BEFORE THE COMMISSION
APPOINTED BY THE OTAGO REGIONAL COUNCIL

UNDER	the Resource Management Act 1991 (RMA)
IN THE MATTER	Of an application by Dunedin City Council for resource consent being processed with reference RM20.280
	BIG STONE FOREST LIMITED, ŌTOKIA CREEK AND MARSH HABITAT TRUST and SOUTH COAST NEIGHBOURHOOD SOCIETY INC
	Submitter

HEARING NOTES OF KELVIN LLOYD

DATED 24 MAY 2022

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HEARING NOTES KELVIN LLOYD

1. Firstly, I'd like to respond to the further evidence of Ms Sievwright who concluded that there would not be any contamination risk to avifauna using habitat at Brighton Beach and Otokia Creek marsh. And I can kind of understand why further effects had not been identified by Ms Sievwright because I myself was only alerted to such effects when I read Mr Rumsby's evidence on bioaccumulation of PFAS substances. I found this evidence alarming.
2. I subsequently reviewed scientific literature on PFAS substances (per and polyfluoroalkyl substances) and their accumulation in the environment. This showed that it is a recent and emerging issue of concern. There are numerous recent scientific articles on PFAS accumulation in freshwater, marine, and terrestrial biota, published in 2020 and 2021. Due to the recent emergence of concern about PFAS accumulation, there is a lack of research in some areas, but there are broad conclusions that can be drawn from the evidence to date.
3. Firstly, landfill leachate is anticipated to be a major point source of PFAS contamination based on international studies[1]. I acknowledge that PFAS substances are numerous, and while research has shown that not all of them are bio-accumulative, some of them are[2].
4. A recent review of PFAS impacts on the environment[3] indicates that:
    a. In the freshwater environment, crustaceans are particularly susceptible to ingesting PFAS substances, and they are also vulnerable to the toxic effects of PFAS substances.

[1] Stockin K.A., Yi, S., Northcott G.L., Betty E.L., Machovsky-Capuska G.E., Jones B., Perrott M.R., Law R.J., Rumsby A., Thelen M.A., Graham L., Palmer E.I., and Tremblay L.A. 2021: Per- and polyfluoroalkyl substances (PFAS), trace elements, and life history parameters of mass-stranded common dolphins (*Delphinus delphis*) in New Zealand. *Marine Pollution Bulletin 173* (2021) 112896.
[2] Ankley G.T., Cureton P. Hoke R.A., Houde M., Kumar A., Kurias J., Lanno R., McCarthy C., Newsted J., Salice C.J., Sample B.E., Sepulveda M.S., Steevens J. and Valsecchi S. 2021: Assessing the ecological risks of per- and polyfluoroalkyl substances: Current state of the science and a proposed path forward. *Environmental Toxicology and Chemistry 40*: 564-605.
[3] Ankley G.T., Cureton P. Hoke R.A., Houde M., Kumar A., Kurias J., Lanno R., McCarthy C., Newsted J., Salice C.J., Sample B.E., Sepulveda M.S., Steevens J. and Valsecchi S. 2021: Assessing the ecological risks of per- and polyfluoroalkyl substances: Current state of the science and a proposed path forward. *Environmental Toxicology and Chemistry 40*: 564-605.

b. Freshwater fish can accumulate high levels of PFAS substances because they feed on crustaceans.
c. Freshwater fish have been shown to be, in general, less susceptible to the toxic effects of PFAS substances.
d. Air-breathing vertebrates show greater toxic responses to PFAS substances.

5. Given these findings, in my opinion, the receiving environment in Otokia Creek is vulnerable to potential release of PFAS substances from the proposed landfill into the creek. Central to this risk is an existing trophic structure where indigenous invertebrates, fish, water birds, and humans are all linked in the food chain.
6. Benthic invertebrates in Otokia Creek in the vicinity of the landfill site are dominated by crustaceans, mud snails, and freshwater clams[4]. Both longfin and shortfin eel are also present[5], and crustaceans and mud snails are important in their diets[6][7]. As crustaceans typically ingest PFAS substances, and eels eat crustaceans, this creates a pathway for movement of any PFAS that crustaceans consume into eels.
7. I understand that both koura/freshwater crayfish and tuna/eels are significant mahika kai for mana whenua, so consumption of eels by mana whenua or other humans could result in toxic effects in human populations. There are also birds such as kotuku/white heron and black shag which as predators further up the food chain could be affected by bioaccumulation of PFAS compounds. Black shag will be feeding on macroinvertebrates, koura, trout, bullies, galaxiids, and eels[8] from Otokia Creek, while kotuku will feed on small fish in the stream, and also have been recorded stealing fish from other birds such as shags[9]. As air-breathing vertebrates, these and other water

[4] Section 3.5 of the ecology report.
[5] Section 3.5 of the ecology report
[6] Sagar P.M., Graynoth E., and Glove G.J. 2005: Prey selection and dietary overlap of shortfinned (*Anguilla australis*) and longfinned (*A. dieffenbachii)* eels during summer in the Horokiwi Stream, New Zealand. *New Zealand Journal of Marine and Freshwater Research 39*: 931-939.
[7] Sagar P.M and Glove G.J. 1998: Diel feeding and prey selection of three size classes of short-finned eel (*Anguilla australis*) in New Zealand. *Marine and Freshwater Research 49*: 421-428.
[8] https://nzbirdsonline.org.nz/species/black-shag
[9] https://nzbirdsonline.org.nz/species/white-heron

birds feeding on freshwater prey could potentially accumulate toxic levels of PFAS should it be released.

8. There haven't been many studies in New Zealand of PFAS accumulation in indigenous species, but a study of common dolphins in New Zealand has shown that they have accumulated PFAS substances[10], illustrating transmission up the food chain.
9. In my opinion there is a clear risk of toxic effects on indigenous biodiversity and humans of PFAS consumption based on a scenario that the controls on the proposed landfill don't fully work and allow PFAS substances to escape into Otokia Creek.
10. This is the basis for my disagreement with Ms Sievwright.
11. In my opinion a risk assessment of potential PFAS contamination of Otokia Creek from landfill leachate is warranted, that takes into account potential sources of PFAS-generating materials in the landfill, and risk reduction by the potential exclusion from the landfill of such materials (e.g. by amending the waste acceptance criteria for the landfill).
12. If the proposed landfill is consented, there should be annual monitoring for PFAS compounds in freshwater biota, including in benthic macroinvertebrates, koura, eels, and trout. It is not clear what could be done to remedy any future PFAS contamination of freshwater biota in Otokia Creek, but absence of PFAS contamination would possibly comfort Otokia Creek stakeholders, and future presence of PFAS contamination could warn against human consumption.
13. In relation to Dr Morris's comments about the wetlands, I note that he agrees that if there is a loss of water supply, there may be invasion of dryland weeds into the wetland. Dr Morris stated that weed control could resolve that issue if it did occur.
14. It may not be always practical for weeding to resolve issues such as dryland species invading wetlands, because invading species may include grasses, rushes, sedges, and/or woody weeds, and some of these can be quite hard to control if they invade into a wetland.

[10] Stockin K.A., Yi, S., Northcott G.L., Betty E.L., Machovsky-Capuska G.E., Jones B., Perrott M.R., Law R.J., Rumsby A., Thelen M.A., Graham L., Palmer E.I., and Tremblay L.A. 2021: Per- and polyfluoroalkyl substances (PFAS), trace elements, and life history parameters of mass-stranded common dolphins (*Delphinus delphis*) in New Zealand. *Marine Pollution Bulletin 173* (2021) 112896.

15. Marsh wetlands are vulnerable to hydrological change as they have finely balanced hydrology, with fluctuating water levels. As such, they are a ‘dryer’ type of wetland and are more easily invaded by dryland species. There is a lot of pressure on marsh wetlands from dryland plants trying to invade, and it’s only the periodic wetness that limits the abundance of these dryland species. Gorse, for example, is already present in the marsh wetland, and would increase in cover or stature if conditions became drier.
16. Weeding could be successful for woody weeds such as gorse, but the issue if the drying effect persists is how long will weeding be undertaken? As when weeding ceases, unconstrained weed invasion will occur, adversely affecting the marsh wetland.