# Amungee NW 1-H petroleum well: Hydraulic fracturing and testing program, Water Quality Monitoring Results

## 1. Background

From 2015 to 2018, Origin Energy (Origin) conducted a water quality monitoring program at the Amungee NW 1-H exploration petroleum well site which is located in EP117 at Amungee Station in the Beetaloo Sub-basin. The objective of Origin's exploration program was to hydraulically fracture (HF) and test the Amungee NW 1-H (Horizontal) Exploration Well. The HF activity was conducted in ten stages in a horizontal well located in the target Velkerri reservoir zone approximately 2,160 m to 2,190 m total vertical depth (TVD) between 27 August and 7 September 2016. Approximately 10.6 megalitres (ML) of HF fluid (approximately 99% water and 1% chemicals) together with 1,135 tonnes of sand was pumped into the target zones via the Amungee NW 1-H exploration petroleum well at a maximum pressure of 10,000 psi in the ten HF stages.

After completion of the HF process, plugs that had been placed in the well to hold in the pumped HF fluid and sand after each stage were drilled out and the fluid, under pressure in the target reservoir, allowed to flowback to surface and via a separator and flare into a holding tank. Flowback sampling commenced on 29 September 2016 and was completed on 30 December 2016. The volume of flowback diminished over time and an increase in hydrocarbons from the reservoir to surface was recorded and flared in a well testing procedure. Approximately 1.96 ML (<20%) of the pumped HF fluid was recovered in the flowback period. The flowback water was evaporated to reduce volume at the end of the well testing operation and transported to Queensland for disposal at a licensed facility. The Amungee NW 1-H well was suspended in compliance with regulatory requirements at that time.

The water quality monitoring program tested for over 50 analytes of the HF fluid for each stage pumped (10 stages) and the flowback water (water produced from the petroleum well following hydraulic fracturing) on 16 sampling occasions from 29 September to 30 December 2016 at the Amungee well site.

A groundwater quality monitoring program was also conducted from the Amungee groundwater monitoring bore that intersects the Gum Ridge aquifer at the Amungee NW 1-H well site. Groundwater testing for over 60 analytes was undertaken on eight occasions commencing in September 2015 until June 2018.

The groundwater quaity results of particular interest from an environmental impact perspective include chloride, and electrical conductivity (E.C.) because these analytes are present in high concentrations in drilling fluids, hydraulic fracturing fluids, well suspension fluids and flowback. Concentrations may be orders of magnitude (100s~1000s) times higher than found in potable (drinkable) water.

Produced waters (including flowback following hydraulic fracturing) that come out of a petroleum well are characterised by high concentrations and mixtures of inorganic salts, organic compounds and other materials. They may contain Naturally-Occurring Radionuclide Material (NORM) from uranium and thorium decay in concentrations higher than routinely observed in environmental water samples. This decay is measured in Becquerels (Bq). One Becquerel is defined as the activity of a quantity of radioactive material in which one nucleus decays per second.

Other useful tracers include barium, boron and strontium which are also typically in higher concentrations in water from hydraulic fracturing activities and well above background values normally seen in groundwater. Dissolved methane is important to monitor as a baseline in groundwater at a well site and over the longer term to confirm petroleum well integrity. There is no guideline drinking water standard for methane, which may be naturally present in groundwater, because it is not toxic.

Drinking water guideline standards provide a useful reference point for groundwater quality baseline data. They are based on annual ingested volume of drinking-water, assumed to be 730 litres/year, and are generally a health safety-factor of ten lower than what is considered an intervention level which is that level at which authorities will then need to make a decision regarding the need to implement remedial measures or to place some restriction on the continued use of the water supply for drinking purposes. Certain standards such as chloride concentration are based on aesthetic rather than health measures.

## 2. Summary of Results

Table 1: Average **±** standard deviation for key analytes in groundwater at Amungee NW bore during monitoring program from eight sampling events from 15 September 2015 to 26 June 2018 compared to HF fluid and flowback fluid from the Amungee petroleum well.

| Key analyte | Drinking Water Guidance | Amungee NW water bore overall | Amungee NW water bore 2015-16 Baseline | Amungee NW water bore Post HF-2018 | HF Fluid 2016 | Flowback Fluid 2016 |
|---|---|---|---|---|---|---|
| **Electrical Conductivity (µS/cm)** | ~ 800 | 1207 ± 432 | 1210 | 1190 | 2,628 ± 836 | 52,056 ± 5,817 |
| **Chloride (mg/L)** | ~ 250 | 105 ± 22 | 103 ± 23 | 114 | 520 ± 22 | 20,887 ± 3,596 |
| **Barium (mg/L)** | 0.7 | 0.11 ± 0.08 | 0.11 ± 0.08 | < 0.01 | 0.091 ± 0.038 | 5.78 ± 14.9 |
| **Boron (mg/L)** | 4.0 | 0.17 ± 0.09 | 0.17 ± 0.09 | < 0.05 | 0.341 ± 0.13 | 63 ± 7.2 |
| **Gross alpha (Bq/L)** | 0.5 | N.A. | N.A. | N.A. | N.A. | 9.2 |
| **Gross beta (Bq/L)** | 1.0 | N.A. | N.A. | N.A. | N.A. | 5.2 |

Table 2: Average, Minimum and Maximum for key analytes in **HF Fluid** at Amungee NW-1 petroleum well from 10 sampling events 27 August 2016 to 7 September 2016.

| Key analyte | Average | Minimum | Maximum |
|---|---|---|---|
| **Electrical Conductivity (µS/cm)** | 2,623 | 2,510 | 2,880 |
| **Chloride (mg/L)** | 520 | 497 | 555 |
| **Barium (mg/L)** | 0.091 | 0.058 | 0.161 |
| **Boron (mg/L)** | 0.341 | 0.18 | 0.63 |

Table 3: Average, minimum and maximum for key analytes in **Flowback** at Amungee NW-1 petroleum well from 16 sampling events 29 September 2016 to 30 December 2016.

| Key analyte | Average | Minimum | Maximum |
|---|---|---|---|
| **Electrical Conductivity (µS/cm)** | 52,056 | 39,000 | 58,300 |
| **Chloride (mg/L)** | 20,888 | 13,600 | 25,400 |
| **Barium (mg/L)** | 5.78 | 1.2 | 8.37 |
| **Boron (mg/L)** | 63 | 30 | 80 |

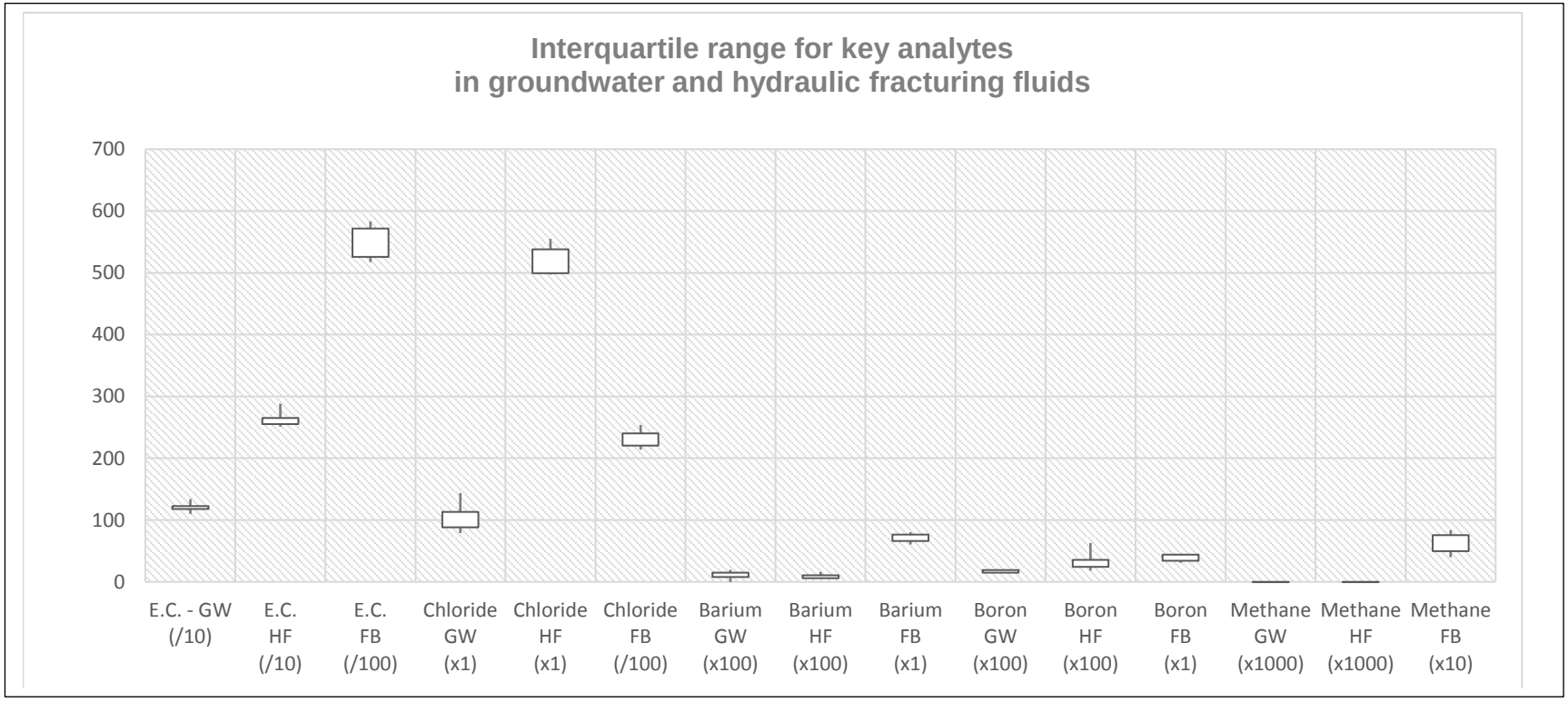


Figure 1: Interquartile range for key analytes in groundwater (GW), hydraulic fracturing fluid (HF) and flow back (FB) at Amungee NW-1 petroleum well. Note the scale factor for each analyte and source.

## 3. Interpretation of results

### Groundwater quality

The groundwater quality monitoring bore at the Amungee NW 1-H well site intersects the Gum Ridge aquifer which is the principle regional aquifer of the Cambrian Limestone aquifer system. The groundwater monitoring data acquired at Amungee NW 1-H prior to hydraulic fracturing in 2016 includes a range of inorganic and organic analytes of interest and also specified in the Code of Practice: Onshore Petroleum Activities in the Northern Territory (the Code) (2019).

Comparison of data acquired at this monitoring bore in subsequent years for the same analytes with the 2015 baseline data indicates that there has been no significant change in groundwater quality at this location based on the suite of more than 60 analytes tested prior to and following HF of the Amungee NW Petroleum Well. The results indicate that the hydraulic fracturing of the Amungee NW-1 petroleum well has not resulted in a detectable residual impact to the Gum Ridge aquifer in this location.

In the data reported in Appendix 1 chloride varied from 79 mg/L to 144 mg/L. The US EPA recommends chloride levels no higher than 250 mg/L to avoid salty tastes and undesirable odors. Corresponding E.C. monitoring data, which correlates with chloride as a proxy, ranged from 1,100 µS/cm to 1,340 µS/cm.

Barium varied from below detection limit of 0.001 mg/L to as high as 0.196 mg/L in the water bores. Recommended maximum level of barium in drinking water is 0.7 mg/L.

Contaminants of potential concern including heavy metals, hydrocarbons including methane, polyaromatic hydrocarbons (PAH) and BTEX are all below limits of reporting (LoR), i.e. not detectable, in the 2015-2018 data set from this bore.

### Hydraulic fracturing fluid

HF fluid was sampled on ten occasions (each HF stage) during hydraulic fracturing activity between 27 August 2016 and 7 September 2016. Results are shown in Appendix 2. Chloride varied from 499mg/L to 555mg/L and was almost double the chloride level in the Gum Ridge aquifer at this location, reflecting the addition of chloride to the HF fluid which is made up with bore water from the Amungee water bore. Corresponding E.C. monitoring data, which correlates with chloride as a proxy, ranged from 2,510 µS/cm to 2,880 µS/cm. Barium varied from 0.058 mg/L to 0.161 mg/L. Boron varied from 0.18 mg/L to 0.63 mg/L. The HF fluid was only mildly alkaline with pH 7.77 to 8.23.

### Flowback fluid

Flowback water was sampled at the wellhead prior to flaring and discharge into the holding tank. Results are shown in Appendix 2. The analysis shows pH was only slightly acidic with pH > 6.4 throughout the flowback period. E.C. increased from 40,600 µS/cm to 57,300 µS/cm during the flowback period. Similarly, chloride increased from 14,100 mg/L to 22,300 mg/L during flowback and was approximately 200 times the chloride concentration of the HF fluid and bore water. Chloride was approximately 80 times the drinking water guidance value. This is much higher than permitted drinking water or wastewater effluent standards and therefore needs to be appropriately managed.

This trend of increasingly extreme salinity (brine) and corresponding reduction in flowback volume over the first month of flowback is typical of shale reservoirs following hydraulic fracturing. The reason for this elevated salinity in flowback water is that the target “source-rock” shale (mudstone), in which the organic matter that forms petroleum was deposited and subsequently buried, occurred in a depositional nearshore marine environment; over one billion years ago in the case of the Beetaloo Sub-basin shales. It is also noted that chloride in seawater averages approximately 18,980 mg/L by comparison.

Barium is also typically elevated in flowback from shale gas reservoirs and serves, among other metals (e.g. strontium and boron), as an additional useful tracer. Marine deposition of barium is

reported to be as barite which is released into the deep ocean during the breakdown and mineralization of organic matter during the sediment burial process and hence is typically elevated in petroleum source-rock shales. Barium varied from 1.2 mg/L to 8.37 mg/L during the flowback and was approximately 60 times the barium concentration of the HF fluid and groundwater. Barium was approximately 8 times the drinking water guidance value.

Boron varied from 30 mg/L to 80 mg/L during the flowback and was approximately 600 times the boron concentration of the groundwater. Boron was approximately 15 times the drinking water guidance value.

As expected in flowback from a hydrocarbon reservoir, elevated volatile organic carbon (VOC) levels were reported (Appendix 2) including dissolved methane, which varied from 1.2 mg/L to 8.37 mg/L in the flowback but prior to flaring. However, no sampling of the composite total flowback water in the tank was conducted.

**Range Comparison of Key analytes in Groundwater and HF Fluids**

A range comparison of key analytes in groundwater (GW), hydraulic fracturing fluid (HF) and flow back (FB) at Amungee NW-1 petroleum well is shown graphically in Figure 1. Note the scale factor for each analyte and source. For example chloride range for FB is divided by 100 whereas GW and HF have a scale factor of 1. The interpretation of results using this graphical method is helpful in visually exploring the data by comparing ranges and range overlap for each analyte in GW, HF and FB. For example the range of electrical conductivity and chloride values measured in groundwater at the well site before, during and (years) after the Amungee NW well operations is significantly lower than both the HF fluid and orders of magnitude lower than FB fluid indicating that contamination of the groundwater at the well site from the HF operations is not detectable. A similar pattern can be seen for other key analytes in Figure 1. The conclusion from this data analysis is that there has been no material change detected in background values of groundwater quality attributable to well operations at the Amungee NW wellsite from 15 September 2015 to 26 June 2018.

**Approximate Composition of Flowback fluid**

In terms of approximate composition, the flowback was found to be comprised of approximately 93% sodium chloride, 5.3% calcium carbonate, 0.8% magnesium chloride, 0.25% barium sulphate, 0.2% potassium chloride and 0.12% boron, which accounts for 99.67% of the flowback constituents (Fig.2).

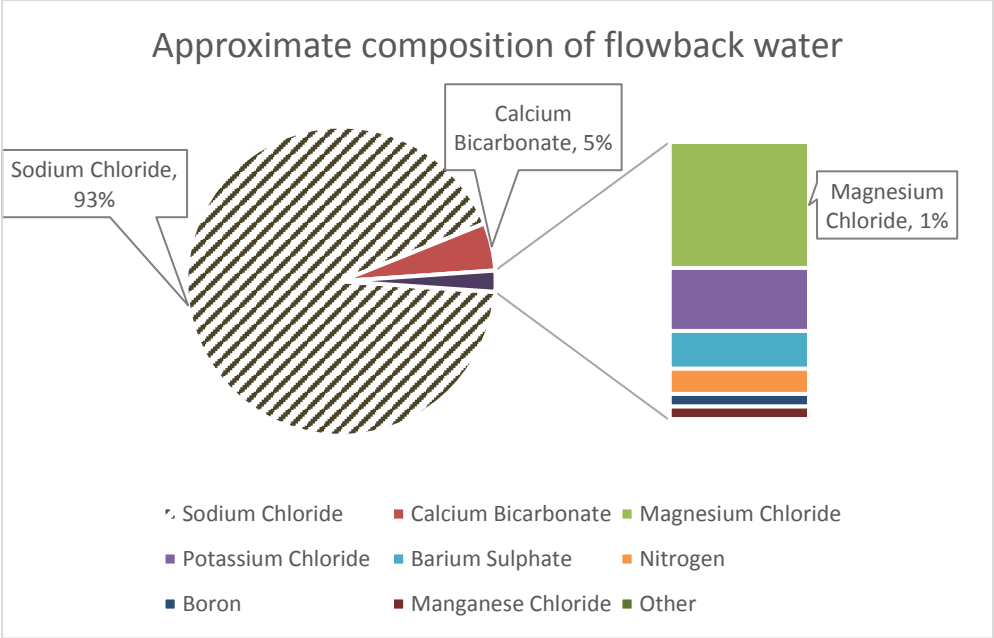


Figure 2: Approximate composition of Amungee flowback water

Contaminants of potential concern in the flowback water, due to their persistence and higher toxicity in the environment, including heavy metals (such as arsenic, cadmium, chromium and mercury), polyaromatic hydrocarbons (such as Benzo(a)pyrene) were all below limits of reporting (LoR), i.e. not detectable.

NORM measurements in groundwater from the Gum Ridge aquifer at Amungee were not conducted. However, one NORM measurement from flowback was 9.2 Bq/L for Gross alpha and and 5.2 Bq/L for Gross beta. This is eighteen times and five times the drinking water guidelines respectively. NORMs commonly precipitate in the flowback tank and accompany non-NORM solids that have been produced with the flowback. For normal exposure situations, it is usually unnecessary to regulate materials with radionuclides of natural origin with activity concentrations below 1000 Bq/kg (ARPANSA, 2008).

In contrast more recent NORM baseline measurements conducted in the Gum Ridge aquifer in the Beetaloo Sub basin (see DENR 2019 Report) reported Gross alpha levels that were as high as four times the drinking water guidelines. This underlines the importance of multiple sampling events for water quality in assessing risk.

The flowback water quality data reported here is consistent with flowback water quality data provided by Falcon Oil from the nearby Shenandoah HF program in the Beetaloo sub-basin in 2011.

The Amungee NW 1-H results are similar to those reported in major studies of flowback from shale plays in North America (Hayes, 2009; Gandhi et al, 2018).

DENR has requested the interest holder to conduct further monitoring at the groundwater bore at Amungee NW 1-H petroleum exploration well site in 2019 for the range of inorganic and organic analytes specified in the Code of Practice: Onshore Petroleum Activities in the Northern Territory (the Code) (2019) to confirm no residual impact from the 2016 HF activities. The residue following evaporation of flowback water is considered a listed waste and therefore must be managed under listed waste provisions of the Waste Management and Pollution Control Act (1998).

## 4. Concluding summary points

- HF activities were conducted in 10 stages at the Amungee NW 1-H petroleum exploration well between 27 August and 7 September, 2016. Approximately 10.6 ML of HF fluid and 1,135 tonnes of sand were pumped into the target reservoir more than 2.0 km below the surface.
- HF fluid and flowback water from the target reservoir in the HF operation were tested for more than 50 analytes during the HF operation and flowback period which ended in December 2016.
- Results indicated that flowback water had approximately 80 times the level of chloride, 8 times the level of barium and 15 times the level of boron respectively of Gum Ridge aquifer values at the well site.
- Groundwater from the Gum Ridge aquifer was tested for over 60 analytes at the Amungee bore undertaken on 8 occasions commencing in September 2015 up until June 2018. No significant changes in groundwater quality were observed in the groundwater quality at the bore.
- The conclusion from graphical range analysis of key analytes in groundwater, hydraulic fracturing fluid and flowback fluid is that there has been no material change detected in natural background values of groundwater quality attributable to well operations at the Amungee NW wellsite.
- Contaminants of potential concern in the flowback water, due to their persistence and higher toxicity in the environment, including heavy metals (such as arsenic, cadmium, chromium and mercury), polyaromatic hydrocarbons (such as Benzo-a-pyrene) were all below limits of reporting i.e. not detectable.
- One NORM measurement was conducted in flowback for Gross alpha which was 9.2 Bq/L

and Gross beta which was 5.2 Bq/L. For normal exposure situations, it is usually unnecessary to regulate materials with radionuclides of natural origin with activity concentrations below 1000 Bq/kg.

- In terms of approximate composition, the flowback was found to be comprised of approximately 93% sodium chloride, 5.3% calcium carbonate, 0.8% magnesium chloride, 0.25% barium sulphate, 0.2% potassium chloride and 0.12% boron, which accounts for 99.67% of the flowback water.
- DENR has requested the interest holder to conduct further monitoring at the groundwater bore at Amungee NW 1-H petroleum exploration well site in 2019 for the range of inorganic and organic analytes specified in the Code of Practice: Onshore Petroleum Activities in the Northern Territory (the Code) (2019) to confirm no residual impact from the 2016 HF activities.

## References

ARPANSA 2008. Safety Guide for the Management of Naturally Occurring Radioactive Material (NORM), Radiation Protection Series No. 15. Commonwealth of Australia

Hayes, T, 2009, *Sampling and Analysis of Water Streams Associated with the Development of Marcellus Shale Gas Final Report* (www.**water**-research.net/naturalgasPA/pdffiles/MSCommission-Report.pdf (PDF file)).

Gandhi, H R, Sadiq, G, Hu and K Hewage, 2018, *Ecological risk assessment of accidental release of flowback water: A conceptual framework. Journal Human and Ecological Risk Assessment* 24(2): 398 to 426.

## Acronyms, initialisms and glossary

| | |
|---|---|
| HF | Hydraulic fracture |
| LoR | Limits of Reporting |
| NORM | Naturally Occurring Radionuclide Material |
| NTU | Nephelometric turbidity units |
| PAH | Poly-aromatic hydrocarbons |
| VOC | Volatile Organic Carbon |

## Units and symbols

| | |
|---|---|
| % | Percentage |
| Bq/L | Becquerel per litre |
| mg/L | Milligrams per litre |
| µg/L | Micrograms per litre |
| ML | Mega litres |
| psi | Pounds per square inch |
| µS/cm | Micro Siemens/centimetre |

# Appendix 1: Amungee – Groundwater quality monitoring bores

| ANALYTE | Unit | EQL | 15-Sep-15 | 22-Sep-15 | 01-Oct-15 | 14-Apr-16 | 31-Jul-16 | 11-Sep-16 | 02-Oct-17 | 26-Jun-18 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Electrical Conductivity (Lab)** | µS/cm | 1 | 1340 | 1220 | 1200 | 1100 | 1170 | 1230 | - | 1190 |
| **Alkalinity (Bicarbonate) as CaCO3** | mg/L | 1 | 369 | 355 | 357 | 399 | 418 | 422 | 432 | 413 |
| **Alkalinity (Carbonate) as CaCO3** | mg/L | 1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| **Alkalinity (Hydroxide) as CaCO3** | mg/L | 1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| **Alkalinity (Total) as CaCO3** | mg/L | 1 | 369 | 355 | 357 | 399 | 418 | 422 | 419 | 413 |
| **Anions Total** | meq/L | 0.01 | 14.2 | 13 | 12.7 | 13.6 | 13.3 | 13.3 | 13.3 | 14.3 |
| **Bicarbonate** | mg/L | | 450 | 433 | 436 | 487 | 510 | 515 | - | - |
| **Carbonate** | mg/L | | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | - | - |
| **Cations Total** | meq/L | 0.01 | 14.4 | 13.4 | 12.4 | 13.3 | 12.9 | 13.1 | 13.1 | 13.3 |
| **Chloride** | mg/L | 1 | 144 | 112 | 107 | 86 | 91 | 79 | - | 114 |
| **Ionic Balance** | % | 0.01 | 0.53 | 1.77 | 1.26 | 1.12 | 1.56 | 0.5 | -0.5 | 3.66 |
| **pH (Lab)** | pH_Units | 0.01 | 7.93 | 8.11 | 7.65 | 7.54 | 7.63 | 7.45 | - | 7.57 |
| **Total Dissolved Solids** | mg/L | 10 | 788 | 726 | 755 | 717 | 752 | 744 | 761 | 734 |
| **METALS** | | | | | | | | | | |
| **Arsenic** | mg/L | 0.002 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | - |
| **Barium** | mg/L | 0.001 | 0.196 | 0.147 | 0.129 | 0.078 | 0.000 | <.001 | <.001 | - |
| **Boron** | mg/L | 0.05 | 0.15 | 0.2 | 0.19 | 0.15 | <0.05 | <0.05 | <0.05 | - |
| **Cadmium** | mg/L | 0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | - |
| **Chromium (III+VI)** | mg/L | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | - |
| **Cobalt** | mg/L | 0.001 | 0.003 | 0.004 | 0.002 | <0.001 | <0.001 | <0.001 | <0.001 | - |
| **Copper** | mg/L | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | - |
| **Fluoride** | mg/L | 0.001 | 1 | 0.5 | 0.5 | 1.2 | 0.5 | - | - | - |
| **Lead** | mg/L | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | - |
| **Manganese** | mg/L | 0.001 | 0.562 | 0.322 | 0.164 | 0.002 | - | - | - | - |
| **Mercury** | mg/L | 0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | - |
| **Nickel** | mg/L | 0.001 | 0.006 | 0.005 | 0.004 | <0.001 | <0.001 | <0.001 | <0.001 | - |
| **Selenium** | mg/L | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | - |
| **Vanadium** | mg/L | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | - |
| **Zinc** | mg/L | 0.005 | 0.012 | 0.010 | 0.012 | 0.016 | 0.013 | - | - | - |
| **HYDROCARBONS** | | | | | | | | | | |
| Methane | mg/L | 0.001 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | - | <0.01 |
| **Acenaphthene** | 1 | µg/L | <1 | <1 | <1 | <1 | <1 | <1 | - | <1 |
| **Acenaphthylene** | 1 | µg/L | <1 | <1 | <1 | <1 | <1 | <1 | - | <1 |
| **Anthracene** | 1 | µg/L | <1 | <1 | <1 | <1 | <1 | <1 | - | <1 |
| **Benz(a)anthracene** | 1 | µg/L | <1 | <1 | <1 | <1 | <1 | <1 | - | <1 |
| **Benzo(a) pyrene** | 1 | µg/L | <1 | <1 | <1 | <1 | <1 | <1 | - | <1 |
| **Benzo(b)fluoranthene** | 1 | µg/L | <1 | <1 | <1 | <1 | <1 | <1 | - | <1 |
| **Benzo(g,h,i)perylene** | 1 | µg/L | <1 | <1 | <1 | <1 | <1 | <1 | - | <1 |
| **Benzo(k)fluoranthene** | 1 | µg/L | <1 | <1 | <1 | <1 | <1 | <1 | - | <1 |
| **Chrysene** | 1 | µg/L | <1 | <1 | <1 | <1 | <1 | <1 | - | <1 |
| **Dibenz(a,h)anthracene** | 1 | µg/L | <1 | <1 | <1 | <1 | <1 | <1 | - | <1 |
| **Fluoranthene** | 0.5 | µg/L | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | - | <0.5 |
| **Fluorene** | 1 | µg/L | <1 | <1 | <1 | <1 | <1 | <1 | - | <1 |
| **Indeno(1,2,3-c,d)pyrene** | 1 | µg/L | <1 | <1 | <1 | <1 | <1 | <1 | - | <1 |
| **Naphthalene** | 1 | µg/L | <1 | <1 | <1 | <1 | <1 | <1 | - | <1 |
| **Phenanthrene** | 1 | µg/L | <1 | <1 | <1 | <1 | <1 | <1 | - | <1 |
| **Pyrene** | 0.5 | µg/L | <1 | <1 | <1 | <1 | <1 | <1 | - | <1 |
| **TPH C6 - C9** | 20 | µg/L | <20 | <20 | <20 | <20 | <20 | <20 | - | <20 |
| **TPH C10 - C14** | 50 | µg/L | <50 | <50 | <50 | <50 | <50 | <50 | - | <50 |
| **TPH C15 - C28** | 100 | µg/L | <100 | <100 | <100 | <100 | <100 | <100 | - | <100 |
| **TPH C29-C36** | 50 | µg/L | <50 | <50 | <50 | <50 | <50 | <50 | - | <50 |
| **TPH+C10 - C36 (Sum of total)** | 50 | µg/L | <50 | <50 | <50 | <50 | <50 | <50 | - | <50 |
| **TPH C10 - C40 (Sum of total)** | 100 | µg/L | <100 | <100 | <100 | <100 | <100 | <100 | - | <100 |
| **TPH C10-C16** | 0.1 | mg/L | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | - | <0.1 |
| **TPH C16-C34** | 0.1 | mg/L | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | - | <0.1 |
| **TPH C34-C40** | 0.1 | mg/L | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | - | <0.1 |
| **TPH C6-C10** | 0.02 | mg/L | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | - | <0.02 |
| **Benzene** | 1 | µg/L | <1 | <1 | <1 | <1 | <1 | <1 | - | <1 |
| **Toluene** | 2 | µg/L | <2 | <2 | <2 | <2 | <2 | <2 | - | <2 |
| **Ethylbenzene** | 2 | µg/L | <2 | <2 | <2 | <2 | <2 | <2 | - | <2 |
| **meta- & para-Xylene** | 2 | µg/L | <2 | <2 | <2 | <2 | <2 | <2 | - | <2 |
| **ortho-Xylene** | 2 | µg/L | <2 | <2 | <2 | <2 | <2 | <2 | - | <2 |
| **^ Total Xylenes** | 2 | µg/L | <2 | <2 | <2 | <2 | <2 | <2 | - | <2 |

**= Analytes of interest in groundwater monitoring at petroleum well sites due to their naturally high levels in petroleum reservoirs and flowback**

# Appendix 2: Amungee – Flow back analysis

| Analyte | Unit | EQL | Flow back 29-Sep-16 | Flow back 05-Oct-16 | Flow back 07-Oct-16 | Flow back 22-Oct-16 | Flow back 25-Oct-16 | Flow back 30-Oct-16 | Flow back 02-Nov-16 | Flow back 05-Nov-16 | Flow back 08-Nov-16 | Flow back 11-Nov-16 | Flow back 17-Nov-16 | Flow back 20-Nov-16 | Flow back 23-Dec-16 | Flow back 26-Dec-16 | Flow back 28-Dec-16 | Flow back 30-Dec-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **INORGANICS** | | | | | | | | | | | | | | | | | | |
| Electrical Conductivity (Lab) | µS/cm | 1 | 40600 | 39000 | 44100 | 52600 | 53500 | 57300 | 57000 | 57300 | 58300 | 54400 | 54800 | 54900 | 51700 | 52300 | 52800 | 52300 |
| Alkalinity (Bicarbonate) as CaCO3 | mg/L | 1 | 474 | 716 | 540 | 566 | 556 | 498 | 465 | 441 | 342 | 364 | 364 | 390 | 377 | 371 | 367 | 384 |
| Alkalinity (Carbonate) as CaCO3 | mg/L | 1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Alkalinity (Hydroxide) as CaCO3 | mg/L | 1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Alkalinity (Total) as CaCO3 | mg/L | 1 | 474 | 716 | 540 | 566 | 556 | 498 | 465 | 441 | 342 | 364 | 364 | 390 | 377 | 371 | 367 | 384 |
| Anions Total | meq/L | 0.01 | 408 | 398 | 443 | 556 | 575 | 622 | 633 | 638 | 644 | 639 | 684 | 685 | 628 | 684 | 611 | 724 |
| Bicarbonate | mg/L | | 578.28 | 873.52 | 658.8 | 690.52 | 678.32 | 607.56 | 567.3 | 538.02 | 417.24 | 444.08 | 444.08 | 475.8 | 459.94 | 452.62 | 447.74 | 468.48 |
| Calcium (Filtered) | mg/L | 1 | 853 | 774 | 980 | 1200 | 1210 | 1270 | 1330 | 1380 | 1380 | 1320 | 1400 | 1410 | 1600 | 1650 | 1740 | 1740 |
| Carbonate | mg/L | | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| Cations Total | meq/L | 0.01 | 464 | 446 | 503 | 555 | 551 | 640 | 666 | 688 | 688 | 599 | 612 | 617 | 674 | 686 | 718 | 713 |
| Chloride | mg/L | 1 | 14100 | 13600 | 15300 | 19300 | 20000 | 21700 | 22100 | 22300 | 22600 | 22400 | 24000 | 24000 | 22000 | 24000 | 21400 | 25400 |
| Fluoride | mg/L | 0.1 | 1.2 | 1.2 | 1.1 | 1.1 | 1.1 | 1.2 | 1.2 | 1.2 | 1.2 | 1.1 | 1.1 | 1.1 | 1 | 1.1 | 1.1 | 1.1 |
| Ionic Balance | % | 0.01 | 6.43 | 5.65 | 6.35 | 0.08 | 2.14 | 1.46 | 2.56 | 3.76 | 3.25 | 3.25 | 5.54 | 5.23 | 3.51 | 0.1 | 8.02 | 0.77 |
| Kjeldahl Nitrogen Total | mg/L | 0.1 | 52.2 | 51.6 | 50.6 | 61.3 | 59.4 | 57.3 | 55.5 | 56.3 | 55.2 | 55.1 | 50.1 | 54.8 | 58 | 60 | 61.5 | 62.1 |
| Magnesium (Filtered) | mg/L | 1 | 147 | 133 | 165 | 233 | 235 | 277 | 284 | 306 | 305 | 271 | 282 | 275 | 272 | 283 | 295 | 295 |
| Methane | mg/L | 0.001 | 1.2 | 6.29 | 5.39 | 6.5 | 6.49 | 3.99 | 4.29 | 5.41 | 5.27 | 4.76 | 5.22 | 6.48 | 7.35 | 8.37 | 7.75 | 7.72 |
| Nitrite + Nitrate (as N) | mg/L | 0.01 | 0.04 | 0.26 | 0.17 | <0.01 | <0.01 | 0.02 | 0.01 | 0.02 | 0.01 | <0.01 | 0.04 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Nitrogen (Total) | mg/L | 0.1 | 52.2 | 51.9 | 50.8 | 61.3 | 59.4 | 57.3 | 55.5 | 56.3 | 55.2 | 55.1 | 50.1 | 54.8 | 58 | 60 | 61.5 | 62.1 |
| pH (Lab) | pH_Units | 0.01 | 6.54 | 6.74 | 6.63 | 6.51 | 6.55 | 6.47 | 6.43 | 6.43 | 6.39 | 6.5 | 6.4 | 6.44 | 6.56 | 6.5 | 6.5 | 6.5 |
| Phosphorus | mg/L | 0.01 | 0.41 | 1.07 | 0.47 | <0.1 | 0.15 | 0.16 | 0.12 | 0.1 | 0.06 | <0.05 | <0.05 | 0.3 | <0.05 | <0.05 | 0.1 | <0.05 |
| Potassium | mg/L | 0.01 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Potassium (Filtered) | mg/L | 1 | 55 | 58 | 60 | 64 | 65 | 76 | 80 | 83 | 83 | 70 | 70 | 69 | 68 | 67 | 70 | 70 |
| Sodium (Filtered) | mg/L | 1 | 9370 | 9080 | 10100 | 10900 | 10800 | 12700 | 13200 | 13600 | 13600 | 11700 | 11900 | 12000 | 13100 | 13300 | 13900 | 13800 |
| Sulphate as SO4 (Filtered) | mg/L | 1 | 20 | 17 | 42 | <1 | <1 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| Total Dissolved Solids | mg/L | 10 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Total Dissolved Solids (Filtered) | mg/L | 10 | 33600 | 30400 | 32300 | 37700 | 31800 | 45500 | 45300 | 45600 | 44300 | 44200 | 46600 | 49200 | 42000 | 44200 | 44800 | 44500 |
| Total Dissolved Solids (Calc.) | mg/L | 1 | 26400 | 25400 | 28700 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Total Dissolved Solids (Calculated) | mg/L | 1 | - | - | - | 34200 | 34800 | 37200 | 37000 | 37200 | 37900 | 35400 | 35600 | 35700 | 33600 | 34000 | 34300 | 34000 |
| Total Hardness as CaCO3 (Filtered) | mg/L | 1 | 2740 | 2480 | 3130 | 3960 | 3990 | 4310 | 4490 | 4700 | 4700 | 4410 | 4660 | 4650 | 5120 | 5280 | 5560 | 5560 |
| **METALS** | | | | | | | | | | | | | | | | | | |
| Arsenic (Filtered) | mg/L | 0.001 | 0.084 | 0.011 | <0.01 | <0.01 | <0.01 | <0.01 | 0.011 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Barium (Filtered) | mg/L | 0.001 | 35.6 | 30.5 | 42 | 63.5 | 68.4 | 68.8 | 74.8 | 77.8 | 68.5 | 60.7 | 65.7 | 66.5 | 66.2 | 71.6 | 77.8 | 80.1 |
| Beryllium (Filtered) | mg/L | 0.001 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Boron (Filtered) | mg/L | 0.05 | 50.9 | 54.5 | 49.4 | 40 | 41.1 | 45.4 | 44 | 43.9 | 45.4 | 34.6 | 33.1 | 34.8 | 35.1 | 34.2 | 31 | |
| Cadmium (Filtered) | mg/L | 0.0001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Chromium (III+VI) (Filtered) | mg/L | 0.001 | 0.035 | 0.048 | 0.034 | 0.032 | 0.03 | 0.031 | 0.032 | 0.033 | 0.031 | 0.01 | 0.015 | 0.013 | 0.025 | 0.028 | 0.031 | 0.029 |
| Cobalt (Filtered) | mg/L | 0.001 | 0.011 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Copper (Filtered) | mg/L | 0.001 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Lead (Filtered) | mg/L | 0.001 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Manganese (Filtered) | mg/L | 0.001 | 1.82 | 1.95 | 1.8 | 2.34 | 2.44 | 2.74 | 2.9 | 3.09 | 2.4 | 2.26 | 2.42 | 2.53 | 2.31 | 2.56 | 2.64 | 2.75 |
| Mercury (Filtered) | mg/L | 0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| Nickel (Filtered) | mg/L | 0.001 | 0.04 | 0.012 | 0.01 | 0.014 | 0.018 | 0.018 | 0.014 | <0.01 | 0.012 | 0.018 | <0.01 | 0.028 | 0.021 | 0.017 | <0.01 | <0.01 |
| Selenium (Filtered) | mg/L | 0.01 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Vanadium (Filtered) | mg/L | 0.01 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Zinc (Filtered) | mg/L | 0.005 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| Gross alpha | Bq/L | 0.05 | | | | | | | | | | | 9.22 | | | | | |
| Gross beta | Bq/L | 0.10 | | | | | | | | | | | 5.22 | | | | | |

# Appendix 2: Amungee – Flow back analysis

| Analyte | Unit | EQL | Flow back 29-Sep-16 | Flow back 05-Oct-16 | Flow back 07-Oct-16 | Flow back 22-Oct-16 | Flow back 25-Oct-16 | Flow back 30-Oct-16 | Flow back 02-Nov-16 | Flow back 05-Nov-16 | Flow back 08-Nov-16 | Flow back 11-Nov-16 | Flow back 17-Nov-16 | Flow back 20-Nov-16 | Flow back 23-Dec-16 | Flow back 26-Dec-16 | Flow back 28-Dec-16 | Flow back 30-Dec-16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **INORGANICS** | | | | | | | | | | | | | | | | | | |
| Electrical Conductivity (Lab) | µS/cm | 1 | 40600 | 39000 | 44100 | 52600 | 53500 | 57300 | 57000 | 57300 | 58300 | 54400 | 54800 | 54900 | 51700 | 52300 | 52800 | 52300 |
| Alkalinity (Bicarbonate) as CaCO3 | mg/L | 1 | 474 | 716 | 540 | 566 | 556 | 498 | 465 | 441 | 342 | 364 | 364 | 390 | 377 | 371 | 367 | 384 |
| Alkalinity (Carbonate) as CaCO3 | mg/L | 1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Alkalinity (Hydroxide) as CaCO3 | mg/L | 1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Alkalinity (Total) as CaCO3 | mg/L | 1 | 474 | 716 | 540 | 566 | 556 | 498 | 465 | 441 | 342 | 364 | 364 | 390 | 377 | 371 | 367 | 384 |
| Anions Total | meq/L | 0.01 | 408 | 398 | 443 | 556 | 575 | 622 | 633 | 638 | 644 | 639 | 684 | 685 | 628 | 684 | 611 | 724 |
| Bicarbonate | mg/L | | 578.28 | 873.52 | 658.8 | 690.52 | 678.32 | 607.56 | 567.3 | 538.02 | 417.24 | 444.08 | 444.08 | 475.8 | 459.94 | 452.62 | 447.74 | 468.48 |
| Calcium (Filtered) | mg/L | 1 | 853 | 774 | 980 | 1200 | 1210 | 1270 | 1330 | 1380 | 1380 | 1320 | 1400 | 1410 | 1600 | 1650 | 1740 | 1740 |
| Carbonate | mg/L | | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| Cations Total | meq/L | 0.01 | 464 | 446 | 503 | 555 | 551 | 640 | 666 | 688 | 688 | 599 | 612 | 617 | 674 | 686 | 718 | 713 |
| Chloride | mg/L | 1 | 14100 | 13600 | 15300 | 19300 | 20000 | 21700 | 22100 | 22300 | 22600 | 22400 | 24000 | 24000 | 22000 | 24000 | 21400 | 25400 |
| Fluoride | mg/L | 0.1 | 1.2 | 1.2 | 1.1 | 1.1 | 1.1 | 1.2 | 1.2 | 1.2 | 1.2 | 1.1 | 1.1 | 1.1 | 1 | 1.1 | 1.1 | 1.1 |
| Ionic Balance | % | 0.01 | 6.43 | 5.65 | 6.35 | 0.08 | 2.14 | 1.46 | 2.56 | 3.76 | 3.25 | 3.25 | 5.54 | 5.23 | 3.51 | 0.1 | 8.02 | 0.77 |
| Kjeldahl Nitrogen Total | mg/L | 0.1 | 52.2 | 51.6 | 50.6 | 61.3 | 59.4 | 57.3 | 55.5 | 56.3 | 55.2 | 55.1 | 50.1 | 54.8 | 58 | 60 | 61.5 | 62.1 |
| Magnesium (Filtered) | mg/L | 1 | 147 | 133 | 165 | 233 | 235 | 277 | 284 | 306 | 305 | 271 | 282 | 275 | 272 | 283 | 295 | 295 |
| Methane | mg/L | 0.001 | 1.2 | 6.29 | 5.39 | 6.5 | 6.49 | 3.99 | 4.29 | 5.41 | 5.27 | 4.76 | 5.22 | 6.48 | 7.35 | 8.37 | 7.75 | 7.72 |
| Nitrite + Nitrate (as N) | mg/L | 0.01 | 0.04 | 0.26 | 0.17 | <0.01 | <0.01 | 0.02 | 0.01 | 0.02 | 0.01 | <0.01 | 0.04 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Nitrogen (Total) | mg/L | 0.1 | 52.2 | 51.9 | 50.8 | 61.3 | 59.4 | 57.3 | 55.5 | 56.3 | 55.2 | 55.1 | 50.1 | 54.8 | 58 | 60 | 61.5 | 62.1 |
| pH (Lab) | pH_Units | 0.01 | 6.54 | 6.74 | 6.63 | 6.51 | 6.55 | 6.47 | 6.43 | 6.43 | 6.39 | 6.5 | 6.4 | 6.44 | 6.56 | 6.5 | 6.5 | 6.5 |
| Phosphorus | mg/L | 0.01 | 0.41 | 1.07 | 0.47 | <0.1 | 0.15 | 0.16 | 0.12 | 0.1 | 0.06 | <0.05 | <0.05 | 0.3 | <0.05 | <0.05 | 0.1 | <0.05 |
| Potassium | mg/L | 0.01 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Potassium (Filtered) | mg/L | 1 | 55 | 58 | 60 | 64 | 65 | 76 | 80 | 83 | 83 | 70 | 70 | 69 | 68 | 67 | 70 | 70 |
| Sodium (Filtered) | mg/L | 1 | 9370 | 9080 | 10100 | 10900 | 10800 | 12700 | 13200 | 13600 | 13600 | 11700 | 11900 | 12000 | 13100 | 13300 | 13900 | 13800 |
| Sulphate as SO4 (Filtered) | mg/L | 1 | 20 | 17 | 42 | <1 | <1 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| Total Dissolved Solids | mg/L | 10 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Total Dissolved Solids (Filtered) | mg/L | 10 | 33600 | 30400 | 32300 | 37700 | 31800 | 45500 | 45300 | 45600 | 44300 | 44200 | 46600 | 49200 | 42000 | 44200 | 44800 | 44500 |
| Total Dissolved Solids (Calc.) | mg/L | 1 | 26400 | 25400 | 28700 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Total Dissolved Solids (Calculated) | mg/L | 1 | - | - | - | 34200 | 34800 | 37200 | 37000 | 37200 | 37900 | 35400 | 35600 | 35700 | 33600 | 34000 | 34300 | 34000 |
| Total Hardness as CaCO3 (Filtered) | mg/L | 1 | 2740 | 2480 | 3130 | 3960 | 3990 | 4310 | 4490 | 4700 | 4700 | 4410 | 4660 | 4650 | 5120 | 5280 | 5560 | 5560 |
| **METALS** | | | | | | | | | | | | | | | | | | |
| Arsenic (Filtered) | mg/L | 0.001 | 0.084 | 0.011 | <0.01 | <0.01 | <0.01 | <0.01 | 0.011 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Barium (Filtered) | mg/L | 0.001 | 35.6 | 30.5 | 42 | 63.5 | 68.4 | 68.8 | 74.8 | 77.8 | 68.5 | 60.7 | 65.7 | 66.5 | 66.2 | 71.6 | 77.8 | 80.1 |
| Beryllium (Filtered) | mg/L | 0.001 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Boron (Filtered) | mg/L | 0.05 | 50.9 | 54.5 | 49.4 | 40 | 41.1 | 45.4 | 44 | 43.9 | 45.4 | 34.6 | 33.1 | 34.8 | 35.1 | 34.2 | 31 | 34 |
| Cadmium (Filtered) | mg/L | 0.0001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Chromium (III+VI) (Filtered) | mg/L | 0.001 | 0.035 | 0.048 | 0.034 | 0.032 | 0.03 | 0.031 | 0.032 | 0.033 | 0.031 | 0.01 | 0.015 | 0.013 | 0.025 | 0.028 | 0.031 | 0.029 |
| Cobalt (Filtered) | mg/L | 0.001 | 0.011 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Copper (Filtered) | mg/L | 0.001 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Lead (Filtered) | mg/L | 0.001 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Manganese (Filtered) | mg/L | 0.001 | 1.82 | 1.95 | 1.8 | 2.34 | 2.44 | 2.74 | 2.9 | 3.09 | 2.4 | 2.26 | 2.42 | 2.53 | 2.31 | 2.56 | 2.64 | 2.75 |
| Mercury (Filtered) | mg/L | 0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| Nickel (Filtered) | mg/L | 0.001 | 0.04 | 0.012 | 0.01 | 0.014 | 0.018 | 0.018 | 0.014 | <0.01 | 0.012 | 0.018 | <0.01 | 0.028 | 0.021 | 0.017 | <0.01 | <0.01 |
| Selenium (Filtered) | mg/L | 0.01 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Vanadium (Filtered) | mg/L | 0.01 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Zinc (Filtered) | mg/L | 0.005 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| Gross alpha | Bq/L | 0.05 | | | | | | | | | | | 9.22 | | | | | |
| Gross beta | Bq/L | 0.10 | | | | | | | | | | | 5.22 | | | | | |