MEMO

To: Otago Regional Council Consent Team

From: Andrew Rumsby

CC: Ōtokia Creek and Marsh Habitat Trust

Date: 28 June 2022

Re: Review of GHD Quantitative Health Risk Assessment for the Proposed Smooth Hill Landfill

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To Whom it May Concern,

Introduction

EHS Support New Zealand Limited (Herein referred to as EHS Support) has undertaken been engaged by the Ōtokia Creek and Marsh Habitat Trust to undertake a preliminary review of GHD (2022) Waste Future 2-Work Stream 3. Extended Water Quality and Quantitative Human Health Risk Assessment (Herein referred to as HHRA). Due to the limited time to review this document EHS Support has been unable to:

1. Independently check calculations and information sources referenced.
2. Independently check the validity of the assumed rate of linear failure.
3. Verify the assumption made within the HELP model.
4. Check the input and output files from GoldSim to verify that they match what is stated in the report
5. Conduct an independent assessment of bioaccumulation risk using the SERDP bioaccumulation model for PFAS which has been developed for US Department of Defense, Department of Energy and US Environmental Protection Agency.

We have limited our comments to the following issues:

1. Suitably of bioaccumulation/biomagnification data used within the assessment.
2. Suitably of the PFAS compounds which have been used to undertake the risk assessment
3. Dealing with Uncertainties within the Risk Assessment and the Potential to underestimate the risks.
4. Risk Assessment of Non-PFAS Persistent Pollutants and emerging environmental contaminants.

General Comments

GHD HHRA appears to use a report format appears to similar format to the Health Risk Assessment that has been undertaken for the Australian Department of Defence environmental and human health risk assessment for Fire-fighting foam PFAS impacted sites. While this report format does follow the EnHealth (2012) Environmental health Risk assessment: Guidance for assessing human

health from environmental hazards, EnHealth (2020) Australian Exposure Factor Guidance and Australian Drinking Water Standards.

However, EHS Support has some concerns with the concerns with only using the Australian guidance documents, which include:

1. They don't include the most up to date PFAS biomagnification model developed by SERDP and more recent advice from other government agencies such as RIVM, Health Canada and US EPA on assessing the risks from PFAS compounds.
2. The Australian Exposure Factors Guidance is different in some places from the exposure factors used within the MfE (2011) Methodology for deriving standards in soils to protect human health.
3. Studies from New Zealand Defence Forces investigation at Woodbourne and Ohakea found a higher degree of bioaccumulation of PFAS compounds in chicken at lower concentrations than is indicated in this report.
4. The GHD HHRA does not appear to reference any of the MPI advice on acceptable PFAS concentrations in fish which is published on the New Zealand Government All of Government PFAS website.

Also, GHD HHRA only undertakes an assessment of 25% home-grown produce, however, the Methodology for Deriving Standards for Contaminants in Soil to Protection Human Health states that "Depending on the circumstances, 10 per cent of home-grown produce may be appropriate (i.e., as for standard residential), whereas 50 per cent is expected to be towards the high end of a more self-sufficient lifestyle that some rural dwellers may adopt".

In NZDF studies around Woodbourne and Ohakea Air Force Bases, there was evidence of up to 100% homegrown produce being consumed at some properties. EHS Support believes that the HHRA should also consider 50% homegrown produce and 100% homegrown eggs and meat production (and 50% produce other food items) (these type of assessment was also down for a number of Australian Defence Force sites as well where relevant (i.e. rural residential communities where present).

EHS Support believes that the GHD HHRA should be updated to reflect a more NZ rural residential setting, and also assess for a higher degree of home-grown produce.

Suitability of Bioaccumulation/biomagnification data

EHS Support has not been able to undertake a detailed review of accumulation factors used in the GHD report. However, the GHD reports appear only to have undertaken a bioaccumulation assessment using bioconcentration factors (BAF/BCF) (i.e. transfer from water to organism) rather than biomagnification or trophic magnification factors (which assesses both uptakes from water as well as dietary exposure). GHD HHRA also does not appear to have been considered by ITRC (ITRC, 2020) or the SEDRP review of bioaccumulation/biomagnification factors. ITRC indicates that the PFOS bioaccumulation factor could be as high as 9,350 for whole fish (which is more than an order of magnitude higher than assumed by GHD).

Some of the data used appear to be based upon field measurements rather than laboratory studies. The MfE report on the impact of per and poly-fluoroalkyl substances on Ecosystems (PDP, 2018) cautioned against using BAF/BCF from field measurements because:

1. The concentration of PFAS compounds in surface water at contaminated sites can vary significantly over time. This is because PFAS compounds tend to be highly water soluble and therefore during, or soon after rainfall events, significant quantities of PFAS compounds can be released which can then result in changes in surface water concentrations. Therefore, without extensive surface water quality datasets, it is difficult to determine the average water concentration that the biota is exposed to over a relevant time period for the organism of interest.
2. Steady-state equilibrium between the organism and surface water may not have been reached.
3. Uncertainties in the feeding ecology and the relative importance of dietary exposure to the overall PFAS exposure to the organism. This may be particularly important for predatory species such as freshwater eels where field-calculated BCF may significantly overestimate exposure to water.
4. Transformation of precursor compounds within the organisms. PFAS compounds are usually a complex mixture of polyfluorinated precursor compounds and perfluorinated compounds. Data exists that indicates that some precursors (such as fluorotelomers) may be metabolised within organisms.

The Society of Environmental Toxicology and Chemistry (SETAC) North America Focused Topic Meeting – Environmental Risk Assessment of PFAS, in August 2019 also concluded that field-based Bioaccumulation/bioconcentration factors of PFAS may underpredict the degree of PFAS biomagnification within aquatic organisms. The use of lab based bioaccumulation/biomagnification factors is also supported by ITRC (ITRC, 2021).

EHS is concerned that because a food-web approach has not been undertaken to assess PFAS accumulation at various trophic levels GHD HHRA may not have considered all of the exposure pathways to aquatic organisms and the effect that dietary exposure/biomagnification through various trophic levels within the ecosystem within Ōtokia Creek. The NEMP requires that an assessment of the type of species being present and trophic level be undertaken for off-site receptors.

The NEMP (2020) recommends that if modelling is uptake based on literature values (as has been done for GHD HHRA) then multiple lines of evidence approach should be adopted. The information should be evaluated, however, to check for the quality of the study and applicability to the site conditions being assessed. This does not appear to have been done by GHD.

EHS Support believes that GHD needs to undertake a more robust assessment of potential BAF/BCF and undertake a food web-based assessment of bioaccumulation factors. EHS Support is concerned that the current assessment methodology may significantly under-estimate the risks to the community from the bioaccumulation of PFAS compounds within aquatic organisms.

Suability of PFAS compounds used in the Assessment

GHD HHRA assessment has focused on three PFAS compounds (PFHxS, PFOS and PFOA), whereas the number of various PFAS compounds which may be present in landfill leachate may be several hundred. GHD acknowledges that there may be other PFAS compounds present it has only focused upon three main PFAS compounds due to the limitations of the availability of information on

toxicological information. This approach is likely to significantly underestimate the risks and does not comply with the recommendations PFAS National Environmental Management Plan (DAWE, 2020)(herein referred to as the NEMP) or other international guidance (Health Canada, RIVM, ITRC and US EPA).

The NEMP states that:

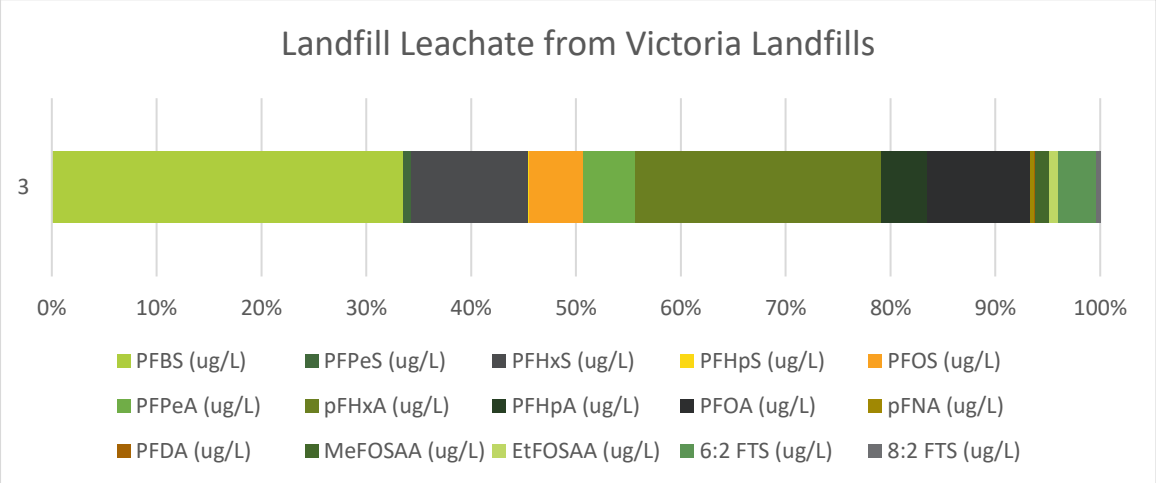
1. different PFAS production methods and subsequent degradation processes can create complex mixtures of many different intentionally produced and unintentionally generated PFAS compounds1 requiring consideration, at least qualitatively, and
2. nature of the source and potential contribution from precursors to risk (qualitative assessment).
3. important that environmental assessments qualitatively consider the likely total mass and distribution of all PFAS present as well as PFOS, PFOA and PFHxS and other specific PFAS of concern.
4. the conceptual site model should also include potential transformation products.

The NEMP also states that if the percentage of other PFAS compounds are low then considering only PFHxS, PFOS and PFOA may be appropriate. However, if the percentage of PFAS compounds is high, then considering only those three compounds may underestimate the risks to environmental receptors.

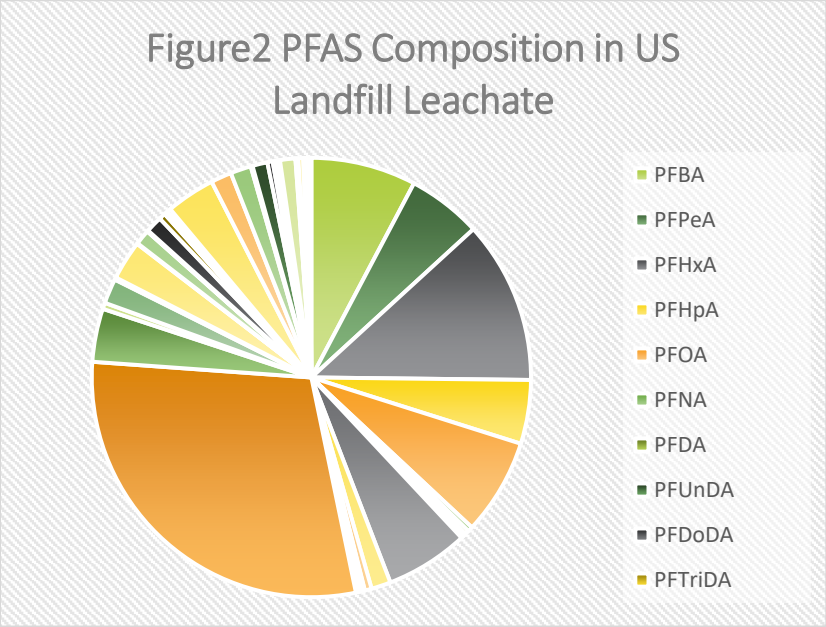
In the case of landfill leachate, PFHxS, PFOS and PFOA are not the major components of landfill leachate. Gallen presented the composition of PFAS compounds in Victoria landfills[2] analysis of PFAS compounds which identified 15 different PFAS compounds being included in landfill leachate, with PFBS on average comprising more than 33% of the total concentration of all PFAS compounds and PFHxS comprising (23% of the total concentration of all PFAS compounds. The sum of PFHxS, PFOS and PFOA comprised only 25% of total measured PFAS compounds (see attached spreadsheet named Victoria landfills PFAS excluded NDs).

[2] The Victoria PFAS landfill leachate data is considered preferable to the Australia wide PFAS landfill leachate study (Gallen, 2017) because it includes more compounds including PFBS.

Figure 1. Composition of PFAS compounds from Victoria Landfills



A more comprehensive suite of PFAS compounds (55 different compounds) was undertaken Lang et al (lang, 2017). This study found that PFPeA (5:3 FTCA)[3] comprised 31% of all measured PFAS compounds, PFHxA comprised 12% of all measured PFAS compounds, PFHpA comprised 7% of all measured PFAS compounds, whereas the sum of PFHxS, PFOS and PFOA only comprised 12% of all measured PFAS compounds (lang, 2017)(see Figure 2).



Research undertaken in Europe also indicates that PFHxS, PFOS and PFOA only comprise a minor fraction of all PFAS in landfill waste (less than 1%).

The NEMP does not recommend a specific approach on how to deal with assessing complex mixtures of PFAS compounds beyond undertaking TOPA and TOF analysis of the samples (which is not

[3] This compound was not measured by Gallen, therefore Gallen dataset is likely to underestimate total PFAS compounds

possible in the case of Smooth Hill as there is currently no leachate to sample). However, overseas guidelines such as RIVM (RIVM, 2018), EFSA (EFSA, 2019), Health Canada, ITRC (ITRC, 2021) WHO/IPCS (Meek, 2011), and US EPA (US EPA, 2021) do provide guidance on how to undertake the assessment. Goodrum et al (Goodrum, 2021) provides a review of the various different approach and recommends, based upon the current state of the science that using a HI approach which groups together various PFAS groups (i.e. all PFSA and compounds which may degrade into PFSA[4] and PFCA[5] and all compounds which may degrade into PFCA compounds). This approach would be consistent with NZ EPA recommendations to measure total PFAS and when assessing PFOA and PFHxS/PFOS compounds to measure all compounds which could transform into either PFOA or PFHxS/PFOS.

EHS Support is concerned that the approach adopted by GHD to focus only on three PFAS compounds may significantly underestimate the ecological and human health risks by these PFAS compounds. The NEMP recommends that regulators adopted the precautionary principle when assessing the risks posed by PFAS compounds. The HHRA prepared by GHD does not adopt this principle within their risk assessment by only assessing the risks associated with three PFAS compounds.

EHS Support recommends that:

1) a hazardous indices approach that sums all PFCA compounds (as well as compounds than degrade into them such as fluorotelomers alcohols compounds and fluorotelomer carboxylic acids) over the FSANZ toxicological reference value for PFOA
2) a hazardous indices approach that sums all PFSA compounds (as well as perfluorinated sulfonamides, perfluorinated sulfonamidacetic acids, perfluoroalkyl sufonamidoethanols, and fluorotelomer sulfonates), and
3) a hazardous indices approach that calculates the hazard indicates of PFBS separately from other PFSA and uses the toxicity reference value developed by the US EPA.

EHS Support also recommends that to validate the use of overseas literature values leachate samples should be Green Island Landfill and analysed for an extended suite of PFAS compounds that includes fluorotelomer carboxylic acids and PFBS as well as Total organic fluoride.

Dealing with Uncertainties within the Risk Assessment

There are a large number of uncertainties associated with the data used by GHD within the HHRA assessment. This includes:

- the amount of leachate leaking from the landfill
- the concentration and type of PFAS within the landfill leachate
- the presented on unidentified PFAS within the landfill leachate that may be transformed in terminal PFAS compounds such as PFHxS, PFOS and PFOA.
- Uncertainties associated with the approach adopted and Bioconcentration factors for various PFAS compounds in aquatic and terrestrial ecosystems.
- Uncertainties within health-based reference toxicological data used within this assessment (for instance US EPA has just published health-based toxicological references values which

[4] PFSA = Pre and Polyfluorinated sulphonic acids and sulphates

[5] PFCA= Pre and Polyfluorinated carboxylic acids.

are over 1,000 times lower than the FSANZ values. There is currently uncertainty over the degree of immunotoxicity of PFAS compounds and the degree of synergistic effects of complex mixtures of PFAS compounds.

While GHD acknowledges some uncertainties associated with the data used in its HHRA it says that it accounts for them these uncertainties by adopting high-end estimates. However, this is not correct in all cases. For instance:

- The 95% concentrations of PFAS are calculated based on the assumption of a normal distribution of the concentration of PFAS in landfill leachate (which is not correct). This approach (using the mean concentration reported by Gallian times 1.96 the standard derivation underestimates (and overestimates) the concentration of some PFAS species. GHD should obtain the raw data from the authors of the publication to calculate the 95 percentile.
- GHD risk assessment only considers a small fraction of PFAS compounds even though all per and polyfluorinated alkyl acids (sum of PFCA and PFSA plus fluorotelomer carboxylic acids) are proteinophillic (protein binding) and therefore accumulate in blood, liver, kidney, muscle tissues and egg yolks.
- Many PFAS compounds are believed to induce toxicity by interactions via PPAR receptors (so additive or syngenetic effects are likely within a complex mixture of PFAS compounds).
- Bioaccumulation factors in whole fish and muscle tissues have been reported to be much higher than the values used by GHD. NZDF studies have reported significant bioaccumulation in New Zealand Freshwater Fish species at lower aquatic concentrations predicted that have exceeded human health criteria. This is also true for the accumulation of PFAS in chicken eggs exceeding FSANZ guidelines at lower concentrations than assumed within the GHD risk assessment.
- There are uncertainties in the toxicology of PFAS compounds with more recent toxicological assessments indicating adverse health effects at much lower values than used within this assessment.
- The bioaccumulation model used does not appear to undertake a trophic level assessment to estimate bioaccumulation and may be missing some ecological exposure pathways (drift of invertebrates and terrestrial organisms consuming terrestrial organisms that have aquatic early life stages (i.e. dragonflies, caddisflies and mayflies).

To account for the uncertainties outlined above EHS Support recommends that a Hazard Indices of 0.5 is used to assess the potential for environmental and human health risk rather than 1 as used by GHD[6].

Risk Assessment of Non-PFAS Persistent Pollutants and emerging environmental contaminants

GHD HHRA assessment has not considered the potential risk associated with other bioaccumulative substances (i.e. mercury and selenium) and persistent organic pollutants (POPs) as well substances of very high concern (SVHC) identified by the European Union (Such as nonyl phenol compounds and alkyl ethoxylate compounds) known to be within landfill leachate.

[6] The US EPA within the regional screening values recommends that a Hazard Quotient of 0.1 is used for a desktop assessment.

GHD argues that the environmental mobility of these compounds is less than PFAS compounds and that PFAS compounds. Figure 3 shows the log Koc for various PFAS compounds (which is a proxy for environmental mobility) and compares it against various PFAS compounds.

Risk Assessment of Non-PFAS Persistent Pollutants and emerging environmental contaminants

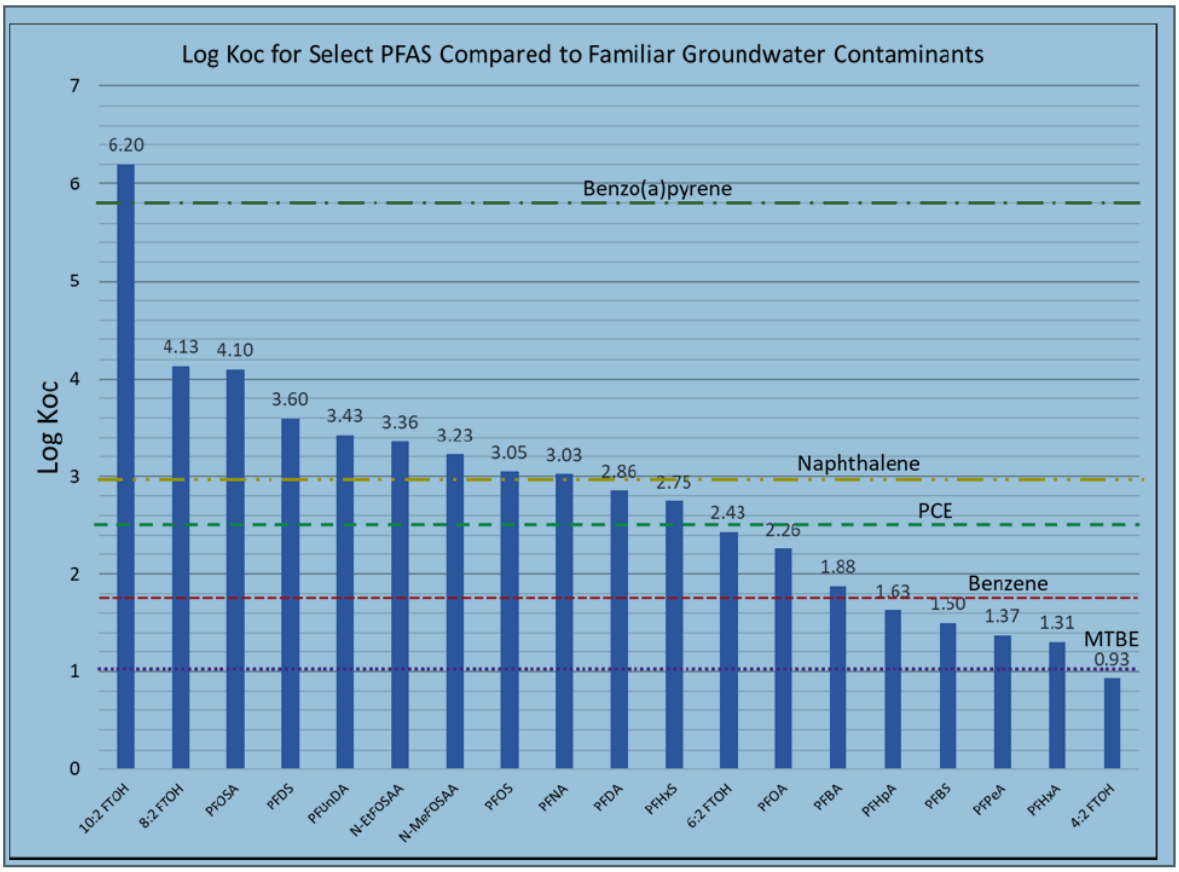


Figure 3. Range of log Koc for select PFAS compounds compared to familiar groundwater contaminants (ITRC, 2020).

Some POPs and emerging contaminants (such as mercury and some alkyl ethoxylate compounds) have similar environmental mobility as well as low toxicity.

In EHS Support opinion, the current GHD HHRA is incomplete because it does not consider the range of environmental contaminants.

References

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