human health to NSW planning authorities.

During its review of these infrastructure tunnelling proposals, the EPA's technical experts recognised the need for a high standard of contaminated groundwater treatment and saw an opportunity to proactively engage with industry to explain regulatory requirements and the use of more advanced treatment processes to protect and restore Sydney's waterways. Without treatment or inadequate treatment, intercepted groundwater from the construction and ongoing operation of this infrastructure could impact the sensitive receiving waterways around Sydney for many years to come.

This paper considers how early engagement on the legislative, policy and technical framework for managing water pollution in NSW helped drive the improved performance of GWTP technology over the decade up to and including 2024. It also presents some of the water quality data from contemporary GWTP discharges in Sydney to demonstrate the ability of these plants to remove key pollutants from contaminated groundwater to prevent or minimise harm and contribute to the restoration and maintenance of the community's uses and values of Sydney's waterways.

## BACKGROUND

**The technical, policy and regulatory framework for managing water pollution in NSW**

The NSW EPA administers the *Protection of the Environment Operations Act* 1997 (the Act) that provides the statutory framework for managing water pollution in NSW. NSW has also adopted the National Water Quality Management Strategy (NWQMS, Australian Government 2018) and Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018) as the policy and technical framework to assess and manage water quality. Section 45 of the Act sets out the matters the EPA must consider when issuing a licence and attaching conditions to that licence, including, for example:

- the pollution that will be caused and its impact on the environment
- practical measures that can be taken to prevent, control, abate or mitigate the pollution and protect the environment from harm,
- the environmental values of water affected by the proposed discharge, and
- practical measures that can be taken to restore or maintain those values.

The NSW EPA's Regulatory Policy (NSW EPA 2024a) and Regulatory Framework (NSW EPA 2024b) describe how the EPA regulates a broad range of activities. The Regulatory Framework is underpinned by eight elements (to listen, educate, enable, act, influence, require, monitor and enforce) that inform a fit-for-purpose approach to regulation based on the circumstances and particular issue. The EPA will use one or more of these elements as needed on a case-by-case basis.

Regulatory decisions and actions are based on the best available information and informed by a range of considerations, including data, research and science and information received from industry and interest groups. The underlying regulatory principles that guide the way EPA makes regulatory decisions include being outcomes-focused, transparent, consistent, cohesive and collaborative.

The EPA applies these decision factors in the context of delivering outcomes that have value to the people of NSW considering legal requirements and precedents and applying the principles of environmental justice.

This regulatory framework informed the negotiations and outcomes regarding contaminated groundwater discharges from the road and rail infrastructure described above, often drawing on the data and evidence provided during the planning approval and licensing process. This included information to consider the risks of actual or potential harm to the receiving waterway and to identify if any further measures were required to ensure the best environmental outcome.

**Regulating discharges to waterways in practice**

Avoiding discharges of pollutants to the environment is EPA's priority as it most often leads to the best environmental outcomes. There are many cases, however, where discharges to waterways cannot be avoided due to site and process constraints and limited reuse opportunities. Where a discharge is unavoidable, the EPA requires a licensee to demonstrate that all reasonable and practical measures have been implemented to minimise or mitigate the pollution and restore or maintain the environmental values of the waterway. In NSW, the environmental values of water are referred to as the NSW Water Quality Objectives (NSW Government 2006).

Once options to avoid a discharge have been exhausted the guiding principles that apply to discharges to waterways are that where environmental values in the receiving waters are being achieved, they should be protected, and where they are not being achieved all activities should work towards their achievement over time.

When considering practical measures, the EPA applies the concept of a 'reasonable level of environmental performance'. This is consistent with the NWQMS and conceptually includes technology-based treatment criteria and other relevant factors (e.g. reducing wastewater and recycling). It involves adopting technology and management practices to achieve certain effluent pollutant levels in economically viable operations, including consideration of contemporary treatment technology.

Where all options to avoid or mitigate a discharge have been exhausted, the EPA can consider a mixing zone where the actions of dilution and/or decay allow the NSW Water Quality Objectives to be met by the edge of the area in which initial mixing occurs.

The EPA only specifies pollutants on a licence where their discharge in all practical terms is unavoidable and measures to control the pollutants and their impacts can be feasibly implemented.

## METHOD

**Early engagement on the framework for managing water pollution**
The EPA engaged with proponents, licensees and practitioners through the planning approval and licensing processes to inform and enable stakeholders. Providing clarity regarding the EPA's regulatory requirements involved clear and consistent communication and utilised resources such as the water pollution discharge impact assessment (WPDIA) guidance (NSW EPA 2022a) available on the EPA's website to complement the existing guidance in ANZG (2018). A WPDIA is a structured, stepwise approach to ensure the relevant technical, policy and legislative requirements are appropriately considered to achieve the best environmental outcomes in the circumstances.

Written correspondence and face-to-face meetings about the assessment process highlighted the EPA's expectation that all practical measures to avoid and minimise impacts be assessed, including use of contemporary treatment technology. The EPA provided detailed feedback on the proponent's proposal and discussions with the proponent or practitioner explored the practical application of the technology and the limits of treatment performance.

The engagement process was iterative, and the EPA provided written and verbal feedback to stakeholders until the final WPDIA included robust assessments and thorough consideration of treatment technologies.

**Setting licence conditions including discharge limits**
The EPA used information submitted in the WPDIA to determine licence conditions, including discharge limits. In many cases the licensees used their GWTP's predicted effluent concentration ranges to nominate limits in their discharge impact assessment. The proposed limits were evaluated by the EPA in consideration of the key regulatory practices, principles and considerations outlined above.

Where the predicted concentration of a pollutant was below the default guideline value at the discharge point, those pollutants represented a low risk to the receiving waterway and were generally not regulated through licence conditions, but initially monitored to confirm predicted treatment performance levels. In some cases, limits were used to define the EPA's ongoing expectations for treatment performance and effluent quality.

Pollutants at concentrations higher than default guideline values required further consideration due to their potential to cause non-trivial harm to aquatic ecosystems. There were some situations in which the EPA required the proposal to be revised, for example:

- If any of the proposed limits were within the acutely toxic range for a pollutant, by reference to the appropriate ANZG (2018) technical brief, they were not accepted as they represent a significant risk of harm to the receiving waterway.
- If the results of mixing zone modelling did not demonstrate that the concentration of the pollutant was reduced to default guideline values at the edge of the near-field mixing zone, or the mixing zone was not minimised.
- If the loads, particularly of nutrients, dominated catchment inputs and presented a risk of stressor effects such as excessive algal growth or other chronic impacts on ecosystem health.

It should be noted that the guideline values in ANZG (2018) are not pass/fail compliance criteria but trigger a need for further consideration as an exceedance (or value outside the preferred range) indicates a potential risk to receptors.

The remaining proposed limits were considered by the EPA in context, with knowledge of, for example:

- predicted influent quality
- magnitude of any exceedances,
- duration of the discharge,
- characteristics of the receiving environment and its sensitivity to pollutants,
- other factors that could mitigate or increase the impacts of each pollutant,
- the performance of similar treatment plants, and
- treatment process robustness and reliability.

If, following consideration of the proposal by the EPA, the predicted concentration of some pollutants remained above guideline values or there was some uncertainty in the plant performance for other pollutants, those pollutants were assigned interim concentration limits and monitored under a proof of performance period. The monitoring program was included on licenses and allowed the interim limits to be reassessed after a suitable period.

In some rare instances, the concentration of a pollutant exceeded the relevant guideline value by many multiples despite appropriate treatment and represented a potential risk of harm to receiving waters. If this occurred, then a Pollution Reduction Program (PRP) to investigate optimising treatment performance or alternative treatments was typically included on the licence.

The licence conditions and discharge concentration limits were fine-tuned through a communication process to account for practical issues or other considerations. The finalised requirements set the performance standard and the improvement expectations for the operating GWTPs.

**Monitoring treatment plant performance**
Monitoring and reporting are standard features of environment protection licences and where interim limits were in place the requirements were initially intensive. For example, daily monitoring was conducted on the first three days of discharges, weekly monitoring for the first month of discharges, fortnightly monitoring for the first three months and then monthly monitoring for the ongoing operation of the plant. Monitoring data on the range of pollutants was collected for treatment plant influent and effluent. If there were no interim limits, then monitoring generally involved monthly monitoring only. In all instances the intensity of monitoring was commensurate with the potential risks to receiving waters.

The range of pollutants monitored included all those regulated by the licence, as well as others that may have been present in groundwater samples close to but below guideline values, and any potential by-products of the treatment process that may indicate the process is not working efficiently. Other standard variables and modifiers such as pH, turbidity, electrical conductivity and oil and grease were also included.

The limit of reporting (LOR) for the analytical technique used for each pollutant was lower than the pollutant's guideline value in ANZG (2018) to facilitate assessment of the potential impacts of the discharge. The techniques used also complied with the *Approved Methods for Sampling and Analysis of Water Pollutants in NSW* (NSW EPA 2022b).

**Reviewing licence limits**
Licence limits were reviewed during plant operation for several reasons, including, for example, the completion of the optimisation or proving period, in response to a request from the licensee for operational reasons, or to address an issue observed by the EPA. In contrast to setting licence limits, reviewing licence limits used operational data which can indicate whether the limit reflects the optimised performance of the plant or requires some adjustment. Revising limits required careful data review to ensure only data that reflected a properly operated and maintained treatment system were considered.

When licence discharge monitoring was reviewed after a commissioning or proving period, the EPA's aim was to revise the limits to reflect the optimised performance. Where data indicated that the GWTP could achieve better effluent quality than the current licence limits, the limit was generally lowered accordingly. However, if the analysis indicated that the plant was not achieving its current limits then other factors were considered similar to when licence limits were initially set.

## RESULTS

**Implemented technologies**
Designing plants to treat contaminated groundwater to prevent or minimise harm and protect and restore the environmental values of waterways challenged licensees to translate the results of their impact assessment into practical measures for treatment of pollutants. Industry proponents and practitioners responded, and the resulting GWTPs had a varying number and range of treatment units depending on the identified contaminants and the nature of the receiving environment. GWTPs now commonly use a range of traditional and advanced treatment processes from simple settling and precipitation of metals to breakpoint chlorination, granular activated carbon and ion exchange. An example simplified process flow diagram showing the types of treatment units is shown in Figure 1.

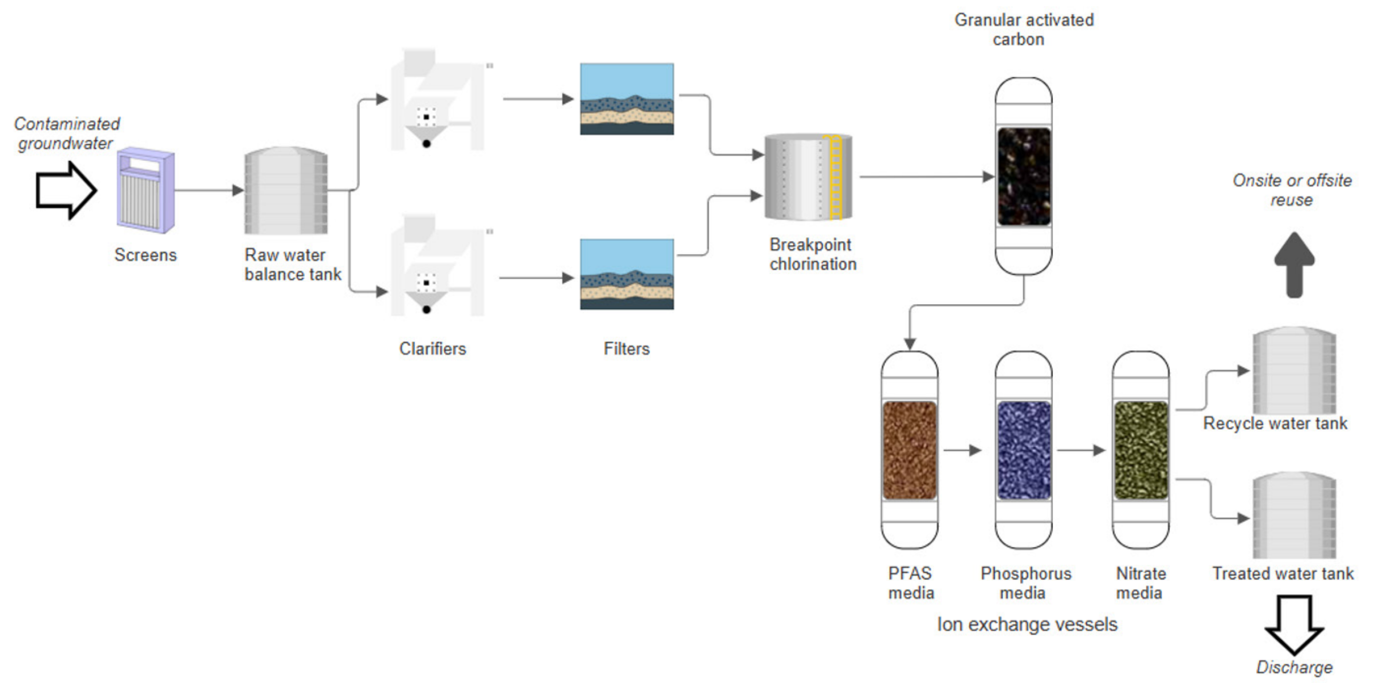


*Figure 1 Example of a treatment process for groundwater contaminated with ammonia, phosphorus, nitrate and PFAS*

In a small number of cases, reverse osmosis (RO) was adopted to reduce salinity levels before discharge. This also further reduced the concentrations of remaining nutrients and metals. As the residual pollutants at the end of this treatment process are very low and meet the criteria for industrial use, a high proportion of the treated water can be reused through processes onsite, significantly reducing discharge volumes and potential impacts on the receiving waterway.

In some situations, discharge locations were adjusted as an appropriate alternative to additional treatment to ensure the effluent characteristics suit the receiving environment. For example, a pipeline was constructed to discharge treated water from a GWTP to where the receiving waterway is naturally brackish as the influent was saline groundwater. This negated the need to reduce the salinity of the discharge through RO treatment.

Waste streams from the processes included screened solids, sludge, filter backwash water and a brine from regenerating ion exchange media. RO also produced a concentrate waste stream. Where possible, these waste streams were returned to the treatment train or reused on or offsite. Where this was not possible, solid waste was sent to landfill and liquid waste to a liquid waste treatment facility.

**Effluent quality**

Licence limits were set in consideration of the matters described above, including the predicted and optimised performance of the GWTPs with consideration of sustaining that performance over the longer term.

As required by their licences, licensees sampled effluent from the GWTPs that discharged to waterways. For most plants the sampling frequency was initially daily, progressing to weekly and then fortnightly. By the end of the third month of operation sampling was largely monthly and this frequency was maintained for the ongoing operation of the plant.

The effluent quality achieved by the GWTPs in response to the licence limits generally reduced the concentrations of toxicants to a level that represented a low risk of harm to receiving waters. Figure 2 demonstrates this for ammonia at a sample of GWTPs over periods of 6 – 18 months, where each

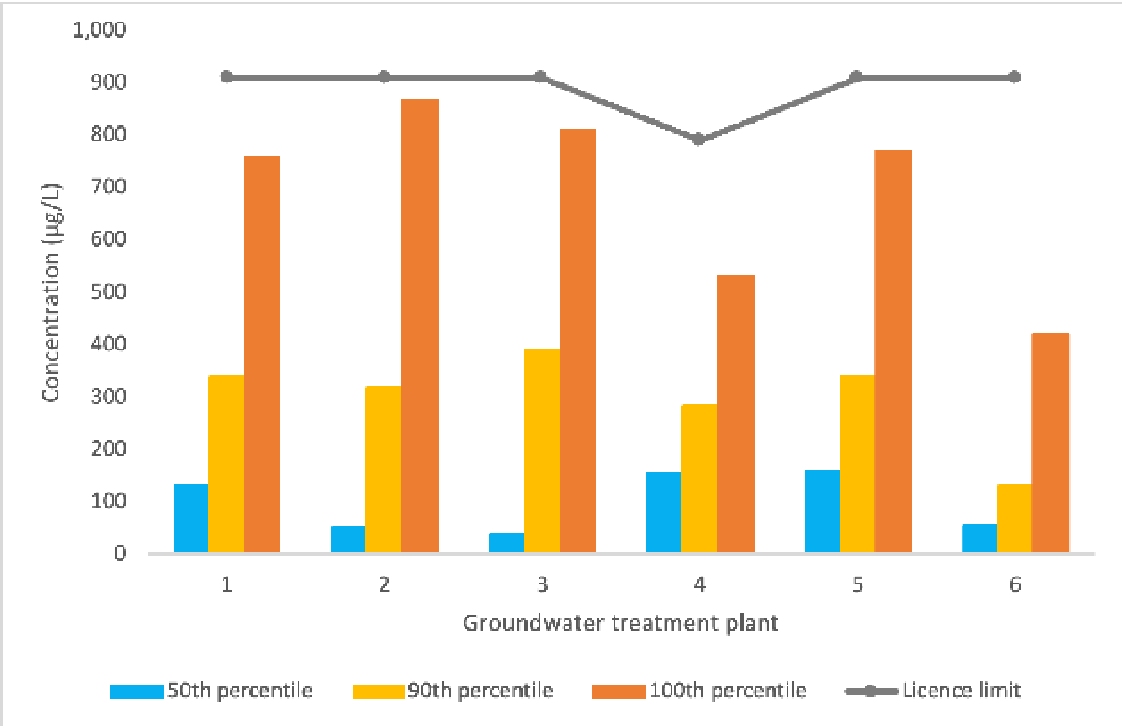


*Figure 2. Ammonia in effluent for a selection of groundwater treatment plants across Sydney*

plant employed targeted ammonia treatment (most commonly, break point chlorination). The licence limits at the selection of plants varied from 750 to 910 µg/L. Even though ammonia in the influent was as high as 6,000 µg/L at some plants, the highest recorded concentrations in the effluent did not exceed the licence limit and were below the toxicant guideline value of 900 /910 µg/L (freshwater/ marine water). The 50th percentile concentration of ammonia in the effluents was less than 150µg/L, which is consistent with concentrations achieved for comparable matrices with similar contaminants and levels of pollution, such as secondary sewage effluent (Brooks, 1999). Note that the sampled GWTP effluents in Figure 2 do not include any that have been treated using RO.

If a process is not achieving pollutant concentrations considered a trivial risk of harm, then the removal efficiency can be used to understand if the process is achieving a 'reasonable level of environmental performance'. A 'reasonable level of environmental performance' is a concept that the EPA applies when considering if a licensee is using adequate practical measures, such as treatment technologies, to reduce pollution.

Figure 3 shows the removal efficiency of chromium VI at a GWTP during 17 months of operation. The removal efficiency is high and reliable with 92% of samples indicating that the concentration in the influent was reduced by more than 80% in the effluent (average removal 92 ± 11%). Influent concentrations of chromium VI were up to 1,400 µg/L and the 90th percentile effluent concentration was 10 µg/L. While above guideline values (ANZG 2018), the effluent concentration is meeting licence limits and unlikely to represent a risk of harm to receptors due to mitigating factors such as the available dilution and mixing in the receiving environment.

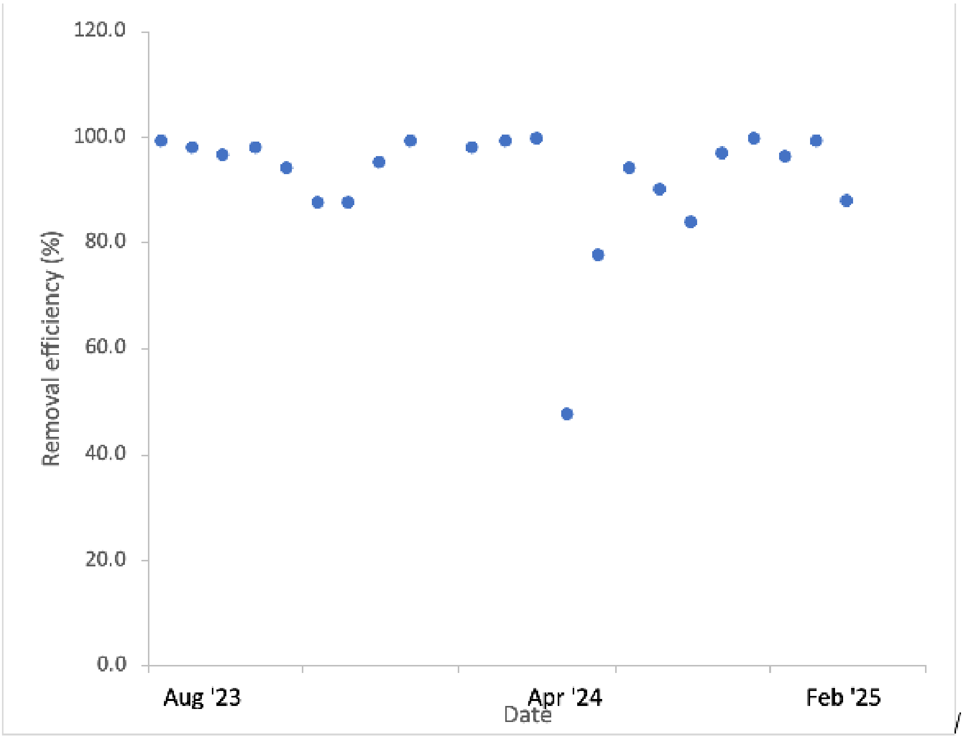


*Figure 3 Removal efficiency of chromium VI at a groundwater treatment plant*

The removal efficiency demonstrates that the process is performing optimally for the given influent and other conditions and is similar to optimal removal efficiency reported for other water and wastewater applications of ion exchange of more than 95% (Rengaraj et al, 2001) and ion exchange with less complicated matrices and various anions that achieved efficiencies of up to 75.08% (Witt et al 2024).

To ensure compliance with licence limits, licensees were required to appropriately maintain their treatment processes. While scheduled maintenance can support optimal performance of most treatment processes, trends in effluent concentrations can indicate the need for maintenance of certain treatment units.

Figure 4 shows the trend in oxidised nitrogen (NOx) concentrations in effluent at a GWTP over an 18-month period and the corresponding NOx influent concentrations. This plant used ion exchange to treat NOx and the trend in NOx concentrations in the effluent is a typical breakthrough curve. The curve indicates when the resin became saturated with NOx and where regeneration has been implemented. One sample from April 2023 and one from November 2023 had NOx effluent concentrations that equalled or exceeded the influent NOx following a period where NOx concentrations were trending upwards, demonstrating that the resin no longer had the capacity to remove NOx from the influent. As this plant was operating in an infrastructure construction environment, regeneration needed to be implemented within a time that was practical and reasonable considering the anticipated inflows to the GWTP due to on-site construction activities and the potential environmental impacts of the discharge.

The decrease in concentrations is indicative of resin regeneration, with effluent NOx concentrations returning to below licence limits at the next sampling event. One sample in early July 2023 also

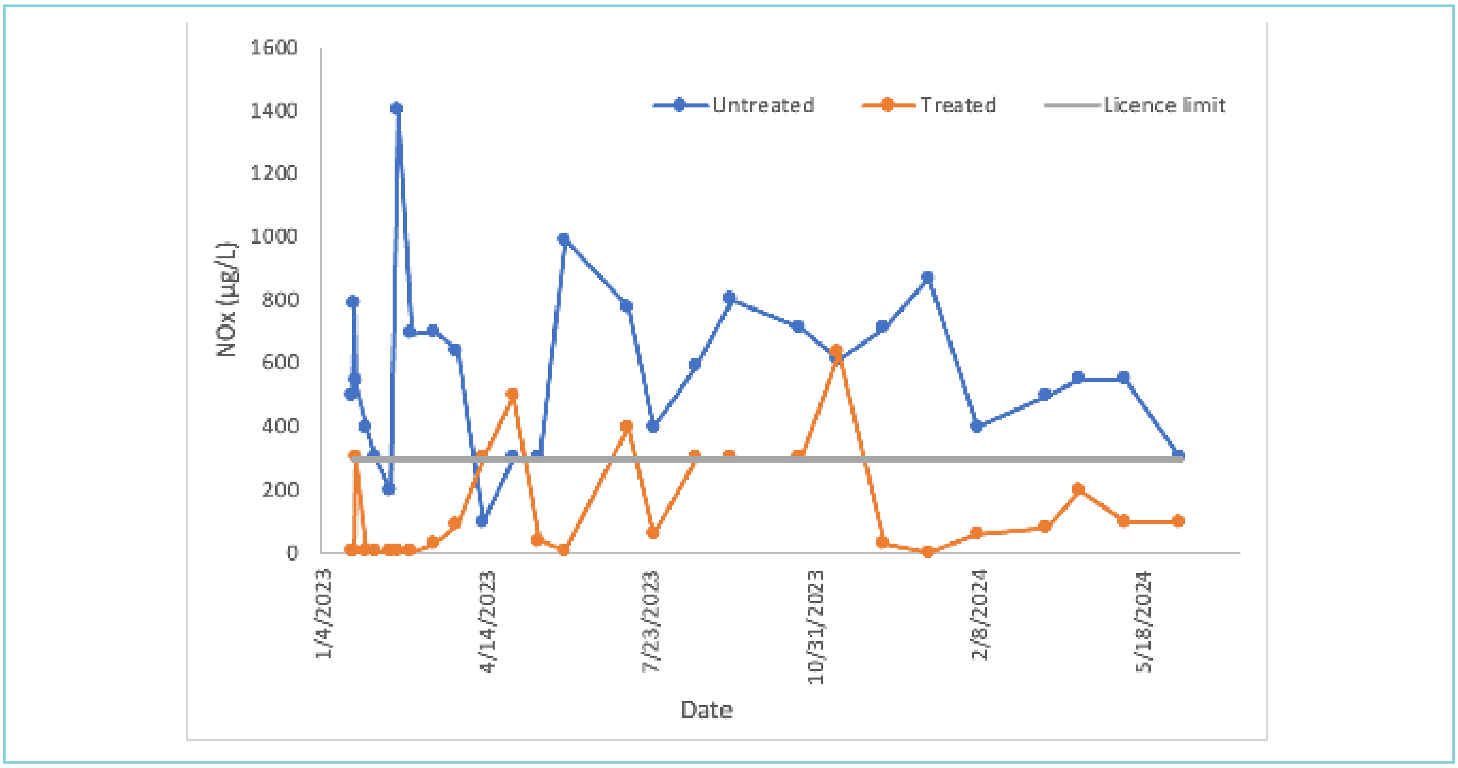


*Figure 4 Trends in effluent and influent concentrations of NOx at a groundwater treatment plant*

exceeded the limit but did not exceed the influent concentrations. The sample in the following fortnight returned to below the limit, allowing the licensee to delay resin regeneration. The concentrations of NOx in the effluent are consistent with the best achievable levels for these type of GWTPs which is around 350µg/L (SciDev, 2022).

**Reviewing licence limits**

Licence limits were reviewed for GWTPs that were recording effluent concentrations of one or more pollutants that were notably different from the limits during a period of proving and/or operation.

Table 1 shows the existing limits and the revised limits for the metals on one of the licences that was reviewed after monitoring confirmed initial performance. The revised limits reflect what can be practically and reasonably achieved for this particular GWTP following optimisation. In this case, the limits have all been lowered but a few still exceed the relevant guideline values (ANZG 2018) indicating a potential risk to receiving waters. To manage this 90th percentile limits were included as well as the revised 100th percentile limits.

In addition, where optimisation did not reduce the concentration of some pollutants to levels that could contribute to the restoration and maintenance of the environmental values in the receiving waterways, the EPA used PRPs that continued to foster innovative approaches to treatment and sought to eliminate the pollutant through other options such as source control. This included technical investigations into treatment options with the EPA following up with field visits and meetings with licensees, consultants and practitioners to monitor improvement. In the case of the GWTP in Table 1, this included investigations into controlling the source of hexavalent chromium.

*Table 1 Existing and revised limits following review of 12 months of monitoring data at a groundwater treatment plant*

| | | | Existing Limit | | Revised Limit | |
|---|---|---|---|---|---|---|
| | **Units** | **Appropiate default guideline value** | **90th percentile** | **100th percentile** | **90th percentile** | **100th percentile** |
| Arsenic | µg/L | 2.3 (As (III)) | | 50 | | 0.8 |
| Cadmium | µg/L | 0.7 | | 14 | | 0.1 |
| Chromium (hexavalent) | µg/L | 4.4 | 70 | | 36 | 38 |
| Chromium (trivalent) | µg/L | 27 | | 150 | | 12 |
| Copper | µg/L | 1.3 | 40 | | 3 | 5 |
| Iron | µg/L | 300 | | 1,500 | | 22 |
| Lead | µg/L | 4.4 | | 30 | 0.2 | 8.5 |
| Manganese | µg/L | 80 | | 2,500 | 45 | 275 |
| Mercury | µg/L | 0.1 | | 0.7 | 0.1 | 0.3 |
| Nickel | µg/L | 7 | | 200 | | 1.4 |
| Zinc | µg/L | 8 | 150 | | 9 | 23 |

## DISCUSSION

**Informed, collaborative approach leads to adoption of improved treatment technologies and efficiencies**
In its licensing decisions, the EPA must balance a range of considerations, including the pollution being caused, the impact of that pollution, the environmental values of receiving waters, and the practical measures that can be taken to maintain or restore those environmental values. This means that, on a case-by-case basis, the level of environmental performance that is reasonable for the type of activity being regulated must be considered. A proponent's WPDIA directly informs these considerations, and the level of assessment required depends on a range of case and site-specific circumstances.

While the planning approval process for projects using GWTPs required formal communication and responses, the licensing phase allowed the EPA to work closely with stakeholders on their understanding of the EPA's assessment requirements, which in turn enabled them to effectively address those requirements in a timely manner.

The WPDIA process also established that the vast majority of pollutants could be treated to levels that represented a low risk of harm to the environment. Over time and through constructive communication, the WPDIAs being reviewed by the EPA quickly progressed to being comprehensive in their identification of pollutants and consideration of appropriate treatment technologies. This led to efficiencies for both the licensee and the regulator, with significantly less time spent reviewing and revising assessments. The subsequent licence conditions and limits for each GWTP were also established quickly and efficiently allowing the proponents and their practitioners to progress treatment plant designs to meet construction timetables.

**Targeted pollutant treatments were the key to meeting licence limits**

By responding to the relevant technical, policy and legislative requirements for managing water pollution, industry has innovated to build highly technical plants with process units not previously used in these situations. The implemented processes, such as break point chlorination and ion exchange, demonstrate that industry is designing, constructing and operating GWTPs with technologies targeted to treat specific pollutants to levels that don't represent a risk to receiving waters.

The EPA recognises that there can be practical limits to the performance of the treatment processes for some pollutants such as ammonia and nitrate. In these cases, the approach in this paper has contributed to very significant improvements in the concentrations of these pollutants in the effluent from GWTPs across Sydney. Further improvements, particularly to ammonia removal by breakpoint chlorination, may be possible if constraining factors such as available site area can be resolved. Expanded available site area can facilitate the installation of multiple treatment vessels, enabling better control of reaction stages and reducing the effects of competing chlorine demand (Pressley et al 1972, Woodard and Curran inc. 2006). Any improvements and their environmental benefits, however, will be considered by licensees in the context of what is practical and reasonable both physically and economically.

**Innovative regulation leads to overall lower pollutant discharges**

Despite adopting targeted, advanced technologies, there were residual risks at some GWTPs, and some licensees were uncertain about their plant's predicted performance. Residual risks were often related to metal concentrations in the effluent. For example, it was anticipated that chromium VI and zinc concentrations would exceed guideline values (ANZG 2018) in the final effluent of a GWTP discharging to an estuarine environment. Using the regulatory approach of managing these risks with interim limits allowed the licensee to commence operations and focus on optimising their processes. In this case, interim limits were established for chromium VI and zinc that were significantly below toxic levels, accounted for the ameliorating effects of the estuarine environment on chromium toxicity, and recognised what was practical and reasonable. This approach yielded benefits, with the GWTPs generally performing much better than anticipated and reducing pollutant concentrations below predicted concentrations.

Placing PRPs on licences to optimise plant performance and seek additional, alternative technologies to treat pollutants furthered the move towards reducing all pollutants to low-risk concentrations. PRPs addressing ammonia and NOx treatment were included on some key licences across different projects. These PRPs required the licensee to investigate optimising treatment performance by considering, at a minimum, treatment reconfiguration and process maintenance. To comply with the PRP, licensees worked closely with their suppliers to secure the most effective, achievable treatment process available in the market. This established a new benchmark for the industry and set expectations for other licensees.

Monitoring effluent concentrations during plant performance optimisation, and particularly during a proving period, provided valuable insight for the licensee and the EPA. The data generated informed future reviews of licence limits and showed that the risk to the receiving environment can be reduced over time, with optimised operation. All NSW Environment Protection Licences are available on a public register allowing other potential licensees to understand the effluent quality that can be achieved from similar sites and the requirements the EPA is likely to put in place.

## CONCLUSION

Collaborative engagement between NSW EPA and proponents, licensees and water treatment plant practitioners in NSW has matured to the point where industry is now well enabled to meet EPA regulatory requirements to adequately understand the risks posed by contaminated groundwater and then design and operate treatment plants that protect and restore waterway uses and values.

This maturation has meant that the majority of pollutants are treated to below guideline values (ANZG 2018) so there are fewer pollutants that require regulation. Most pollutants in groundwater intercepted by tunnelling projects are now treated to levels that don't cause harm and discharges contribute towards the restoration or maintenance of the community's uses and values of Sydney's waterways. This is a significant outcome for waterway health and the community more broadly in Sydney.

## ACKNOWLEDGEMENTS

Image from Vecteezy.com
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