Faculty of Science and Engineering

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Reply to “Review of Harvey et al. (2015) Project 1094-15” by TasWater and Water Research Australia

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Summary

This reply responds to and outlines a number of important failures, oversights and shortcomings of the recent TasWater commissioned review of "*Identification of the sources of metal (lead) contamination in drinking waters in north-eastern Tasmania using lead isotopic compositions*" by Harvey, P.J, Handley, H.K. and Taylor, M.P. (2015) published in *Environmental Science and Pollution Research*. The TasWater review was authored by Priestley, T., Gaston, T. and Mosse, P. from Water Research Australia.

Critically, this reply responds to the following aspects raised in the TasWater review:

1. **Connection and relevance of the Moorina Power Station to the Pioneer Drinking Water Supply**
2. **Quantity of data**
3. **Questions and comments relating to site descriptions, sampling and analytical methods**
4. **Application of lead isotope compositions for determining the source of contamination**
5. **Professionalism**
6. **Sediment**
7. **True colour**

The authors conclude that based upon the evidence presented in this reply that TasWater's review has not added anything new or material to Harvey et al. (2015).

Reply to Review of Harvey et al. (2015) Project 1094-15

1. Connection and relevance of the Moorina Power Station to the Pioneer Drinking Water Supply

One of the largest points of contention raised in the TasWater review is the connection of the Moorina Power Station to the drinking water supply of Pioneer. As a result of the erroneous conclusions drawn by the review described herein, Harvey et al. dismiss any statements that the Moorina Power Station does not supply *any* water to the Pioneer Dam and subsequent drinking water supply.

Page 7 of the TasWater review outlines the reticulation network and provides a schematic diagram to illustrate the connection (Figure 1 of the review), dated **2010**. The accompanying text says the following (page 7):

> "*The diagram shows that at that time water **was*** [our emphasis] *supplied to the Pioneer Dam from the **Frome Dam*** [our emphasis] *via an open raceway and a series of 100 mm diameter polyvinyl chloride (PVC) pipes".*

The text then informs the reader (page 7):

> "*Information from TasWater states that, since around **2009*** [our emphasis]*, the water supply to Pioneer is **no longer*** [our emphasis] *sourced from Frome Dam or the raceway infrastructure immediately below it".*

Later in the TasWater review a citation is provided for a communication from Wright (2015) that states the following, without providing a specific date for disconnection of the Frome Dam (page 13):

> "*The Pioneer Dam is fed by the open Pioneer water race which originally extended from Frome Dam to Pioneer and supplied water to the Moorina Power Station on the way. Water from the Frome Dam has not now supplied Pioneer for **several years*** [our emphasis]. *Water that is transferred from the race to the Pioneer Dam is water trapped by the open race from surface water runoff and small watercourse intercepted by the race between the site of the old Moorina PS and Pioneer*".

The statements made by and relied upon within the TasWater review are inherently contradictory and as a result provide no concrete or useful information.

In an earlier report (2013) commissioned by Ben Lomond Water (now TasWater), the following statement was made:

> "*The **Pioneer water scheme sources water from the 3600 ML Frome Dam*** [our emphasis] *owned by Moorina Hydro Pty Ltd and located to the south of the town. The water is transferred via an 8 km water race and 480 m PVC pipe to PE pipe suspension bridge crossing the Ringarooma River" (GHD 2013a).*

To complicate the issue further, the schematic provided as Figure 1 of the review, which has no clear scale, depicts only one disconnection between the Frome Dam and the section labelled Pioneer Race. Assuming that this is correct and referring to the text again, this disconnection only prevents transfer of water from the Frome Dam through the first 900 m of the 8 km water race. This contention is supported by another Ben Lomond Water (now TasWater) commissioned report from 2013 that states (GHD 2013b):

> "*Ben Lomond Water holds a licence to extract water from the 3600 ML Frome Dam. However the water race to supply the town from this source is not operational for the first 900 m of its 8 km length due to the recent installation of an irrigation pipe in **2010*** [our emphasis]".

Applying some deductive reasoning to clarify these important arguments about the source of lead we note the following:

Given that Moorina Power Station is, according to the TasWater review and confirmed on Google Earth, located a distance of approximately 5 km from the town of Pioneer, a disconnection of 900 m of the water race downstream of the Frome Dam results in 2.1 km of race upstream of the Moorina Power Station from which surface water can be derived from the surrounding catchment.

This distance of open-channel network is further confirmed by Mr Mike Cooke (former Water Warden for Pioneer, former part owner/operator of the Moorina Hydro-Electric Scheme and overseer for the Winnaleah Irrigation Scheme). Mr Cooke reported in a communication to M.P. Taylor (04/05/2015) that the connection between the Moorina Power Station and the Frome Dam was/is as follows:

> *"No further pipework was incorporated in the channel work from the weir* [at Frome dam] *below the dam to the head of the penstock supplying the power station, a distance of around 2.7 kms.*"

Clarification of this issue is quintessential to the crux of the sources of lead because the TasWater review hinges, in part, on the complete rejection of Harvey et al.'s (2015) data collected from the Moorina Power Station. It is important because the data from the Moorina Power Station delineates a significant source of contamination and one that is likely to have been ongoing for decades, representing chronic exposes via the potable water supply.

The TasWater review comments further (page 10):

> *"It appears that the paper's authors did not fully understand or appreciate the exact scope of the current water supply system".*

Careful analysis of the review reverses this argument back to the authors of the TasWater review by virtue of their contradictory statements on page 7, Figure 1 (TasWater review), the additional evidence provided in the GHD reports (GHD 2013a; b) and commentary by Mr Cooke. Thus, on the basis of the information supplied in the TasWater report it is impossible to **not** consider the Moorina Power Station and its infrastructure as a source of contamination as was proposed in Harvey et al. (2015). Consequently, all comments regarding the dis-connection of the Moorina Power Station from the Pioneer drinking water supply in the TasWater review should now be disregarded.

2. Quantity of data

Comments are made throughout the TasWater review about the quantity of data collected. Harvey et al. (2015) collected 179 samples, generating 716 data points. Given that the TasWater review collected zero new data, it is difficult to comprehend how the study could be described as being deficient in data.

3. Questions and comments relating to site descriptions, sampling and analytical methods

The quality and reliability of the data was ensured through a rigorous QA/QC program, as detailed in the Supplementary Data section of the paper (Supplementary Data 1 – see attached). The quality assurance program for the water samples was 17 (field blanks and trip banks)/96 samples in total (18 % of samples). The reviewers would know that this exceeds the minimum 10 % for QA/QC for analytical purposes. Laboratory analysis was carried out using the National Measurement Institute's NATA accredited method, which includes all relevant QA/QC protocols.

The TasWater review makes a number of references to sample locations. It is unclear if the TasWater reviewers have viewed the supplementary material available with the online publication but all details of sample locations are included as GPS co-ordinates, which can be plotted easily using Google Earth. Samples collected from private properties cannot be accurately identified as this poses significant issues with privacy. Homeowners were protected by the addition of a suitable margin of error to the georeference location data.

The reviewers also suggest the methods and protocols used in the study were unclear (page 12):

> *"A lack of duplicate samples and repeat analyses, combined with an unclear sampling protocol, is a major weakness of the paper."*

However, judicious review of the article's section on Material and Methods, the Supplementary Data and the references provided at the end of the paper makes it abundantly clear that the study used a robust approach that relied on Australian Standards or world's best practice. The TasWater review identifies an omission of the Supplementary Data (temperature). This is available from the authors on request. Concern is raised about the flush periods for samples collected from within the properties. Australian Standard AS/NZS 5667.5:1998 s.4.1.5 Sampling procedure - Consumer's Taps says "*if the effects of materials on water quality are being investigated then the initial draw-off should be sampled*". The TasWater review raises concern about residents collecting a water sample from their own taps. This procedure has been applied in multiple domestic and international sampling programs and is *de facto* approach (see examples: Fertmann et al. 2004, Meyer et al. 1998, Pieper et al. in press).

Another concern raised was that samples were collected from stagnated water (page 20):

> *"Much of the data in Harvey et al. (2015) appears to be based on first flush sampling of water after extended periods of stagnation in the pipes and local plumbing. These samples do not accurately represent the quality of the main body of water within the distribution system".*

Not only were first draw samples collected following overnight stagnation (8 hr equivalent) for investigation of property plumbing, a 30 second and three minute (where possible) draw was also collected to determine the contribution of lead from off the property. The TasWater review's own calculations about stagnation in the reticulated supply note the following (page 11-12):

> *"Based on the system drawing provided by TasWater, and only including pipes in the direct line from the primary 100 mm feed main, the calculated volume for the western part of the town (including the 100 mm feed main) is approximately 5.2 kL and for the eastern part of town (including the 100 mm*

feed main) is approximately 3.8 kL. Therefore is seems likely that the water in the mains is fairly well turned over on a daily basis".

Harvey et al. therefore fail to see how the water collection protocol in the private properties is erroneous and that water was collected from anything but normal usage conditions.

Of the 29 sites sampled as filtered and un-filtered on the first field visit, only six of these sites exhibited a difference in lead concentration between the fractions. Based on that dataset, the collection of further filtered and un-filtered samples was deemed to not be a worthwhile avenue of further investigation. Consequently, only un-filtered samples were collected on the second field visit. Regardless, the filtered and un-filtered fractions for the first field visit were reported in the Supplementary Data. In hindsight, the filtered and un-filtered samples may have been useful from the second sample collection period to determine the particulate lead (>0.45 μm) fraction of those samples with detectable lead concentrations. Nonetheless, given the weight of evidence regarding the source of lead contamination in the drinking water supply presented by Harvey et al. (2015) it would have had little impact on the conclusions reached.

4. Application of lead isotope compositions for determining the source of a contamination event

It is evident that the authors of the TasWater review do not fully comprehend the application of lead isotopic compositions for determining the source of lead. This is evidenced by their apparent poor understanding of Soto-Jiménez and Flegal's (2011) Torreón lead smelter study from Mexico, upon which they rely. The TasWater review stated the following in regard to this study's contamination source discrimination using lead isotopic compositions (page 8):

"*For example, Soto-Jiménez and Flegal's (2011) found that the lead isotope ratios of dust, soil and aerosols from a smelting area of Mexico were indistinguishable from each other making it impossible to apportion the dominant source of lead."*

The review erroneously goes on to state (page 8):

"Therefore, investigations require that the different sources of lead be isotopically distinct…"

Careful reading of Soto-Jiménez and Flegal's (2011) study should have resolved that conundrum for the reviewers, because the dominant and prevailing source of environmental lead in Torreón is a single dominant source of ore, producing a uniform environmental isotopic composition largely indistinguishable from the source materials. In the case of Torreón the environmental lead impacting air, soil, dust and blood lead is the ore processed by the local smelter. Indeed in the conclusions of the Soto-Jiménez and Flegal's (2011) study, the authors state clearly:

"The data show that lead concentrations and stable isotopic composition in environmental samples revealed that pollutant lead is mostly from contemporary emissions from the smelter"

Lead isotopic analysis can be used to supplement environmental investigations in two ways: (1) To discriminate between sources where there are multiple possible contaminant origins; (2) To assess the effect of a single pollutant source on the environment, where analysis of samples can confirm that the source investigated is responsible for the dominant contamination.

We note that M.P. Taylor had suggested to Mike Brewster, the TasWater CEO, that it might be prudent to source an expert in lead isotopic composition analysis, and Dr Ashley Townsend (University of Tasmania) was suggested. Alternatively, Professor Brian Gulson, who is one of Australia's most published experts in the use and application of lead isotopes for environmental analysis would have been an excellent choice.

The TasWater review attempts to further discount the lead isotope compositions determined in the Harvey et al. (2015) study by suggesting that repeat sample collection may result in different lead isotopic ratios. Given the consistency of the drinking water lead isotope compositions across different sample sites, including the sample collected 35 km away in Ringarooma, it is clear that repeat sampling would not have provided any further insight, which is that the lead sources are not natural.

Concern was also raised about the reproducibility of the laboratory results. Each sample analysed for lead isotopic analysis is bracketed with a standard reference material and therefore the standard reference material is analysed repeatedly, generating robust indicative standard deviation data output. Further, the isotope compositions of the water presented in Harvey et al. (2015) were significantly different from the local bedrock isotope compositions. This fact is undisputable and allows us to draw the conclusion that the lead contamination is **not** natural.

Application of source apportionment calculations was rejected by the TasWater review. Rather than discount these calculations, our study shows clearly that large quantities of the lead in the drinking water can be apportioned to the same lead used in the large water supply pipelines. This shows clearly that the lead in the drinking water supply is not naturally occurring and has been contributed to the water supply by the infrastructure. Aside from these things, two points remain abundantly clear:

(1) The occurrence of measurable and significant lead only occurs once the water passes through the infrastructure network. This conclusion is also reflected in additional (unpublished) data gathered by the Tasmanian Department of Health and Human Services;
(2) Isotopic data from relevant published sources and this study make it clear that the source is not naturally occurring.

5. Professionalism

In section 4.1 it reads (page 13),

> *"the use of the term Cesspit to describe part of a water supply system lacks a professional and objective approach to the study".*

This is the name given to the inflow area above the Pioneer Dam, which the community uses to identify the site and is meaningful to them.

We were disappointed that after conversations with TasWater about our willingness to ensure the reviewers understood the approach and purpose of the study, these offers were not taken up. If they had been, then some of the aforementioned issues would not have arisen. Misunderstandings around the geo-location of data could have been rectified in one of two ways (1) plotting up of the GPS locations of the data (Supplementary Data 2) using Google Earth; (2) Contacting the authors for clarification.

6. Sediment

The TasWater review dedicates a large proportion of text to the water and sediment in the Pioneer dam. Specifically, attention is drawn to the elevated lead concentrations in the *sediment* of Table 1 (416 µg/L and < 7 µg/L). A section of text ascribed to TasWater reveals the following in regard to that concentration (page 15):

> *"Attached are the two analytical reports covering these sampling events. Previously unless otherwise specified as a sediment investigation, the laboratory's normal process for "sediment" samples with very low solids was that they are tested as water and hence reported with "water" units (AST#59735)".*

and

> *"Unfortunately this only adds to the problem of interpreting the data. If the samples only had "very low solids" then it is difficult to see how they are in fact sediment samples".*

This is an important point as TasWater have attributed the lead in the water supply to the sediment. The analysis that was performed on these samples (as a water method) would not extract the lead fraction bound to the limited sediment. TasWater have relied upon this invalid data to form the basis of their sediment bound lead argument. Harvey et al. (2015) has shown that there is no naturally occurring high concentrations of lead anywhere in the Ringarooma River Catchment, either in soils, bedrock or water. Moving forward, this argument is redundant as there is no evidence of sediment bound lead in significant concentrations to generate lead in water above the Australian Drinking Water Guideline.

The TasWater review fails to address the remainder of the data presented in Harvey et al. (2015), which highlights elevated lead concentrations detected in tap water samples collected in Gladstone and Ringarooma. Had these samples been considered by the TasWater review it would have been clear that any notion of sediment bound lead, or naturally occurring lead contaminating the water supply is misleading and incorrect.

7. True colour

A section on true colour of the Pioneer Dam is included on page 15 and 16, under section 4.2. Figure 2 (erroneously referred to and labelled in the TasWater review as Figure 1) relied upon by the authors does not have a y-axis or a clear x-axis, rendering the bar charts meaningless. In any case, these new data are irrelevant to the Harvey et al. (2015) study as colour does not explain source apportionment and was not relied upon in the study.

Conclusion

Based upon the evidence presented here, it is clear that TasWater's review has not added anything new or material to the Harvey et al. (2015) study. Indeed, it has merely confused the matter. The review contains several inaccurate and contradictory statements with regard to the Pioneer water scheme; contains poor understanding of the methods and data quality used in the study; and displays a weak grasp of the utility of lead isotopes, which are critical to the source apportionment aspect in the Harvey et al. (2015) study.

References

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