MEMO

To:	Stantec
From:	Agrimin Technical Team
Subject:	Long Term Pump Test Evaluation
Date:	13 November 2021

1. Overview

Brine extraction from infiltration trenches is the proposed mining method for the Mackay Potash Project. Agrimin excavated 23 trenches across the on-lake portion of the project area, these trenches were typically 100m in length and 6m deep. Monitoring bores (piezometers) were installed at each trench site and at varying distances from the trench. Short term pump tests were conducted at 19 trenches to provide pumping and drawdown data that were used to calibrate hydraulic conductivity parameters in the lake groundwater model. Two locations were selected to undergo long term pumping tests to record groundwater drawdown responses (if any) on the lake islands and analyse the influence of "wet season" rainfall on the water table and groundwater chemistry. The pumping tests were run for 6 months over the 2018-2019 wet season. The tests also aimed to increase the understanding of the hydraulic properties of the near surface sediments and quantify long-term trench performance.

Trench 02A (T02A) and Trench 13 (T13) locations (See Figure 1), were selected based on their proximity to lake islands, as well as contrasting hydrogeological properties of the surficial lakebed sediments in those areas. Groundwater chemistry and abstraction rates were monitored for the duration of the tests.

Weather events during the wet season are typically either regional and wide-spread rainfall to the lake and surrounding areas, or scattered, bringing heavy rainfall to isolated areas. As T13 is located approximately 60km north east of the Pilot Pond weather station, it was necessary to monitor rainfall at the pumping test locations so that representative rainfall data could be used to analyse the results. Tipping bucket rain gauges equipped with data loggers were set up at both trench locations to record localised rainfall data for the duration of the pumping tests. Pilot Pond, T02A and T13 rain gauge data is presented in Figure 2.

2. Objectives

The long-term pump testing aimed to address the following:

- Record groundwater drawdown in the trench and in close proximity to the trench within the monitoring piezometers (up to 100m away);
- Record groundwater drawdown on islands adjacent to the infiltration trench, up to 1000m away;
- Monitor water chemistry at regular intervals over the duration of the pump test, and
- Record how significant rainfall events affected recharge and impacted on groundwater drawdown.

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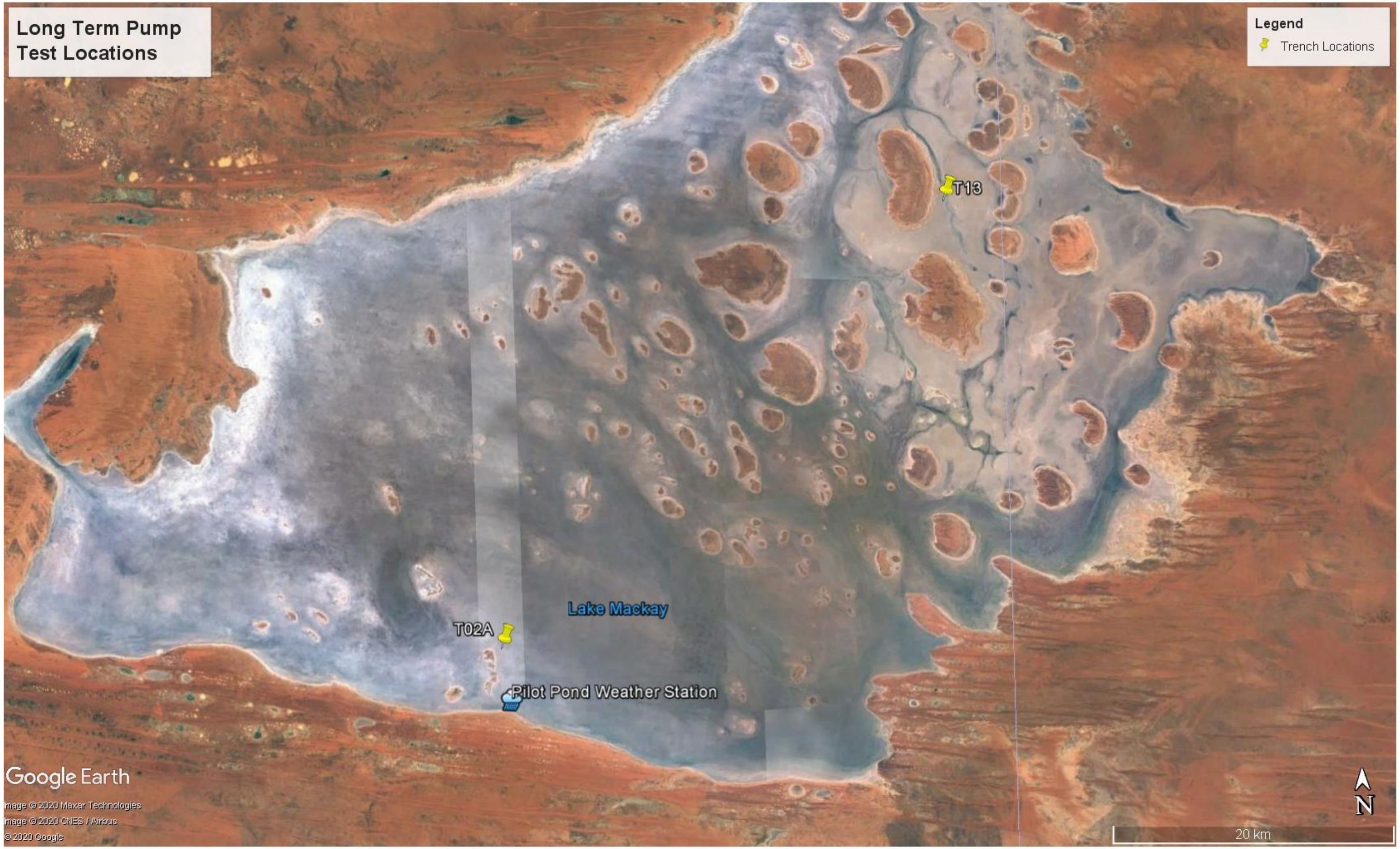

Figure 1 – Long-term pumping test trench locations.

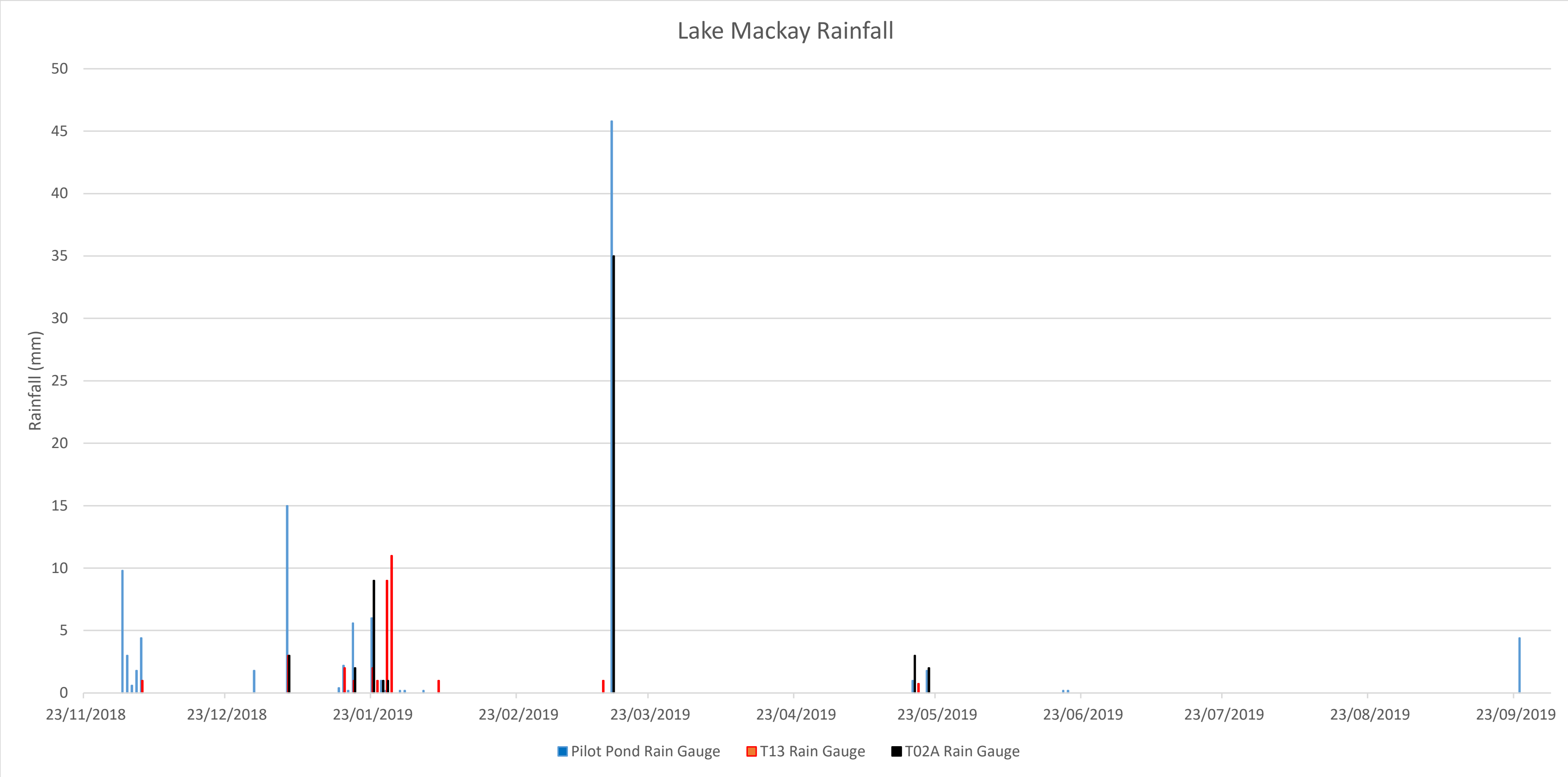

Figure 2 – Rainfall data for pumping test period

3. Trench Pump Tests

3.1 T02A

3.1.1 Location

T02A is located 4 km from the southern shoreline of Lake Mackay, in the central-western region of the lake (See Figure 1).

3.1.2 Pump Test Setup

- Generator and submersible pump
- Flex drive pump
- Flow meter and valve assembly
- 500m discharge lay flat hose

3.1.3 Pumping Test Methodology

The pumping test commenced on the 2nd of December 2018. The first stage of the pumping test involved lowering the trench water level below the baseline ground water level and removing the trench storage. The baseline trench water level was 0.50 mbgl and was lowered to 3.30 mbgl in the first 25 days of the pumping test. Once the target pumping water level had been achieved the flow rate was reduced to match the groundwater inflow rate. The initial steady state trench flow rate was 0.72 L/sec and was further reduced to 0.45 L/sec as the test progressed. The flow rate for the final 4 weeks of the pumping test was 0.25 L/sec. Flow rates over the duration of the pumping test are presented in Figure 3.

The flow rate was adjusted if an increase or decrease in the trench water level was detected. The trench flow rate, water level and piezometer water levels were measured and recorded at regular intervals throughout the duration of the pump test. Pumping equipment failures and extreme weather events resulted in periods of time when the abstraction rate from the trench was zero, this resulted in fluctuations in the trench water level. Following a period of no pumping, the pump flow rate was increased to lower the trench water level and restabilise the test. These events have been annotated on the trench flow rate plot, Figure 3 – Trench 02A pumping test flow rates and Table 1 - T02A Trench water level annotation comments (see Figure 3 – Trench 02A pumping test flow rates). Water level drawdown trends for the trench and associated monitoring piezometers are presented in Figure 4 and in Figure 5 (MD stands for 'manual dip' measurement).

The test ended on the 27th June 2019 following 207 days of pumping. Monitoring of the trench and piezometer recovery water levels continued after pumping was stopped.

Table 1 - T02A Trench water level annotation comments (see Figure 3 – Trench 02A pumping test flow rates)

Annotation	Comment
1	Drawdown trench water level at beginning of test
2	Stabilize trench water level by reducing pump flow rate
3	Pump off due to generator failure
4	Increased flow rate to drawdown trench water level
5	Flow rate reduced to stabilize trench water level
6	Trench water level at surface due to inundation event, pump off
7	Flow rate increased to drawdown trench water level
8	Reduce flow rate to stabilize trench water level

9	Pump failure
10	Reduce flow rate to stabilize water level

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3.1.4 Pumping test data

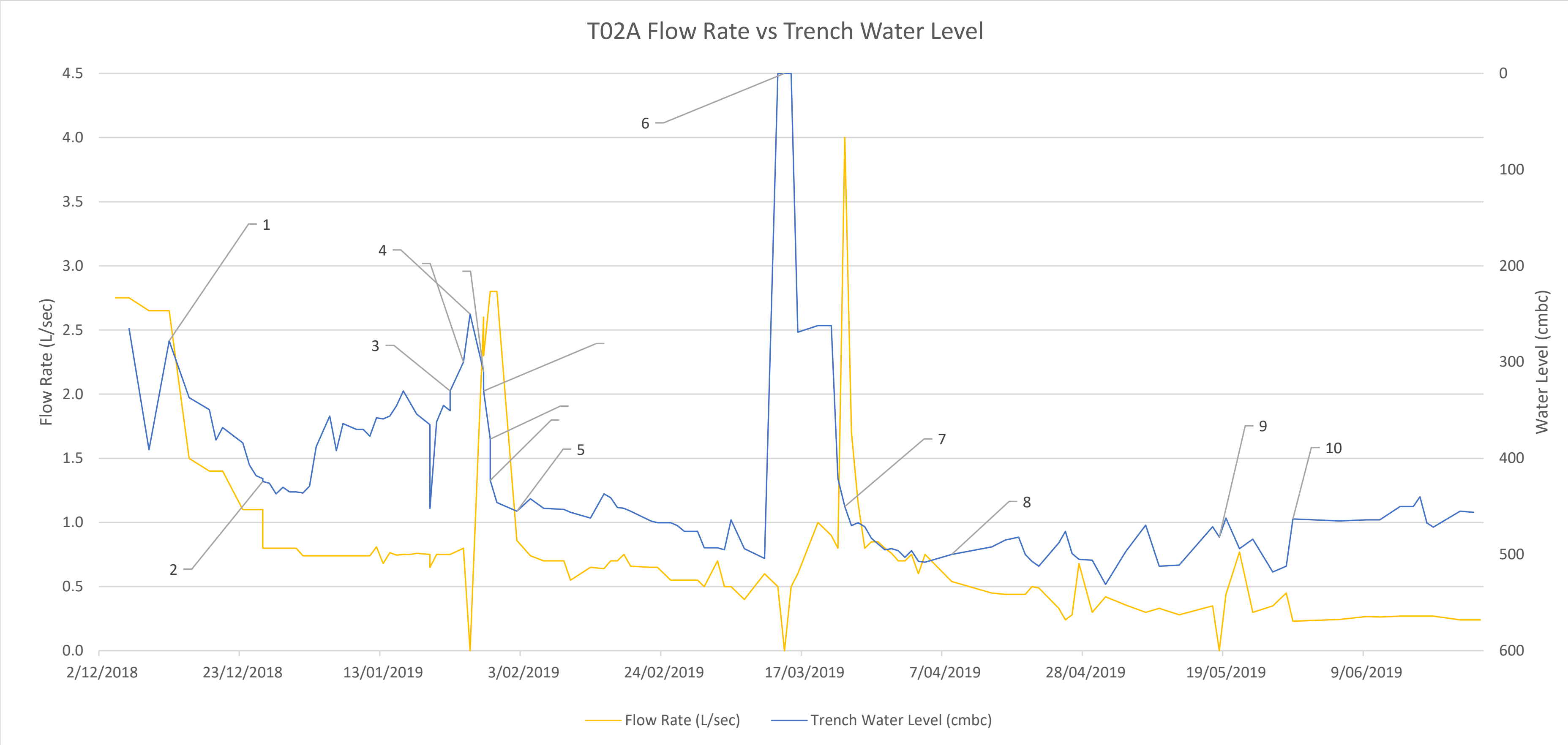

Figure 3 – Trench 02A pumping test flow rates & water level data

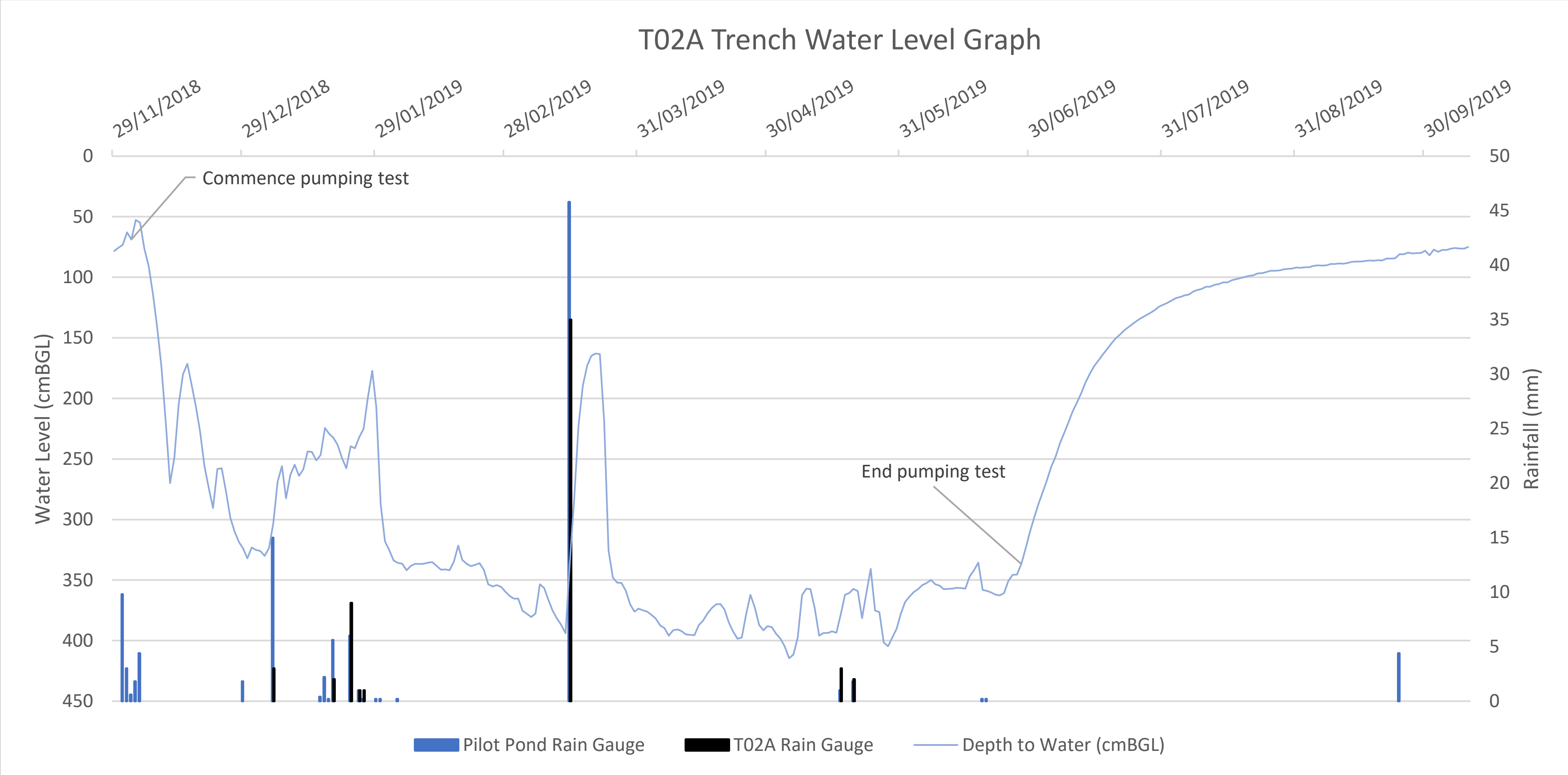

Figure 4 – Trench 02A water level

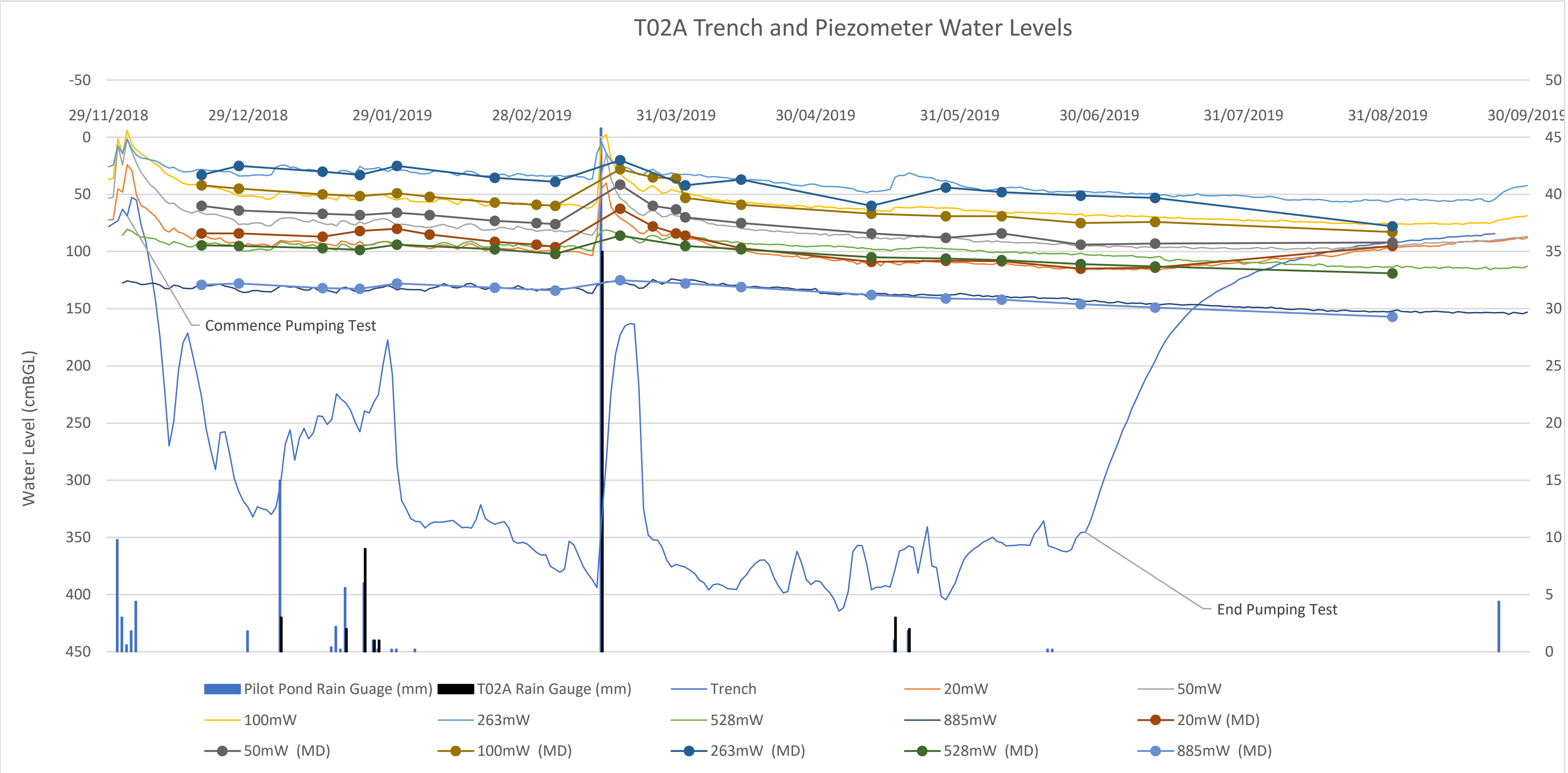

Figure 5 – Trench 02A piezometers-water levels

3.1.5 Groundwater Chemistry

A total of 122 groundwater samples were taken from Trench 02A and the surrounding piezometers. Samples were taken at regular intervals throughout the duration of the pumping test. Samples were assayed for total dissolved solids and a suite of target ions. A plot of trench and monitoring piezometers assay results are presented in Appendix C and Appendix D. Comments for the annotations are presented in Table 2.

3.1.6 Results and discussion

3.1.6.1 Drawdown and yield trends

- Data loggers were installed at T02A approximately one week before the pump test commenced. This was so that baseline water levels could be recorded. The initial increasing and decreasing water level trend observed in the trench and monitoring piezometers during this period was due to rainfall inundation of the surface of the lake surrounding T02A. This rainfall even was recorded by both the Pilot Pond weather station and trench rain gauge.
- Throughout the course of the pumping test, several pump stoppages occurred and resulted in fluctuations of the trench water level. Flow rates were temporarily increased following a pump failure to lower the trench water level and re-stabilize the test. Overheating of the pumping equipment was the primary source of equipment failure as the daytime atmospheric temperatures during the first 4 months of the test frequently exceeded 45°C. Some of the pump stoppages coincided with rainfall events which indicates that rainfall may have also affected the pumping equipment. Several mechanical failures were also experienced during the test.
- An isolated 45 mm rainfall event on the 15th March 2019 resulted in the pump failing and the trench flooding. The water level of the trench rose to ground level as a result of the rainfall (annotation 6 on Figure 3). Following this event, the trench pumping rate was increased to draw down the water level to re-establish the pre-storm trench water level. The piezometers recorded groundwater levels at or above the lake surface. In the month following the inundation event, the groundwater level gradually stabilized back to pre-inundation levels.
- Drawdown trends in the monitoring piezometers showed very gradual responses to trench level fluctuations. This is due to the low hydraulic conductivity and permeability of the near surface lake bed sediments in this region of the lake.
- At the conclusion of the pumping test, the pump was switched off and the trench water level allowed to recover back to pre-pumping levels. All data loggers within the monitoring piezometers remained in place for the duration of the recovery period. The trench water level rapidly recovered over a period of approximately 18 days. A delayed and slow recovery response in the 20 m and 50 m piezometers was observed once the trench water level had recovered over approximately 2 weeks.
- The remaining monitoring piezometers continued to show a steady decreasing trend in water levels until the next rainfall event in early September 2019.

3.1.6.2 Chemistry

- Groundwater chemistry results for the trench and surrounding piezometers showed no significant overall change as a result groundwater abstraction during the pumping test.

- Trench groundwater sample concentrations were initially elevated at ~280,000 mg/L and experienced some fluctuations due to rainwater dilution because of two rainfall events (8.4 mm and 45 mm, respectively) that occurred during the test. The concentration stabilized at ~260,000 mg/L following four months of pumping.
- No defined salinity gradient was identified between T02A and the adjacent island. Salinity between the trench and 263mW monitoring bore are between 200,000 mg/L and 260,000 mg/L. There is a decrease in the island bores, 528mW and 885mW, to between 114,000 mg/L and 162,000 mg/L (Appendix H).(*Note, the T02A island classification (small) is not the same as the T13 island (landform) classification).*

Table 2 -T02A TDS chart annotations (see Appendix C)

Annotation	Comment
1	Trench concentration recovering following a 19.6 mm rainfall event over 5 days
2	Concentration decrease following 8.4 mm rainfall over 4 days resulting in localised inundation at the trench.
3	Concentration decrease following severe 45.8 mm rainfall event resulting in localised inundation at the trench.

3.1.6.3 Island impacts

- No variation in island groundwater chemistry was observed throughout the pumping test.
- 885mW piezometer showed no response to the pumping test. All fluctuations detected are part of lake wide seasonal trends in response to evaporation and rainfall recharge.

Plate 1: (A) T02A prior to commencing pumping test, (B) Water level during pumping test, (C) Pumping equipment, (D) T02A rain gauge, inundated lake surface in background, (E) Trench after inundation event, (F) Monitoring piezometer data download.

3.2 T13

3.2.1 Location

T13 is located in the north eastern region of the lake, adjacent to one of three landform islands. See Appendix B – T13 location and piezometer layout.

3.2.2 Pump test setup

- Generator and submersible pump
- Flex drive pump
- Flow meter
- 500m discharge lay flat hose

3.2.3 Pumping test methodology

The pumping test commenced on the 3rd of December 2018. The first stage of the pumping test involved lowering the trench water level to below the baseline groundwater level. The static trench water level was 0.86 m bgl and was lowered to 2.45 m bgl in the first 30 days of the pump test. Once the target water level had been achieved, the flow rate was reduced to match the groundwater inflow rate. The initial steady state trench flow rate was approximately 1.20 L/sec and was further reduced to 1.10 L/sec as the test progressed. Flow rates over the duration of the test are presented in Figure 6.

The flow rate was adjusted if an increase or decrease in the trench water level was detected. The trench flow rate and water level and piezometer water levels were measured and recorded at regular intervals throughout the duration of the pumping test. Pumping equipment failures resulted in periods of time when the abstraction rate was zero, resulting in fluctuations in the trench water level. Following a period of no pumping, the flow rate of the pump was increased to lower the trench water level and restabilize the test.

The test was ended on the 2nd June 2019 following 184 days of pumping. Monitoring of the trench and piezometer recovery water levels continued after the pumping had ended. Hydrographs for the T13 pumping test are presented in Figure 7 and Figure 8. (MD stands for 'manual dip' measurement).

Table 3 – T13 water level annotation comments (see Figure 6)

Annotation	Comment
1	High flow rate at beginning of test to draw down trench water level
2	Flow rate decreased due split in suction hose
3	Pump off due to mechanical issue
4	Pump off due to mechanical issue, pump replaced
5	Pump off due to mechanical issue
6	Flow rate increased to draw down trench water level
7	Flow rate reduced to stabilize trench water level
8	Pump off due to mechanical issue, pump replaced
9	Pump off due to mechanical issue, pump replaced
10	Flow rate increased to draw down trench water level
11	Reduce flow rate to stabilize trench water level
12	Pump off due to mechanical issue
13	Increase flow rate to draw down trench water level
14	Reduce flow rate to stabilize trench water level

3.2.4 Pumping test data

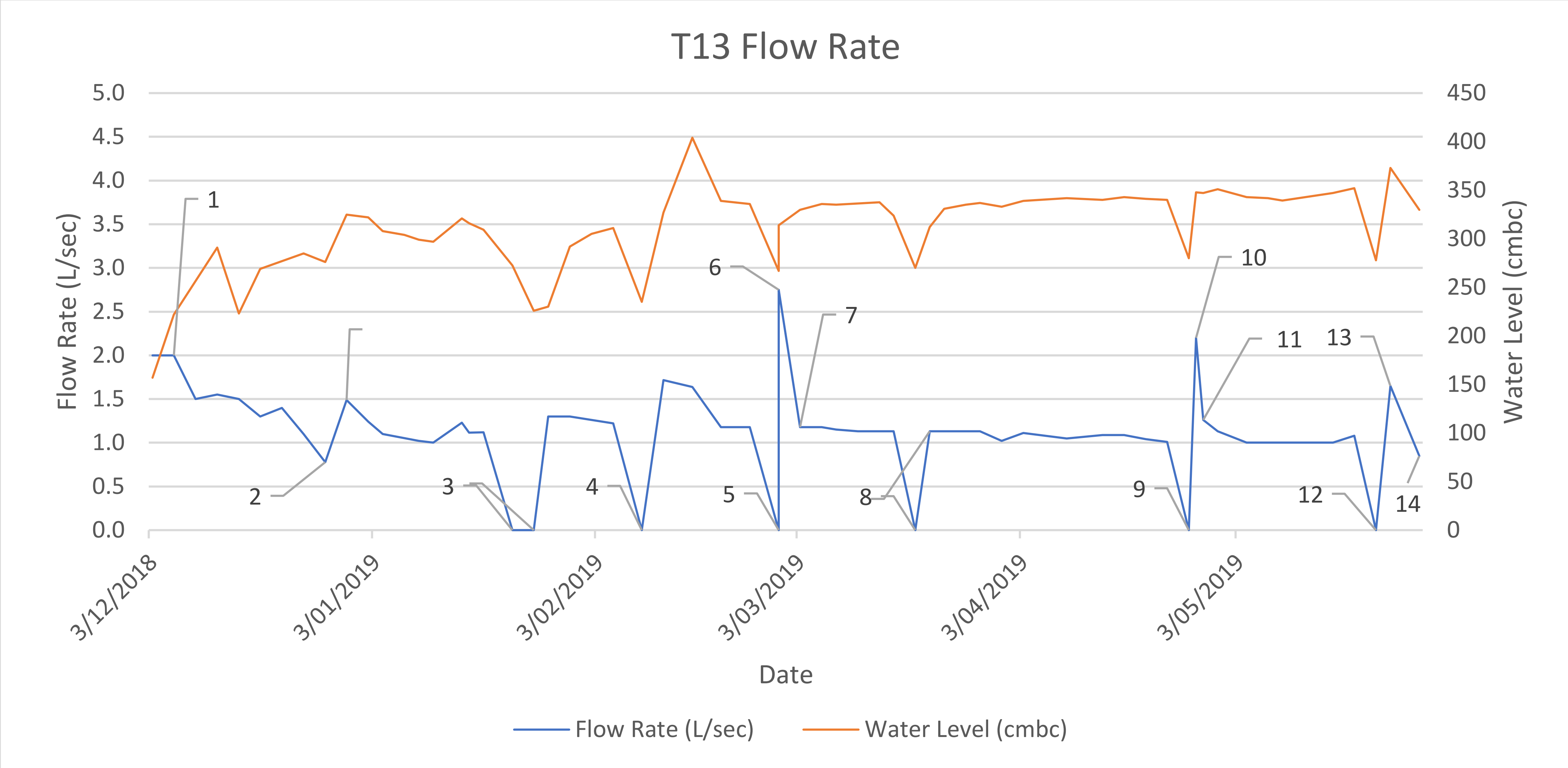

Figure 6 – Trench 13 pumping test flow rate graph

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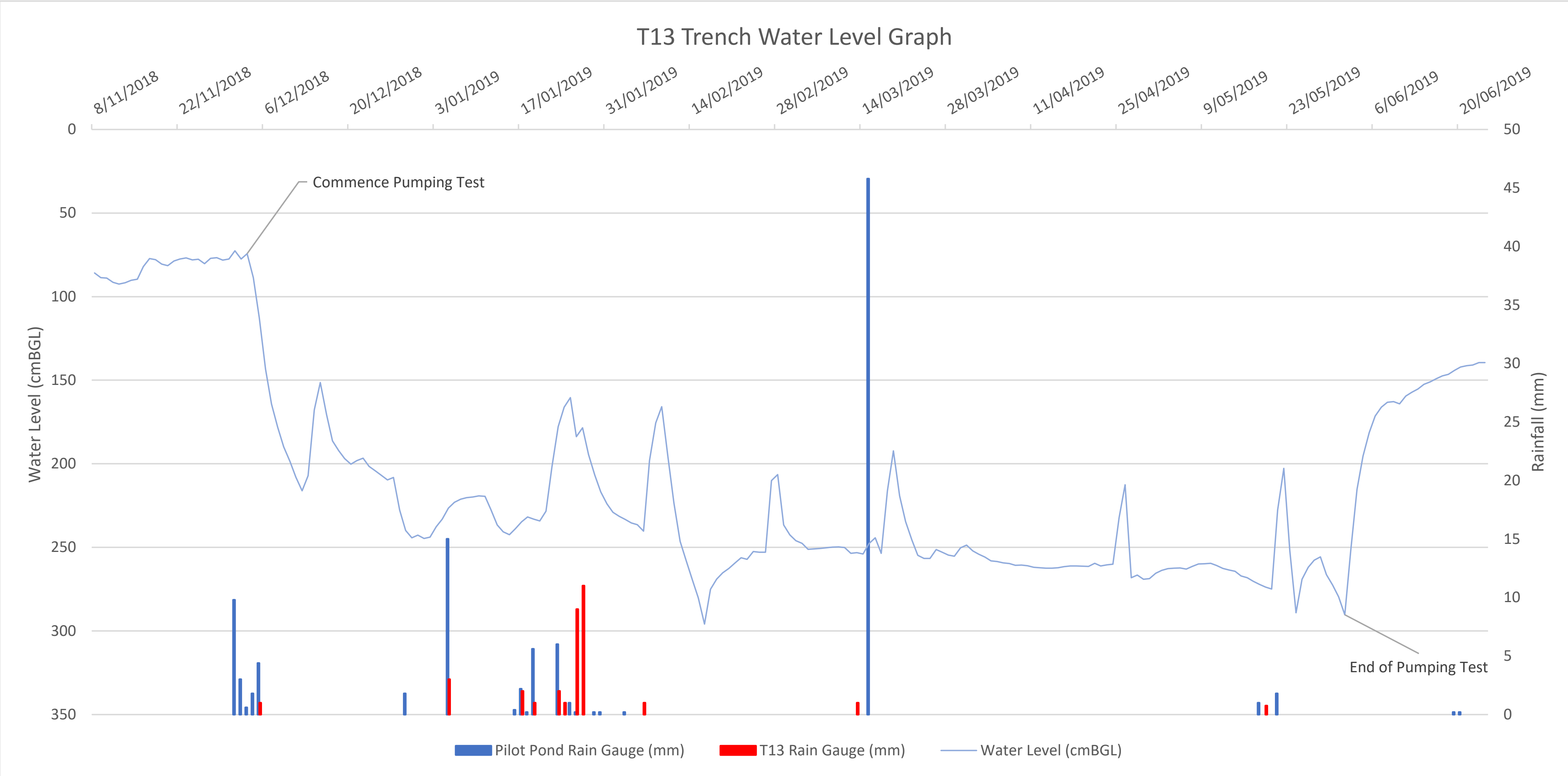

Figure 7 – Trench 13 data logger plot

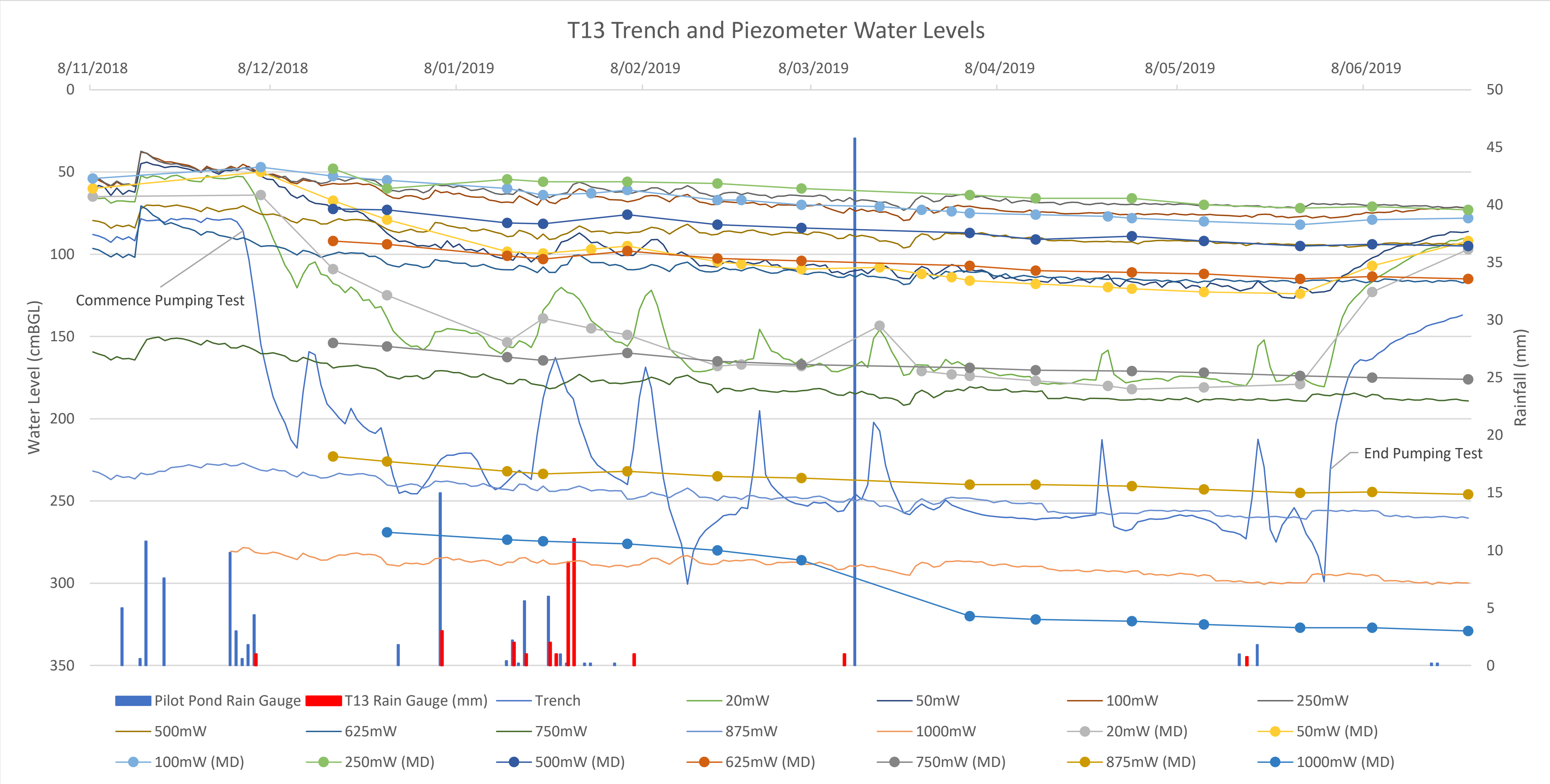

Figure 8 – Trench 13 piezometer graph

3.2.5 Groundwater chemistry

A total of 135 groundwater samples were taken from T13 and the surrounding piezometers. Samples were taken at regular intervals throughout the duration of the pumping test. Samples were assayed for total dissolved solids and a suite of target ions. A plot of trench and monitoring piezometers assay results are presented in Appendix E and Appendix F. Comments for the annotations are presented in Table 4.

3.2.6 Results and discussion

3.2.6.1 Drawdown and yield trends

- The near surface lakebed sediments in the eastern region of the lake where T13 is located have higher permeability due to the higher coarse sand content in the upper 3m. The steady state pumping test flow rate was approximately 1.0 L/s.
- Drawdown due to pumping was observed to extend out to the 500mW piezometer. This lateral drawdown extent is due to the higher hydraulic conductivity of the sediments in the eastern section of the lake.
- The monitoring piezometers located in the riparian zone leading onto the island adjacent to T13 (625mW, 750mW, 875mW and 1000mW) showed no response to trench pumping drawdown. The gradual declining water level trend observed in the hydrographs for these monitoring points is part of a lake wide declining groundwater level trend associated with below average seasonal rainfall.
- When the pumping test was terminated, the trench recorded a rapid initial water level recovery over a period of ~6 days, followed by a more gradual increase for the remainder of the recovery period. This sharp recovery trend was due to the high hydraulic conductivity of the lake sediments. The recovery trend in the 20mW piezometer closely reflected the trench trend due to its close proximity and the high hydraulic conductivity. The 50mW, 100mW, 250mW and 500mW monitoring piezometers all showed more gradual recovery rates, with the steepness of the trends decreasing with distance from the trench.

3.2.6.2 Chemistry

The initial brine sample taken at the beginning of pumping (1) returned an elevated concentration due to the water in the trench being evapoconcentrated in the period leading up to the pumping test. The concentration decreased to levels reflective of true groundwater chemistry once the evapoconcentrated water had been displaced from the trench (2). The chemistry of the trench remained consistent for the duration of the test with no major fluctuations observed.

Table 4 – T13 chemistry plot comments (see Appendix E)

Annotation	Comment
1	Initial high concentration due to evaporation of standing water in trench
2	Trench brine concentration decrease following displacement of evapoconcentrated brine.

Groundwater salinity in the monitoring piezometers between T13 and the island piezometer 1000mW (MC13) indicated the presence of a decreasing salinity gradient (Figure 9, Appendix F and Appendix G). The lake groundwater salinity was ~225,000 mg/L in the 20mW, 50mW and 100mW monitoring piezometers. Between the 250mW and 750mW monitoring piezometers the salinity decreased from 200,000 mg/L to 65,000 mg/L. These points are located in the riparian zone and correspond to a gradual increase in elevation. The salinity decreases to between 32,000 mg/L and 42,000 mg/L in the 875mW and 1000mW monitoring piezometers.

The 1000mW (MC13) monitoring piezometer is drilled through island sediments into lakebed sediments. It is thought that the water column in the bore is stratified, with less saline water sitting atop more saline water at depth. The brine sampling technique used to obtain all samples with a salinity average of ~40,000 mg/L was completed by lowering a PVC bailer into the water in the upper most zone of the casing. This resulted in a discrete water sample taken from the water column.

It is likely that the three anomalous samples (between 61,000 mg/L and 89,000 mg/L TDS) are as a result of lowering the bailer to the bottom of the hole resulting in a composite sample made up of a mix of more saline lake water and lower salinity island sediment water.

3.2.6.3 Island impacts

No direct impact from the long-term pump test was detected in the monitoring bores on the island adjacent to T13. A gradual decreasing water level trend was observed in the island monitoring bores which is associated with a seasonal water level fluctuation observed in all the on-lake monitoring piezometers.

4. Conclusions

Results from the two long term pumping tests were successful in providing drawdown data for the development of the lake groundwater model.

No directly obvious groundwater drawdown was observed within the piezometers installed on the lake islands during the pumping tests. All groundwater fluctuations on the islands are a result of seasonal fluctuations in response to rainfall infiltration and evapotranspiration process.

Trench and piezometer chemistry monitored through the wet season and during recharge events, indicates that the effects of dilution are limited, and the TDS concentration of the groundwater returns to baseline levels shortly after the inundation event. Sampling of the piezometers between T13 and the adjacent island was successful in identifying a decreasing salinity gradient toward the island.

On going monitoring of lake and island groundwater levels and regional and local precipitation will continue for the foreseeable future. Hydrographs will be updated on a quarterly basis.

Further island and riparian zone hydrogeological investigations, including drilling and pump testing are planned for 2021. Specific island groundwater models will also be developed.

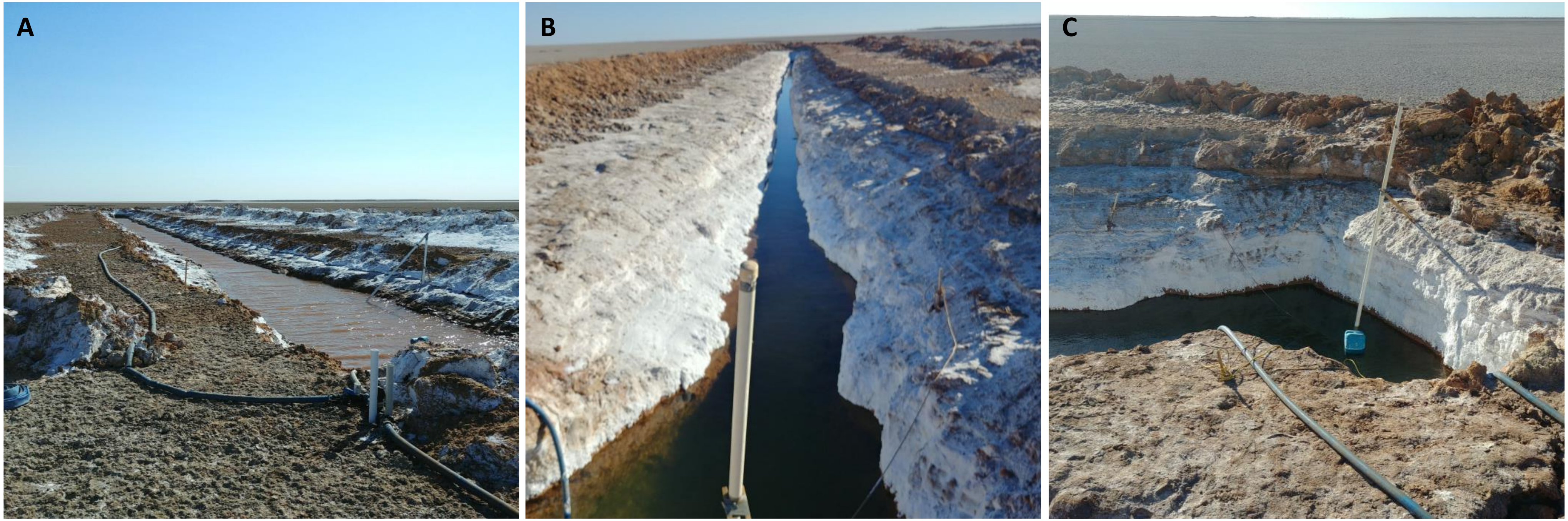

Plate 2: (A) T13 prior to commencing pumping test, (B) Water level during pumping test, (C) Trench monitoring piezometer.

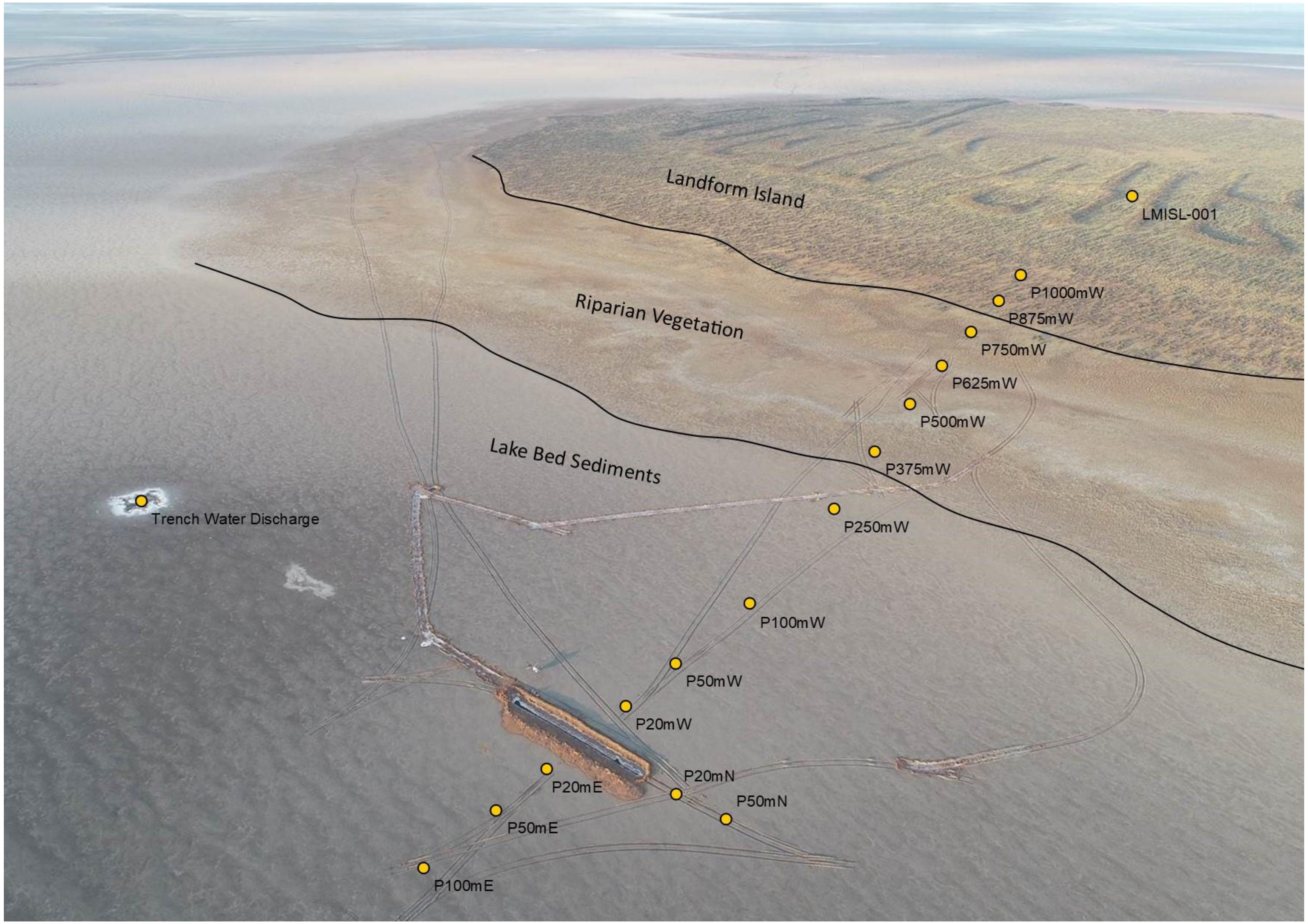

Figure 9 - T13 trench and piezometer layout

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5. Appendices

Appendix A- T02A location and piezometer layout.

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Appendix B – T13 location and piezometer layout

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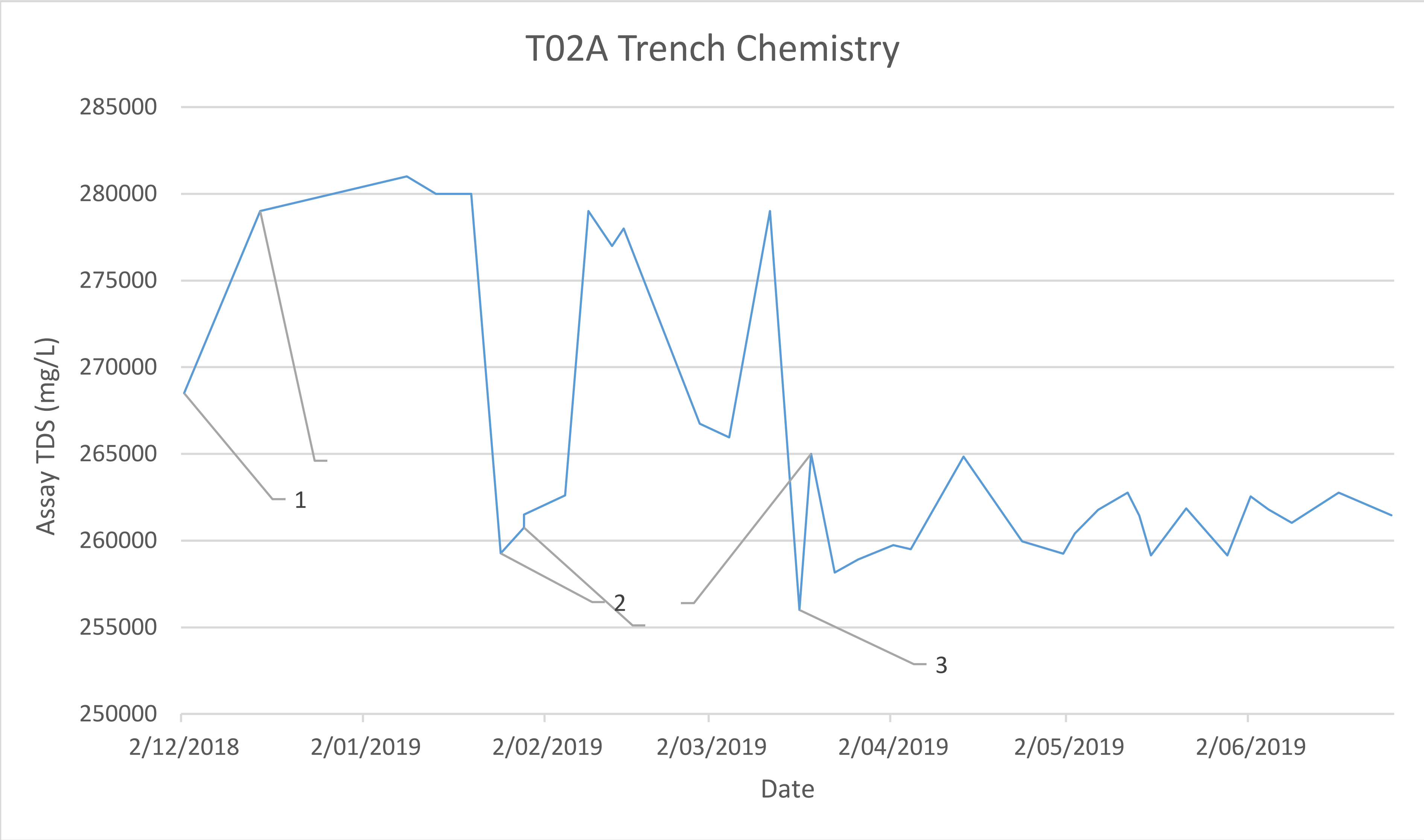
Appendix C – T02A pumping test trench chemistry



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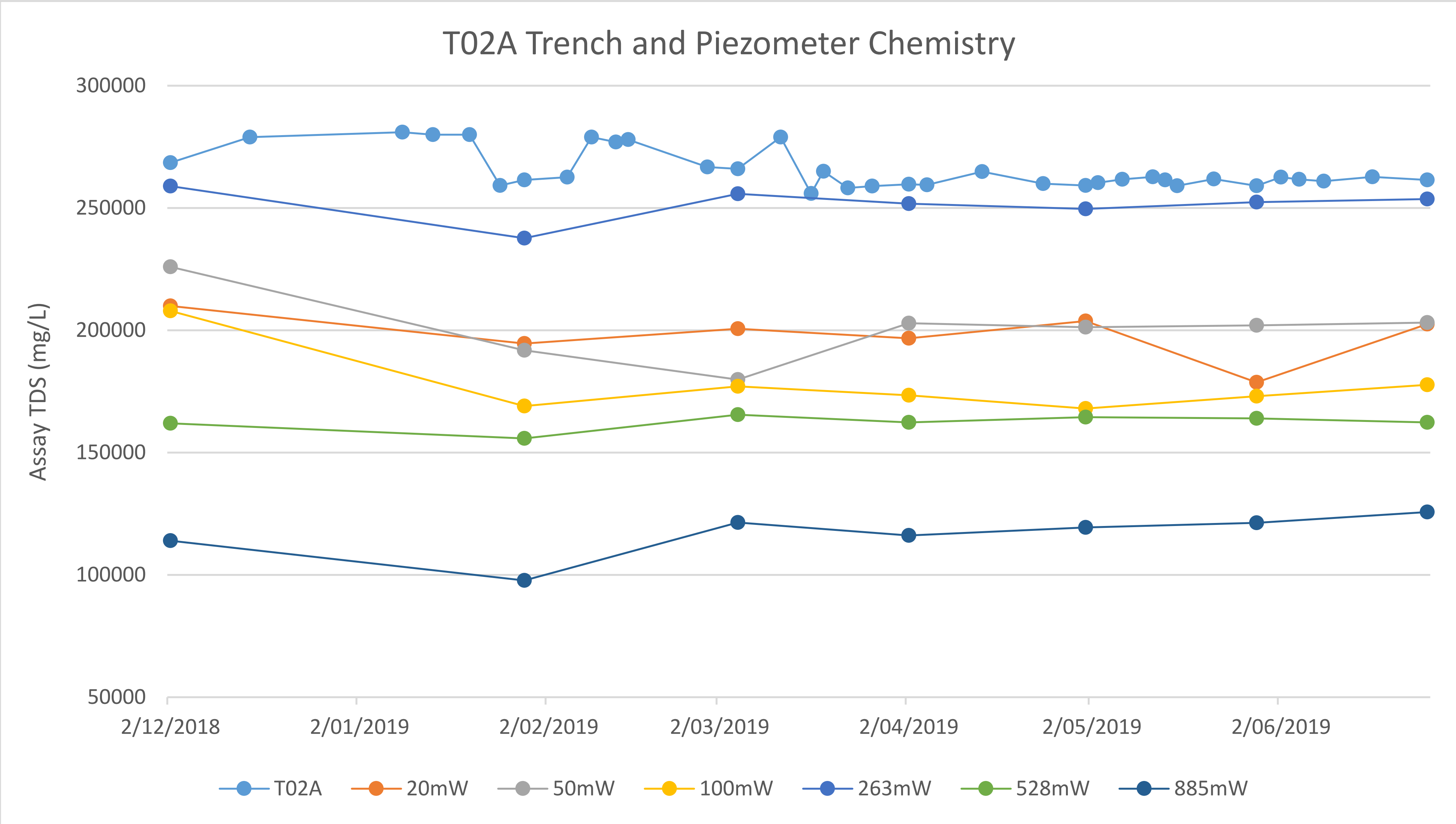
Appendix D – T02A piezometer chemistry



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Appendix E – Trench 13 chemistry

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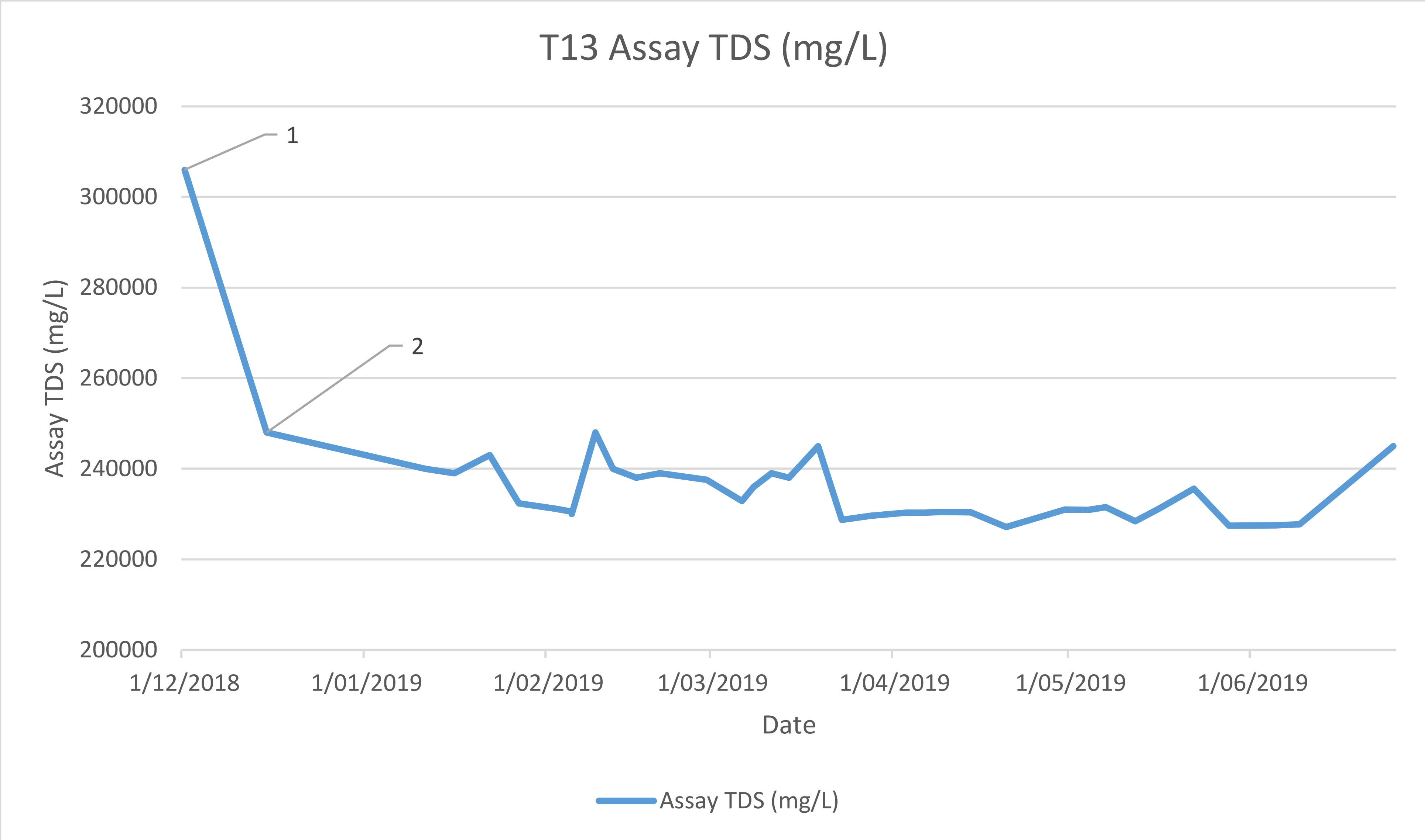

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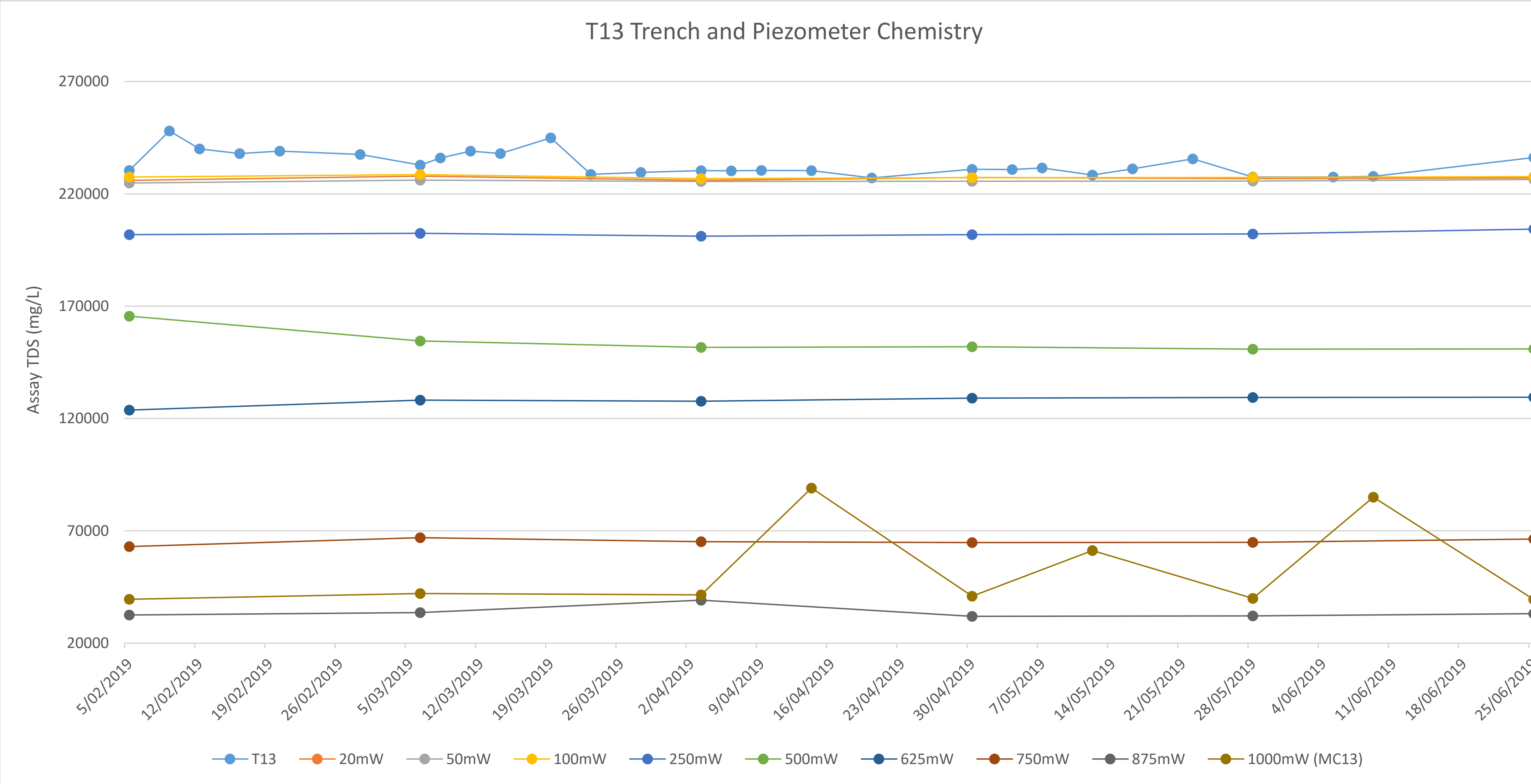
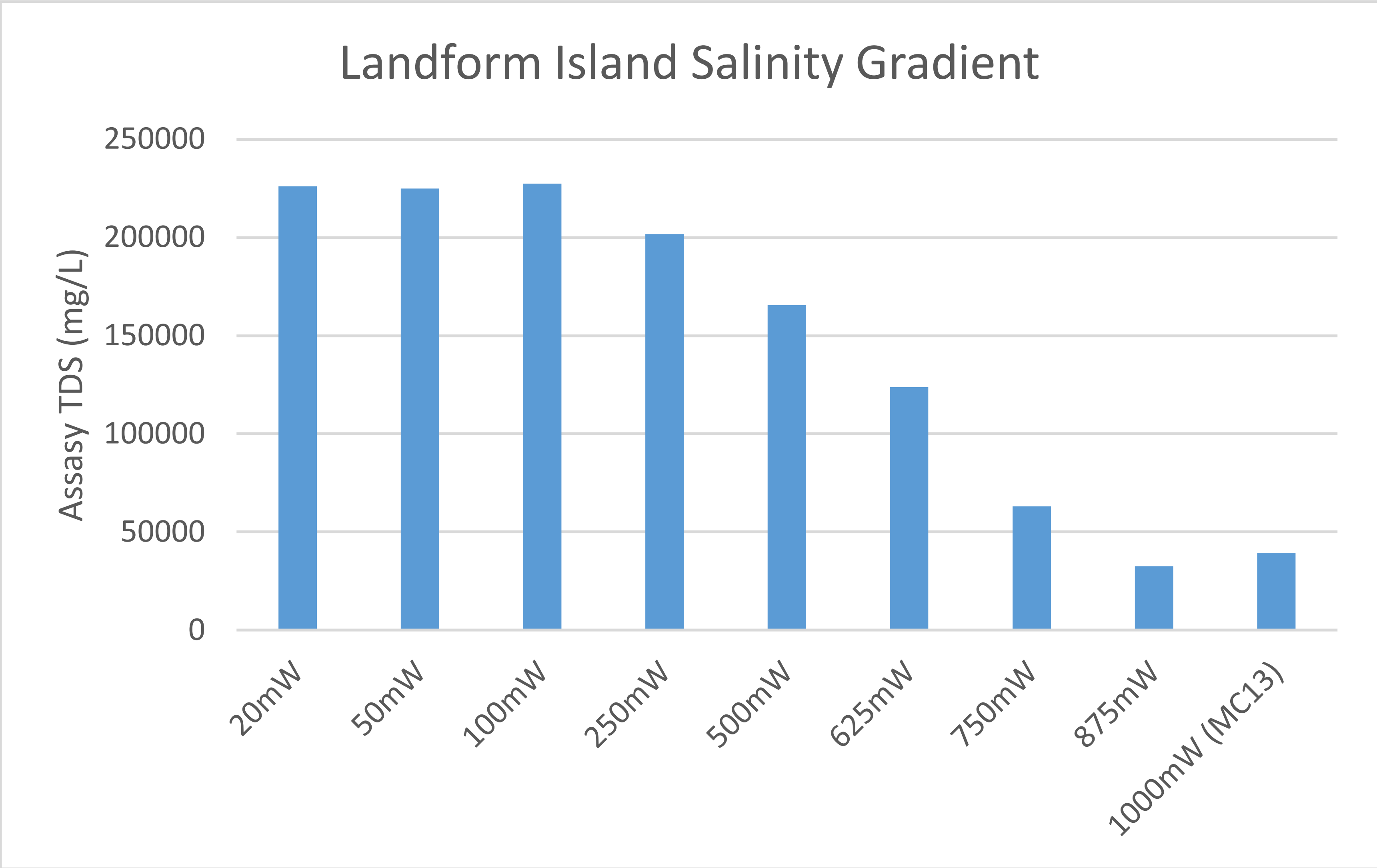
Appendix F – T13 trench and piezometer chemistry



Appendix G – T13 piezometer salinity gradient



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Appendix H – T02A piezometer salinity gradient