PFAS Ecological Risk Study

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Abstract

The presence of Per– and Polyfluoroalkyl Substances (PFAS) in treated wastewater and reuse schemes has the potential to impact sensitive species in the surrounding environment. It is important that the latent risk resulting from domestic baseline concentrations of PFAS be assessed in order to prioritise resources allocated to further investigate and possibly remediate sites of high ecological importance. This investigative study will aim to develop the risk assessment framework for site prioritisation, and review the sensitivity of protected ecological species with regards to PFAS. The objectives shall be achieved through data collection and analysis in the form of a literature review, the development of a site prioritisation framework followed by case studies on sites of varying priority and the ranking of those sites.

1. Introduction

Per– and polyfluoroalkyl substances (PFAS) are a group of manufactured chemicals with past and current uses in a variety of industrial processes and consumer products such as textile coatings, non-stick cookware, electronics, mist suppressants and firefighting foams since being developed in the 1950's (Department of Health, 2019). The National Environmental Management Plan for PFAS, developed by the heads of all State and Territory Environmental Protection Authorities was finalised and published on 16 February 2018. It contained assessment criteria for notable PFAS compounds perfluorooctanoic acid (PFOA), perfluorooctane sulfonate (PFOS) and perfluorohexane sulfonate (PFHxS) (HEPA, 2018). The Department of Water and Environmental Regulation has adopted the published NEMP and requires environmental investigations to adhere to these guidelines.

There were several key findings from the literature review. The physical and ecological fate and transport of PFAS is dependent on chain-length and functional group. It was also deduced that the species that are highly vulnerable to PFAS largely depended on the diet of the species relative to body size. Insectivorous secondary animals are the most vulnerable to PFAS impacts. These species are commonly birds and reptiles although this group can also include mammals (ECCC, 2017). The at risk species in aquatic fauna are fairly unknown compared to terrestrial fauna.

The following objectives will be achieved within the scope of this project:

- Develop a detailed understanding of the ecological effects, fate and transport of PFAS within selected wastewater treatment plant (WWTP) sites in WA.
- Develop a cohesive framework that prioritises sites based on ecological, cultural and social significance of land surrounding WWTPs, and whether sites house protected species that are vulnerable to PFAS.
- Identify and develop a detailed understanding of sensitive local receptors of concern and the receiving environment.
- Develop a plan/framework in regards to next steps for the state-wide risk study.

The findings and tools created throughout the project will aid the Water Corporation in determining the level of ecological priority given to all 109 WWTPs and reuse schemes.

2. Site Ranking Process and Case Studies

The objectives are being achieved through a literature review, site screening for four case studies, the development of a site prioritisation framework, case studies and a site ranking exercise for all WWTPs and reuse schemes.

The site prioritisation framework was developed to rank sites in varying levels of priority. This first set of criteria is related to environmental and ecological sensitivity as well as the likelihood and severity due to the method of wastewater discharge, as shown in Table 1.

Table 1 Environmental and ecological component to the site prioritisation framework

Criteria	Negligible	Low	Moderate		High
1. The proximity of discharge point to protected areas/species (40%)	**0%** >10km	**10%** 5km-10km	**20%** 1km-5km	**30%** 500m-1km	**40%** <500m
2. Method of treated wastewater discharge (20%)	**0%** Evaporation ponds	**5%** Ocean outlet pipeline	**10%** Reuse	**15%** Infiltration ponds	**20%** Surface water discharge
3. Classification of vulnerable protected species (insectivorous – birds, reptiles, mammals) (20%)	**0%** No protected species	**5%** No vulnerable protected species	**10%** Protected omnivorous tertiary consumer	**15%** At least one omnivorous protected secondary consumer	**20%** At least one insectivorous protected secondary consumer
4. Environmental Significance of Receptor (20%)	**0%** Developed Site	**5%** Undeveloped Site	**10%** Ecologically Sensitive Area	**15%** Non-RAMSAR wetland	**20%** RAMSAR Wetland

This set of criteria renders a rank out of 100%, 0% meaning the lowest level of priority and 100% meaning the highest level of priority. Criteria one and two in Table 1 represent the likelihood of PFAS existing within an area and criteria three and four represent the severity of impact of PFAS of the receptors at these sites. The reason why the likelihood of PFAS present in an area is of a higher combined weighting (60%) is because it is not resourcefully optimal to treat for a locational receptor that has no PFAS. Criteria three and four are of equal importance because one represents the impact of PFAS to known at risk species and the other, potentially at risk through important environmentally significant sites. The sites are then marked against a criterion regarding the social and cultural significance of the land of the receptor. The social and cultural ranking used is shown in Table 2.

Table 2 Social and cultural component to the site prioritisation framework

Criteria	Negligible	Low	Moderate	High	
Social and cultural significance of Receptor (100%)	**0%** No known social and cultural significance	**25%** Regular social use (local use)	**50%** Popular societal use (tourist destinations)	**75%** Nationally recognised site	**100%** Internationally recognised site Aboriginal heritage site

The cumulative results of the two rankings are shown in Figure 1.

The case studies are inclusive of WWTPs and their associated reuse schemes and involved developing a conceptual site model, identifying the significance of the land and site characteristics for four sites of varying hypothesised priority – one low, one medium and two high. Species profiles were also created for highly vulnerable species found within the site proximity. The results of the case studies will be outlined in Section 3 and will be used to callibrate the site prioritisation framework.

The site ranking will be conducted using the geospatial software ArcGIS with the integration of the site prioritisation framework outlined.

3. Results and Discussion

3.1 Case Studies

Figure 1 outlines the site rankings for the case studies conducted thus far.

3.1.1 Location A

Location A was hypothesised to be a low priority site since there is a signficant distance from the receptor, the ocean. It was found that there were no protected insectivorous secondary species present in the area, however there were two protected omnivorous secondary species. Several environmentally sensitive areas were identified around seven kilometers away, however these are located upgradient from ground water flow meaning that the treated wastewater discharge is not likely to impact those areas. There are two registered Aboriginal heritage sites north of the case study site, however this is hydraulically cross-gradient and groundwater will not flow in that direction. Based on the site priortisation framework Location A was ranked as low priority.

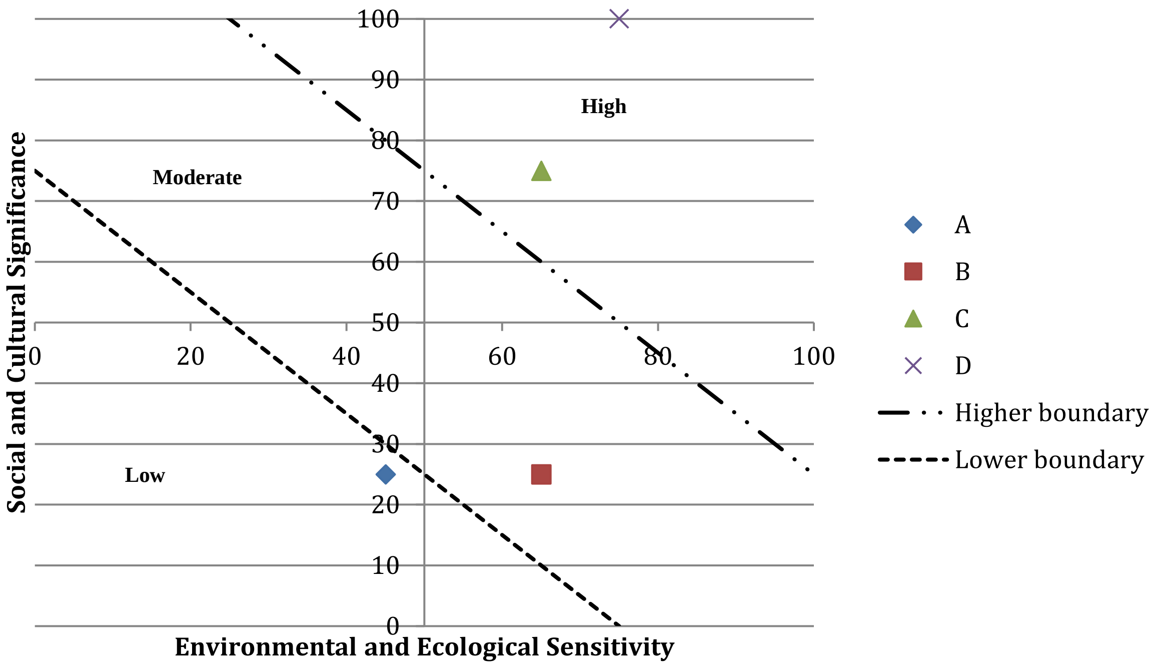

Figure 1 Site pioritisation ranking of the case study sites

3.1.2 Location B

Location B was hypothesised to be a medium priority site because of a sensitive receiving environment, a culturally and environmentally significant estuary, located a moderate distance from the site. It was found that there was a protected insectivorous secondary species found near the receiving environment. There are various sites of environmental and cultural significance west of the site. The local hydrogeology suggests that groundwater flows toward the environmentally and culturally significant receptor, however it is expected that PFAS compounds from the reuse site be sufficiently diluted on reaching the receptor due to the distance. Because the receptor is a nationally recognised site located a moderate distance away, Location B was ranked as medium priority using the site prioritisation framework.

3.1.3 Location C

Location C was hypothesised to be a high priority site because of its close proximity to the ocean. It was found that there were no insectivorous protected secondary species however there were two omnivorous protected secondary species. There were several environmentally sensitive areas, important wetlands and Aboriginal heritage sites around 500m from the reuse schemes in the area however the direction of groundwater flow generally flows towards the ocean. Because the reuse schemes are within a nationally recgonised site, Location C was ranked as a high priority site using the site prioritisation framework.

3.1.4 Location D

Location D was hypothesised to be a high priority site because of the treated wastewater discharge into a channel that then flows into the river. It was found that there were two protected insectivorous secondary species. There were several environmentally sensitive areas, including important wetlands and registered Aboriginal heritage sites within 1.6km from the site. Location D was ranked as a high priority site using the site prioritisation framework.

3.2 Species Profile: Crested Shrike Tit

Below is a brief example of a species profile conducted for the Crested Shrike-Tit at one of the locations. The Crested Shrike-Tit is a medium sized bird and resides in the north-west of Australia. It forages for invertebrates, mostly in foliage, branches, and the trunk and bark across a range of eucalypt and other tree species (Department of the Environment and Energy, n.d.). Based on other similar species, it has a food ingestion rate of 0.06kg wet weight and water ingestion rate of 0.01L/day (AECOM, 2018). These values were derived from an equation from ingestion rate.

$$I_i = \frac{IngR_i}{BW}$$

I_i represents the ingestion rate (kg/kg body weight/day), $IngR_i$ represents the ingestion rate of media (kg/day) and BW represents the body weight of the organism.

There is not much information on the diet of Northern Crested Shrike-tits however a study on foraging behaviour in New South Wales rendered the diet distribution described in Figure 2 where the arrows represent the direction of species uptake between trophic levels (Noske, 2003).

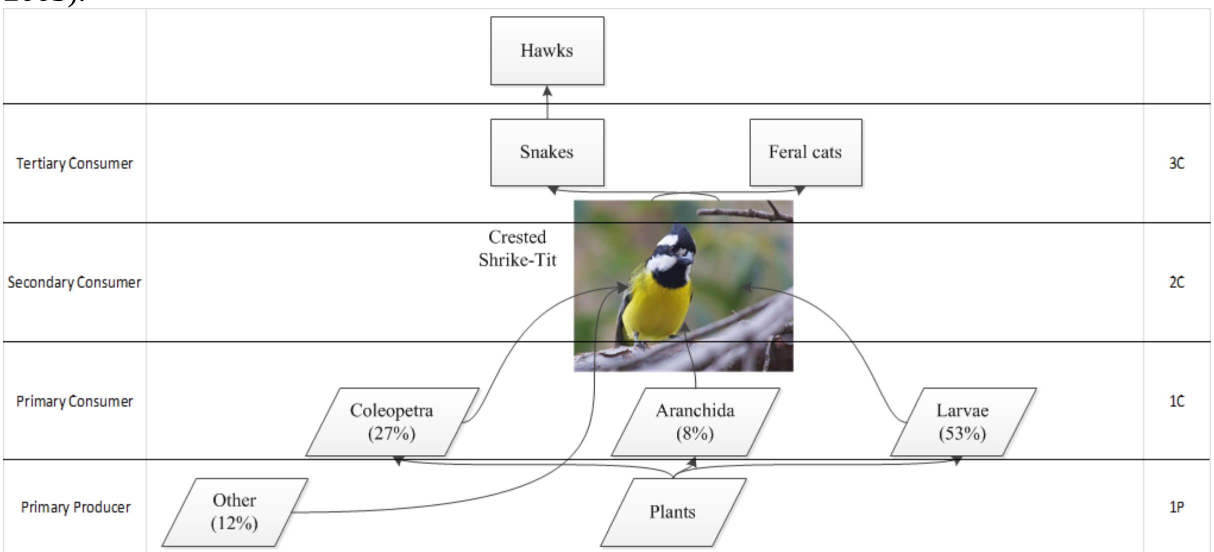

Figure 2 Crested Shrike-Tit Food Web

4. Conclusions and Future Work

The case studies have shed light on the fact that the sensitivity of receptors and distance is crucial in determining the end receptors of treated wastewater and probable risk. A sensitivity analysis will be conducted for the top 20 high priority sites to rule out sites that are of lesser concern due to the opposing direction of groundwater flow.

Another key takeaway is that it is worth assessing the diets of species due to dietary composition, soil ingestion, water ingestion, body weight and daily intake.

Other future work involves determining the threshold for PFAS in sensitive species, drawing up conceptual site models for the case studies, developing guidelines of the site prioritisation framework and ranking the WWTPs and reuse schemes through ArcGIS. More work needs to be done in refining the boundaries for the site prioritisation ranking plot outlined in Figure 1 and the social and cultural ranking system.

5. Acknowledgements

I would like to thank Ben Stone and Anas Ghadouani for their endless support and guidance. I would also like to thank my colleagues at the Water Corporation within in the Environment and Contaminated Sites team, Yamin Ma and Ben Kyle as well as Nicholas Langridge and Jai Denda for supporting me in my professional development which has aided the project.

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