6. Discussion

6.1 Physio-chemical properties

The pH of the groundwater at the Site is considered slightly acidic, and was typically less than 5.5 during the 2017 monitoring period. Groundwater at the Site is considered to be relatively fresh, with TDS typically below 300 mg/L. Location SE5D reports a significantly larger range than other locations with the highest TDS recorded in March (687.7 mg/L) and the lowest TDS recorded in October (68.9 mg/L).

These results are consistent with historical trends, as discussed in Section 6.7.

6.2 Major ions

Chloride concentrations are generally considered low, likely related to the fresh (low TDS) groundwater observed across the Site. Location SE5D reported the highest chloride concentrations (348 mg/L in March, 298 mg/L in October), which was more than double the other well locations and exceeded the NPUG criteria. Sodium concentrations were also more than double the other well locations. Calcium, potassium and magnesium concentrations are considered to be low and stable over the monitoring period.

6.3 Metals

The majority of guideline exceedances for the investigation (Section 5.4) are attributed to dissolved metals, particularly those exceeding the adopted FWG criteria. Numerous exceedances of this guideline occurred for aluminium, copper and zinc. It is noted that these guidelines are applicable to the protection of fresh water ecosystems (such as rivers and streams, or groundwater dependant ecosystems). Whilst there are no known aquatic ecosystems present on-site, the ephemeral waterway Crooked Brook is located approximately 1 km to the south and south west of the Site (not considered directly down hydraulic gradient of the Site).

Total iron concentrations exceeded the LTIG criteria for the majority of locations. These exceedances commonly also exceeded the NPUG criteria.

6.4 Nutrients

In general, concentrations of nitrogen (in the form of nitrate, nitrite, ammonia) are considered to be low across the Site and did not exceed any of the adopted assessment criteria. However, total nitrogen concentrations at SE6 and CCBH2 as well as total phosphorus concentrations at SE10 and CCBH2, slightly exceeded the Long-term irrigation criteria. The highest concentrations of total nitrogen and total phosphorus occurred at CCBH2 (8.9 mg/L and 1.02 mg/L respectively), which is located down hydraulic gradient of the Site potentially indicating an onsite source.

6.5 Organics

Concentrations of TRH were reported above the LOR at CCBH2 in October (200 µg/L), including the following fractions; $TRH_{>C10-C16}$ minus Napthalene (F2), $TRH_{>C10-C16}$ Fraction and $TRH_{>C10-C40}$ (sum of total).

Concentrations of PFAS were reported above the LOR at CCBH2 and SE3D in the March 2017 GME only. These include the following analytes at CCBH2:

- 10:2 Fluorotelomer sulfonic acid (0.06 µg/L)

- Perfluorobutane sulfonic acid (0.02 µg/L)
- 6:2 Fluorotelomer sulfonate (0.08 µg/L)
- Perfluorooctanoic acid (PFOA) (0.01 µg/L)
- Perfluorohexanoic acid (PFHxA) (0.05 µg/L)
- PFAS (Sum of Total) (0.16 µg/L).

And the following analytes at SE3D:

- Perfluorooctane sulfonic acid (PFOS) (0.02 µg/L).
- PFAS (Sum of Total) (0.02 µg/L).

The concentrations of the PFAS compounds detected are considered below the relevant human health and environmental screening values (HEPA, 2018) however, given that these locations are down hydraulic gradient of the Site, and were not detected in up gradient bores; it potentially indicates an onsite source. PFAS compounds were not detected at concentrations above the LOR at these two locations in the October 2017 GME.

BTEX, PAH, Phenols, PCBs, OCP and OPP were reported below the LOR for both of the biannual sampling events for all samples analysed.

6.6 Spatial trends

No spatial trends or differences were apparent for the majority of analytes reported.

The most notable observations were:

- The up-gradient location SE5D reporting the highest TDS, aluminium, chloride and sodium concentrations.
- The up-gradient location SE5D reported concentrations of metals above the LOR consistent with down-gradient bores.
- The down-gradient locations CCBH1 and CCBH2 reporting the highest pH, total iron, total nitrogen and total phosphorus concentrations.
- The down-gradient location CCBH2 reporting the highest TRH and PFAS concentrations.

While SE5D appears to have different characteristics to other monitoring bores, it is located over 700 m away from the nearest monitoring bore (SE3D). It is not well understood why the water quality appears to be impacted in SE5D given its location up-hydraulic gradient of the Site.

PFAS analytes were reported in bores CCBH2 and SE3D. Given that these locations are down-gradient of the Site, these detections may be resulting from the activities on Site.

6.7 Historical trends

Groundwater monitoring was undertaken between October 2005 and April 2016 by Stass Environmental. Historical monitoring data is provided in Appendix F.

Monitoring locations SE1, SE3, SE4, SE9 and SE10 historically had bores that were functional from 2005 and decommissioned in 2015. New bores were drilled directly next to the decommissioned well during the next monitoring round in 2016. The historical data from the decommissioned bores are considered separately, however, given that the locations are the same they are considered comparable to the new bores. Decommissioned bores are identified by "Dd" in the historical monitoring data (Appendix F).

A [redacted] trend analyses ($p < 0.01$) was undertaken on the historical data, which identified the upwards and downward trends in the data over the monitoring period (2005 – 2017). A summary of the trend analysis is provided in Table 10.

The trends that were observed in the existing bores *and* the decommissioned bores are shown in **bold**. The trends that were reported in the decommissioned bores but not in the existing bores are shown in *italics*.

The data collected during 2017 is consistent with historical data and there are no clear spatial trends within the historical data. The most notable observations were:

- Upwards trend of nutrient concentrations across all locations except SE4D (up-gradient) and SE3D, SE8D (down-gradient).
- Upwards trend of chloride concentrations across up-gradient locations (SE4D, SE5D) but also the cross gradient location (SE1D) and one down-gradient location (SE8D).
- General downward trend in zinc and TDS concentrations at the majority of locations across Site.
- Concentrations of metals, BTEX, TRH and PAH remain consistently low across Site over time.

Table 10 Data trends over the historical monitoring period (2005 - 2017)

Location		Man Kendall Trend Analysis	
Location Context	**Sample ID**	**Trending Up**	**Trending Down**
Cross Gradient	SE1D	Cl, **NO_3**, NO_x, **N**, **Pb**	*Cl*, *TDS*, *Zn*
Down Gradient (Primary Leachate Pond)	SE3D	*Pb*, *K*	*NO_3*, *N*, *TDS*, *Zn*
Upgradient (Leachate Evaporation Ponds)	SE4D	Cl, *Zn*	*NO_3*, *N*, *K*
Upgradient (site)	SE5D	Cl, NO_3, **Pb**, Zn, NH_3	N, TDS
Down Gradient (Crystal Pigment Cell 1)	SE6D	NO_3, N	Cl, K, TDS, Zn
	SE7D	NO_3, N	Cl, K
	SE8D	Cl, K, TDS	Zn
Down Gradient (Leachate Evaporation Ponds)	SE9D	**NO_3**, NO_x	*K*, *Zn*
	SE10D	NO_x	*K*, *TDS*, *Zn*
Down Gradient	CCBH1	Not enough data points to generate a trend.	
	CCBH2		