Memo

To:	Georgie Austin
From:	Darren Paul
Subject:	**McCrae Landslide Board of Inquiry - Assessment of additional information provided by South East Water between 21 July 2025 and 8 August 2025**
Our ref:	PS224394-WSP-MEL-GEO-MEM-004
Date:	**13 August 2025**

1. Introduction

We refer to our causation report on the McCrae Landslide dated 21 July 2025 (ref: PS224394-WSP-MEL-GEO-REP-001) (causation report). That report was prepared based on factual information that had been made available to us prior to the date the report was submitted. Subsequent to the issue of that report, further factual information has been received from South East Water. We have since reviewed that information. This technical memorandum has been prepared as a supplement to our causation report and has been prepared for the purposes of:

- Setting out new information that was not previously considered in our causation report.
- Providing commentary on the relevance of the new information provided to the assessment of the causes of the McCrae landslides that occurred in November 2022 and January 2025.
- Providing commentary on what can be inferred from the new information in relation to the causes of the landslides at McCrae.
- Providing commentary on whether the new information alters the conclusions set out in our causation report and what those changes are, if any.

Based on our review of the additional information provided, we do not consider there to be cause to change the conclusions set out in our causation report.

2. Additional Information Provided

Additional information has been provided either subsequent to the issue our causation report or at a date nearing the submission of that report which resulted in its being unable to be considered. The additional information received is summarised in Table 2.1 along with an indication as to whether this new information is of relevance to the assessment of causation set out in the causation report. Where relevant, cross reference has been provided to indicate where further discussion has been provided on this new information.

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Table 2.1 Information received after 21 July 2025.

Report / File Name	Reference	Author	Commissioned by	Date Received	Relevance
Technical Memorandum – Geochemical Analysis of Groundwater Provenance	Not available	SMEC	SEW	Unknown	Additional information provided discussed in Section 3.1.
McCrae Water Quality Database	Not available	SMEC	SEW	Unknown	No new information was provided in this document. The updated revision addresses minor data gaps in the previous revision. Not discussed in this memo.
Flow Rate from a Longitudinal Split in a PVC pipe, McCrae	SME.0001.0001.0515	Dr Jakobus E van Zyl Dr Andrew Brown	SEW	1 August 2025	Additional information provided discussed in Section 3.2.
Digital Elevation Model (DEM) 5 Meter Grid of Australia derived from LiDAR	SME.0001.0001.0513	Geoscience Australia	N/A	1 August 2025	Relevance to report negligible. Not discussed in this memo.
ICSM LiDAR Acquisition Specifications and Tender Template	SME.0001.0001.0506	ICSM	N/A	1 August 2025	Relevance to report negligible. Not discussed in this memo.
Board of Inquiry into McCrae Landslide	SME.0001.0001.0501	SMEC	SEW	1 August 2025	Update to report dated 21 July 2025. This report is discussed in Section 3.3.
LEAF test COC and QC reports	SME.0001.0001.0517 to SME.0001.0001.0533	SMEC	SEW	3 August 2025	COC and QC reports for data provided in previous report. No new test data included. Not discussed in this memo.
McCrae EC 1:5 soil:water tests [email]	SME.0001.0001.0534	SMEC	SEW	3 August 2025	Additional information provided discussed in Section 3.4.
McCrae Landslide Geochemistry Report	SEW.0001.0002.4199_0005	C.M.Jewell & Associates	SEW	8 August 2025	Additional information provided discussed in Section 3.5.
Reports of Well Testing	SME.0001.0001.0535 to SME.0001.0001.0539, SME.0001.0001.0541	SMEC	SEW	11 August 2025	Additional information provided discussed in Section 3.6.
Permeameter Testing Spreadsheet	SME.0001.0001.0540	SMEC	SEW	11 August 2025	Provides the raw data of permeameter tests however no new results have been provided. Not discussed in this memo.

3. Commentary on Additional Information

This section provides commentary on each item of additional information, where it has been considered of relevance to do so.

3.1 Technical Memorandum – Geochemical Analysis of Groundwater Provenance, SMEC

This technical memorandum summarises the results of geochemical testing undertaken on select groundwater samples, with the results set out on a Durov diagram. On this memorandum we make the following commentary:

- The Durov diagram and the water types shown on that diagram cannot be used identify the source of the water sampled from the landslide headscarp in January 2025 with certainty, if at all. For example, if mains water from the Bayview Road burst travelled along subsurface pathway(s), picking up ions as it flowed along those pathways, it could exhibit the chemical composition measured in the January 2025 samples. This is consistent with mains water than exfiltrated at surface in several locations, including a pothole at the junction of Waller Place and Charlesworth Street and which had chemical compositions similar to the water that was sampled from the landslide headscarp in January 2025.
- Testing on the January 2025 samples indicated an elevated EC and other ions compared to the mains water but has a composition comparable to other water samples such as those sampled from basement drainage at 5 and 7 Prospect Hill Road.
- The shallow aquifer in the upper part of the catchment is unsaturated (e.g. SMEC BH01, BH02), so water from the leak could migrate to the base of the aquifer before moving laterally. When that water came into contact with the saturated part of the aquifer, it may have displaced the existing water in the aquifer ahead of it, so that the pressure increase could migrate ahead of the water chemistry change. The seepage sample could represent that early pre-existing perched groundwater, before the discharge was dominated by water sourced from the Bayview Road mains leak. Alternatively, if there was less mixing between the mains water and the existing water, there may have been a gradient in water chemistry from the base to the top of the saturated zone at the landslip. The existing water with higher chloride would be at the base, where the sample was collected from.
- Samples from locations upgradient of the landslide site, but downgradient of the Bayview Road leak indicate low EC water during or shortly after the mains leak was repaired, followed by higher EC measured in later samples taken once the leak flow had reduced or had passed the sample location. This pattern may have also occurred with the discharge water at the landslide location in January 2025. However, without high quality samples of the seepage from the landslide over time, this cannot be demonstrated.
- It is assumed that the seepage water sampled from the landslide headscarp in January 2025 is representative of the change in water conditions which triggered the January 2025 landslides, and that the chemistry of that water can be used to trace the source of the additional water. A single sample collected shortly after the landslide does not provide conclusive evidence. It is accepted that perched groundwater was present in the shallow aquifer prior to the landslide, which could have been derived from rainfall, irrigation or other leaks (stormwater, water etc) within the local catchment area. The chloride concentration of this shallow 'interface' groundwater is already a mixture from these sources and flow pathways and is likely to have mixed with water sourced from the Bayview Road leak.

The information provided in this technical memorandum does not affect the opinions or conclusions provided in our causation report.

3.2 Flow Rate from a Longitudinal Split in a PVC pipe, McCrae, van Zyl and Brown

A report has been prepared by Dr Jakobus E van Zyl and Dr Andrew Brown to discuss the flow rate and leak-soil interaction from the 2024 Bayview Rd pipe burst event. We provide the following commentary on this report:

- The soil properties used for the analysis set out in this report are based on Borehole WR174 BH01 which did not encounter colluvial materials. The majority of the leak–soil interaction analysis presented is based on these geotechnical

properties. We do not consider these properties to reflect the expected subsurface conditions at the Bayview Road leak location.

- The report states that '*Since the McCrae leak was located at 4 o'clock, the fluidised zone would not have been directed at the soil surface. However, it is likely that water would have preferentially moved along zones of higher permeability or lower resistance'*. We agree with this statement insofar as the development of preferential flow paths was likely as the leak developed. However, the report appears to discount the possibility that a preferential flow path developed lateral to the pipe or below the pipe based on a photograph taken during the pipe repair. These photos are somewhat inconclusive as the excavation process can disturb the subsurface profile particularly when the soils are saturated. Similarly, a clear view of the base of the underside of the pipe is not available in these images. If a subsurface preferential flow path had developed, the remainder of the analysis would be significantly impacted.
- Site observations indicating surface flow and the presence of a waterspout are dated 30 December 2024. There is reasonable consensus that the leakage volume was significant by at least October 2024, with observations of impacts at Waller Place reported in November 2024. There has been no evidence provided of surface flow prior to 30 December 2024, despite two months of ongoing leak detection activities in the McCrae area.

Whilst we consider that whilst the estimated proportion of flow that issued from the leak to have reached the surface may be overestimated in this report given the above commentary, the proportion of water that infiltrated from the leak was sufficient to migrate to the McCrae escarpment and to trigger the landslide on 5 January 2025. As such, the information provided in this report does not affect the opinions or conclusions provided in our causation report.

3.3 Board of Inquiry into McCrae Landslide, SMEC

A revised causation report prepared for South East Water by SMEC (SME.0001.0001.0501) has been provided. Additional information provided in that revised report includes lab test results for particle size distribution testing, moisture content and permeability. On this report we make the following commentary:

- Geotechnical laboratory testing included in the revised report was limited to tests associated with BH WR174, the borehole drilled by Douglas Partners at the water tank situated northwest of the Mornington Peninsula Freeway. We note that the geology encountered in this borehole generally does not represent the expected geology at the landslide site, nor that expected along the likely flow path between the leak site at Bayview Avenue and the January 2025 landslides, with granitic soils encountered from 0.2 m depth.
- All tests provided are applicable to granitic soils and are unable to inform geotechnical or hydrogeological properties of the colluvial soils in which the water is modelled to have flowed.
- Regarding geochemistry, no additional sections, figures, or appendices and no new analytical results were included in this revision. Methods (e.g. LEAF column tests and geochemical modelling) as set out in Appendix E of the report and the associated dataset provided are the same as per the previous report revision.

Additional information provided in this report does not affect the opinions or conclusions provided in our causation report.

3.4 McCrae EC 1:5 soil:water tests, SMEC

Email correspondence providing a summary of EC measurements for HA02 have been provided. We make the following commentary on this information:

- Results are provided for an EC 1:5 soil:water test from a sample obtained from hand auger, bore HA02 (terminated at 1.2 mbgl). HA02 is located at the T-intersection of Viewpoint Road and Prospect Hill Road. The EC values provided are low, indicating low-salinity soil.
- We note that these results are from a single bore at advanced to a shallow depth and are not representative of all soil types along the possible subsurface flow pathway(s).

Information provided in this email correspondence does not affect the opinions or conclusions provided in our causation report.

3.5 McCrae Landslide Geochemistry Report, C.M.Jewell & Associates

A report was prepared by C.M. Jewell & Associates which discusses the available geochemistry data and provides opinion on the relative proportion of water that could be attributed to different sources based on the chemistry of the water measured on samples obtained from the landslide headscarp in January 2025. We provide the following commentary on this report:

- There appears to be consensus that deep groundwater did not contribute to the seepage (e.g. Figure 4 Interpretative hydrogeological cross section from the SMEC causation report). Section 4 of that report and the SMEC causation report suggest shallow perched groundwater at the interface of colluvium and weathered granite (water from SMEC BH03 and BH04) contributed to the seepage at the landslide headscarp in January 2025. However, the water balance calculation set out in Section 7.5 uses a chloride (Cl) concentration of 480 mg/L from deep groundwater (SMEC BH02). A more appropriate value of between 100 mg/L and 170 mg/L as observed in SMEC BH03 and BH04 should be considered in this approach. Given this, the water balance provided and associated conclusions derived from this report are not reflective of both our and SMEC's the conceptual hydrogeological model of the site.
- Table 4 of the Jewell report suggests 66% of the inflow could be attributed to interface groundwater. However, when calculated as a percentage of the mass inflow, using the same input parameters, the proportions for mains leakage and interface groundwater are estimated to be 0.6% and 96.1% respectively (Table 3.1). If a Cl concentration of 170 mg/L is used for the interface groundwater, the proportion of interface water would be 89.7%. This high theoretical proportion of interface water is unrealistic and suggests that the water sampled at the landslide headscarp in January 2025 was dominated by mains water, as there was no permanent shallow perched groundwater to provide the proportion needed to derive the measured chemical composition on the seepage water sampled in January 2025. The lack of available natural shallow perched groundwater is supported by evidence of attempted water sampling from Coburn Creek and PSM shallow bores in June 2025, which were reported as dry and only held water intermittently as observed at other times by PSM, WSP, and SMEC.

Table 3.1 Calculation of % inflow of each water source using the mass inflow

	Values from SEW.0001.0002.4199_0005, Table 4							WSP calculation
Water	**% inflow**	**Cl concentration**	**Infiltration rate**	**Mass inflow**	**Head scarp outflow**	**Outflow concentration**	**Mass outflow**	**% inflow using mass inflow**
Main leakage	9	20	0.014	0.28				0.6
Interface GW	**66**	**480**	0.099	47.52				**96.1**
Irrigation	15	20	0.023	0.46				0.9
Drainage	10	80	0.015	1.2				2.4
Sum	**100**			49.46	0.15	330	**49.5**	**100**

- Irrigation water and mains leak water are assumed to have the same chemistry at their source. The water that originated from the mains leak would have travelled further over the ground surface and through the ground, giving more opportunity for it to pick up chloride. The water balance estimation uses all of the irrigation water volume assumed to be within the ground before it is mixed with water that could have originated from the Bayview Road leak. The irrigation water would be infiltrating from above the landslide location, very close to where the seepage emerged and has less opportunity to pick up chloride, whereas mains water derived from the more distant Bayview Road leak would migrate towards the base of the perched aquifer, from where the discharge was collected.
- The seepage water sampled in January 2025 likely comprises a mixture of different water sources. However, the mixing mechanism has not been proven. In contrast, mains water derived from the Bayview Road leak has been shown to travel and pick up ions along the pathway(s), for example at potholes at the junctions of Waller Pl and Charlesworth St, and Coburn Ave and Charlesworth St.

- The existence of shallow perched water at sufficient volume is also questionable as indicated by the following calculation which considers the mixing of mains water from the Bayview Rd leak and perched water at one of the potholes (at the junction of Waller Pl and Charlesworth St):
  - The Cl concentrations are: mains water - 20 mg/L (a), shallow perched water - 250 m/L (b) and the pothole (after mixing) - 120 mg/L (c), respectively.
  - Assuming 70% of the 37 ML burst volume reached the pothole.
  - The mixing proportions are: x (mains water) and y (shallow perched water), with $x + y = 1$ and $ax + by = c$). The required volume of perched water is 19.9 ML.
  - If only 30 % of the burst volume reached the pothole, the required volume of perched water is 8.5 ML.
  - The mixing ratio is about 56.5% mains water and 43.5% perched water.
- The report appears to suggest there is no evidence of a possible 'original gully' in proximity to the site based on an aerial image from 1939. We do not consider this reliable evidence to inform this assumption given geological features such as gullies and colluvial deposits form over hundreds of thousands of years and their formation is very likely to predate the 20th century.

Information provided in this email correspondence does not affect the opinions or conclusions provided in our causation report.

3.6 Reports of Well Testing, SMEC

A series of report outputs for slug tests conducted in BH01, BH02, BH03, BH04 and WR174 BH01 were provided which support the summarised slug test results set out in SMEC's Board of Inquiry into McCrae Landslide report (SME.0001.0001.0501). We provide the following commentary on the information provided:

- The methodology for the slug testing is not described in the associated report (SME.0001.0001.0501). Initial water displacement ranged from 0.37 m (BH04) to 5.58 m (BH02), so it appears that a consistent known slug volume was not used.
- BH03 and BH04 are the two tests which relate to the perched aquifer. The BH03 test interpretation relies on only five seconds of data, recovering from 0.67 m displacement to around 0.11 m displacement in that time. This may be enough to indicate fast recovery (high conductivity) but cannot be relied upon for an accurate quantification of conductivity. A large error margin should be considered to apply to this result. BH04 has more data (50 seconds), however only recovers to around 75% of the initial displacement. This indicates slower recovery, but with low confidence in the numerical result.
- The highest result of 6 m/day (7×10^{-5} m/s) for BH03 is within the range WSP adopted for sand (10^{-5} m/s) to gravelly sand (10^{-4} m/s) for the colluvial aquifer to inform the estimate of travel time for water from the Bayview Road leak to the January 2025 landslide site as described in our causation report.

Information provided in these documents does not affect the opinions or conclusions set out in our causation report.

4. Conclusion

Based on our review of the additional information supplied by South East Water since the issue of our causation report dated 21 July 2025 and as set out in Table 2.1, the opinions and conclusions provided in our causation report remain unchanged. We understand we have now considered all technical information related to the causes of the November 2022 and January 2025 landslides that has been provided to the BOI by South East Water up to 12 August 2025.

Irrelevant & Sensitive

Darren Paul
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