Regulatory Statement: Monitoring of Electrical Conductivity in the Beetaloo Sub-basin

Purpose

The environmental regulator in the Department of Environment, Parks and Water Security administers the Petroleum (Environment) Regulations 2016. The environmental regulator is committed to providing clear information in relation to the way the onshore petroleum industry is regulated in the NT.

The Department has received a number of queries in relation to groundwater quality, and specifically electrical conductivity results.

This regulatory statement provides clarity in relation to how and why electrical conductivity is monitored in relation to onshore petroleum exploration in the Northern Territory.

Regulatory Requirements for Groundwater Monitoring

The *Code of Practice: Onshore Petroleum Activities in the Northern Territory* specifies that groundwater monitoring must be undertaken in accordance with the *Preliminary Guideline: Groundwater Monitoring Bores for Exploration Petroleum Wells in the Beetaloo Sub basin* (the Groundwater Guideline).

The Groundwater Guideline was developed in response to recommendations 7.11 and 7.13 in the *Final Report of the Scientific Inquiry into Hydraulic Fracturing in the Northern Territory* (the HFI Report).

Government took a precautionary approach in developing the Groundwater Guideline, in recognition that the onshore petroleum industry in the Northern Territory was in its early stages. The Groundwater Guideline incorporates both control monitoring bores upstream and impact monitoring bores downstream of petroleum wells.

The Groundwater Guideline requires a single groundwater monitoring bore to be established for each aquifer encountered. If there is more than one aquifer present, the multiple bores are termed an "array". Sampling from the entire depth of an aquifer is achieved by requiring the bore casing of a groundwater bore to be perforated and screened at the top, middle and the bottom of each aquifer encountered. It is not necessary to establish three separate bores (each targeting the top, middle and bottom of an individual aquifer) in order to obtain a representative sample of water quality in the aquifer; to do so would unnecessarily increase environmental risks.

Use of Electrical Conductivity as an Indicator

Conductivity is a measure of the ability of water to pass an electrical current. Because dissolved salts and other inorganic chemicals conduct electrical current, conductivity increases as salinity increases. Conductivity is useful as a general measure of water quality. Significant changes (usually increases) in conductivity may indicate that a discharge or some other source of disturbance has decreased the relative condition or health of the water body and its associated biota (USA EPA).[1]

Consistent with the HFI recommendations, electrical conductivity is one of a number of analytes used as an indicator of any leak from a petroleum well. Groundwater containing fluids used in hydraulic fracturing (called 'flowback fluid' when it returns to surface) and naturally occurring formation water (called 'produced water') typically have electrical conductivity readings orders of magnitude greater than aquifers with potable water.

Ministerial approval conditions were placed on EMPs requiring interest holders to continuously monitor electrical conductivity, consistent with the HFI recommendation 7.11. Typically, data loggers, which record data continuously at predefined intervals, are fitted with two sensors – one sensor measuring and recording electrical conductivity and the other sensor measuring and recording groundwater pressure as a proxy for water level. Frequency and timing of sensor value recording is configurable with all data stored within the logger, downloaded to a computer during field servicing. All measuring instruments exhibit drift and a reduction in accuracy over time, which may be caused by a reaction between the sensor head and the water being monitored.

Irrespective of the parameter being monitored by the logger, best practice dictates that water samples are collected and analysed on a routine basis to validate the logger data. Verification values should be collected using a process and instrumentation of the same or higher accuracy than that of the logger. Verification values for electrical conductivity in groundwater are typically collected by collecting a sample at the same elevation in the bore as the logger and measuring conductivity using a calibrated hand held meter. This field verification data can be further validated by analysing the sample in an accredited laboratory where the conductivity is measured by instruments to an accuracy well beyond that capable of loggers and field meters. Field and laboratory verification is a key component of the quality assurance process, identifies instrumentation failure or sensor degradation and ensures confidence in the logger data.

Early monitoring in the Beetaloo Sub-Basin has consistently shown:

- The electrical conductivity sensor is very sensitive to encrustation. In the Beetaloo Sub-basin this has resulted in significant drift and erroneous readings over time. It is suspected that chemical and mineral reactivity of groundwater with the sensors is the cause of the issue. This can only be resolved by high frequency maintenance and calibration, which negates the benefits of collecting data via an automated logger.
- The ability of an electrical conductivity probe to detect any change in groundwater quality will be compromised if the probe is not situated where groundwater is 'flowing' across the bore screen. The results recorded will reflect the electrical conductivity of stagnant water in the bore, rather than the electrical conductivity of water in the aquifer.
- Even if extremely well-positioned within the bore, the electrical conductivity probe only detects changes in a minute portion of the aquifer, i.e. only at the elevation of the sensor, not through the full thickness of the screen/aquifer.
- To detect a change in groundwater quality, the bore must be located precisely down-gradient of a well, and local groundwater flow gradients are likely to vary (e.g. most likely due to pumping of neighbouring bores).

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[1] <https://www.epa.gov/national-aquatic-resource-surveys/indicators-conductivity#:~:text=Conductivity%20is%20a%20measure%20of,conductivity%20increases%20as%20salinity%20increases>.

The best method for providing accurate and reliable water quality data is to pump groundwater from the bore, ensuring flow from the aquifer, prior to collecting samples for analysis.

Electrical Conductivity Monitoring Results

Electrical conductivity readings since 2019 from a Control Monitoring Bore (CMB) and Impact Monitoring Bore (IMB) at Tanumbirini show elevated readings from the electrical conductivity sensors. Figure 1 shows the results of electrical conductivity monitoring for the Tanumbirini CMB and IMB, for both logger readings and laboratory analyses, from 2018 to early 2022. Figure 1 also shows the time at which hydraulic fracturing occurred in 2019 and 2021 and that a higher frequency of laboratory verification readings were collected immediately after fracturing. Figure 2 shows electrical conductivity results from laboratory analysis only, to demonstrate the close alignment of results between the CMB and the IMB, noting the difference between the minimum and maximum values recorded is less than 200 µS/cm.

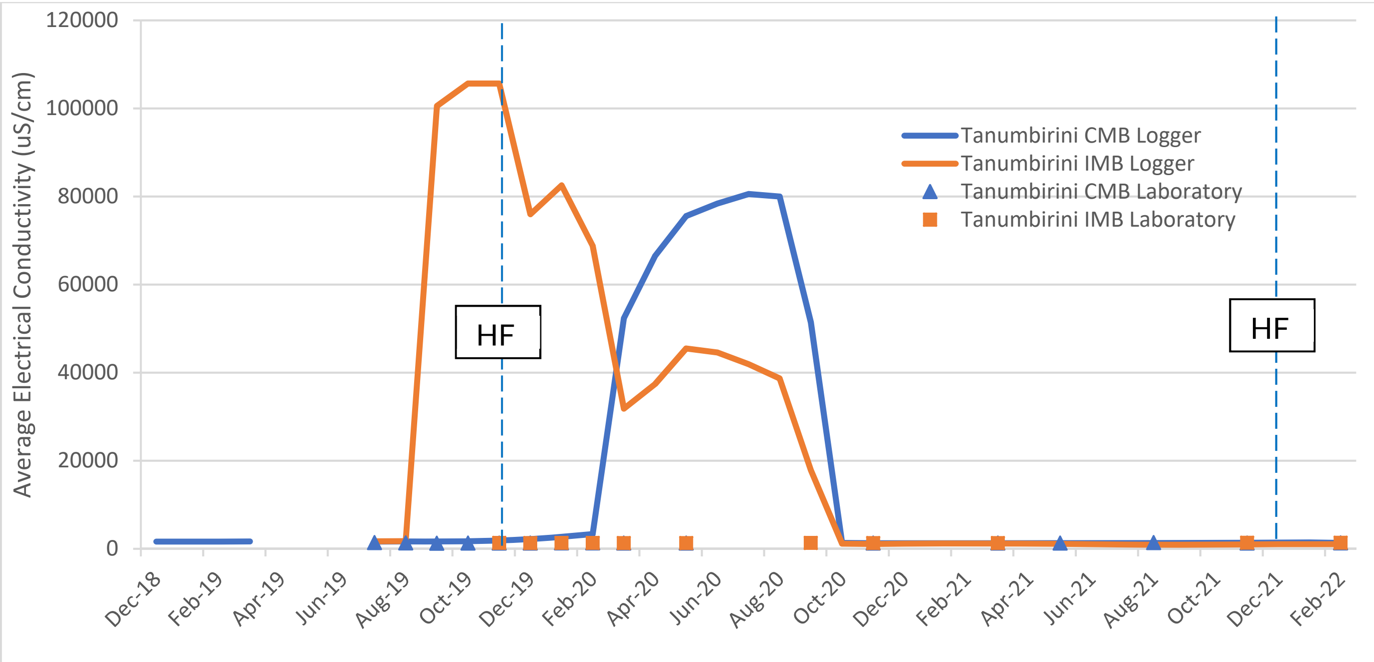

Figure 1 In situ logger and laboratory electrical conductivity readings at a Tanumbirini CMB and IMB 2018 to 2022

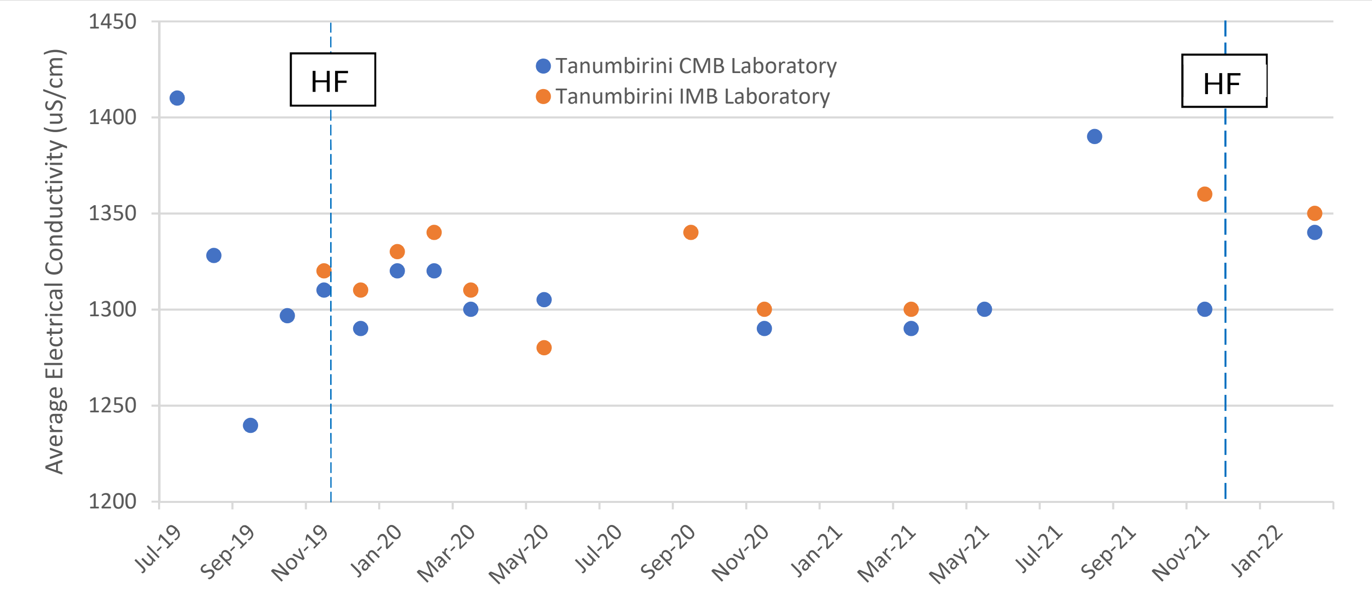

Figure 2 Laboratory electrical conductivity readings at a Tanumbirini CMB and IMB 2018 to 2022

The monitoring results clearly show there was no appreciable change in electrical conductivity over time at either of the control or impact monitoring bores, including during and after hydraulic fracturing.

Groundwater Pressure Monitoring Results

Another indicator of any breach in the casing or cement seal of a petroleum well during hydraulic fracturing is groundwater pressure, which can provide instantaneous detection through a change in groundwater pressure during hydraulic fracturing. In contrast, a change in water quality may take much longer to be detected in a monitoring bore.

Water level pressure monitoring is undertaken continuously before, during and after hydraulic fracturing. The hydraulic fracturing period is considered the highest risk period for potential impact to level/volume of groundwater resource as this is when petroleum wells would be under the most pressure.

Groundwater level pressure monitoring (shown as groundwater level) undertaken at the same Tanumbirini CMB and IMB from late 2018 to early 2022 is in Figure 3. The two periods during which hydraulic fracturing as undertaken is also shown. This monitoring data demonstrates there has been no permanent change to groundwater levels from the hydraulic fracturing activity at Tanumbirini.

Note the pressure time series data does not exhibit the spurious data demonstrated in the electrical conductivity data despite being collected by the same instrument indicating that the pressure sensor is less susceptible to fouling than the electrical conductivity sensor.

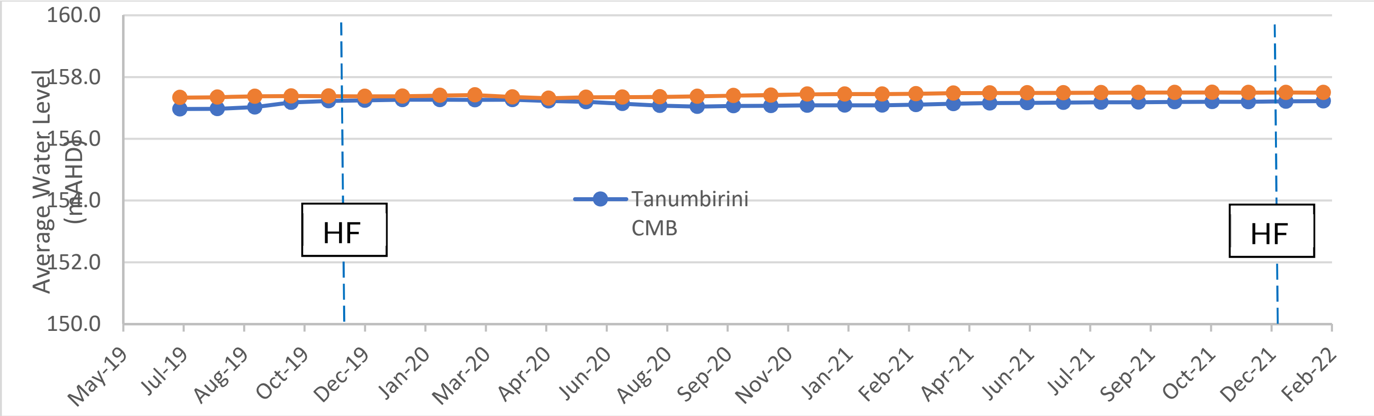

Figure 3 Tanumbirini CMB and IMB water level pressure October 2018 to January 2022

Review of Groundwater Monitoring

The Groundwater Guideline was developed in 2018 as a draft guideline to support establishing baseline groundwater data for onshore exploration. The Groundwater Guideline will be reviewed in 2022-23.

It is intended that the groundwater data collected to date will inform an independent review of the Groundwater Guideline prior to production activities, to determine its ongoing suitability, the potential for improved methods of monitoring, its applicability to other regions in the NT outside of the Beetaloo Sub-basin and its applicability for conventional petroleum activities.