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Investigation of Coastal Perth Basin North for Jurien Bay Town Water Supply with AEM

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SUMMARY

Jurien Bay is a small coastal town located 220km North of Perth, Western Australia, and relies on groundwater for town water supply (TWS). The bore filed is situation in the shallow Tamala limestones North Perth Basin. In late summer and autumn in 2020 the towns production bores recorded significant unprecedented increases in salinities.

Airborne electromagnetic (AEM) survey was planned and undertaken to improve the understanding of the likely causes of rising salinity within the borefield and assist in water source planning. The secondary aims were to map the extent of the saline water interface and to improve understanding of the hydrogeology of the area.

The 2021 AEM survey successfully mapped the extent of the saline water interface (SWI) and delineated other major hydrogeological features. The saline water interface was mapped as approximately 200 to 300 meters west of the production borefield. It was interpreted that the increased salinity in the production bores was more likely due to the thin freshwater aquifer being impacted by up-coning of underlining brackish groundwater, and not the inland movement of the coastal SWI. The AEM survey also confirmed the presence of major faults and fresh groundwater in the deeper aquifers such as the Lesueur Sandstone. This information has been crucial in planning for future water sources.

Key words: Airborne Electromagnetics, Saline Water Interface, Upconing, Water Supply, Shallow Aquifer, Hydrogeology.

INTRODUCTION

Jurien Bay is a small coastal town located 220km north of Perth, Western Australia, and is completely reliant on groundwater for town water supply (TWS). Water is sourced from a borefield located 4 km north-east of the town. The borefield is comprised of three production bores (Figure 1). Jurien production bores recorded significant unprecedented increases in salinities in late summer and autumn in 2020, prior to winter rainfall and groundwater recharge.

No previous AEM surveys had been flown at Jurien Bay however SkyTEM™ surveys had been flown over similar hydrogeological setting approximal 100km south at Guilderton in the coastal Northern Perth Basin. Assessment of this data set and knowledge the lithological and hydrogeological units gave confidence that AEM survey was likely to be successful.

An AEM survey was planned and undertaken with 75m flight line spacing covering the existing borefield and 225m line spacing extending to the north. The SkyTEM™ survey was flown between the 28th and 30th August 2021. The survey consisted of 254 line km. With the gaps in the survey representing areas that were not able to be flown due to the presence of town infrastructure, such as the port and housing.

HYDROGEOLOGY AND BOREFIELD BACKGROUND

The town water supply relies on three production bores 2/00, 1/07 and 2/07 (Figure 1). The production borefield is abstracting groundwater from a highly transmissive superficial Tamala Limestone aquifer, screened from 10 m to 22 m below ground level. The unequipped bore 29/01 is screened in the Lesueur Sandstone 189 to 249 mBGL. The current groundwater licence from existing bores is for 420 ML per annum and the current demand is very close to this allocation with the 2021-2022 demand at 414ML.

A seasonal increase in salinity has occurred over the long term in the system with an increase in salinity seen in late summer to autumn, and then decreased following winter rainfall recharge. In April 2020 all production bores recorded a significant increase in this peak salinity, more than double that of previous years increases. As a result, a temporary

reverse osmosis water plant was installed by Water Corporation to treat salinity. This significant increase in peak salinity has continued each summer and autumn to present. Two possible sources were proposed for the increases in salinity seen in the production bore field; up-coning of brackish water from the underlying Woodada Formation, or inland movement of the saline water interface. AEM surveys were aimed at determining which of these scenarios was most likely.

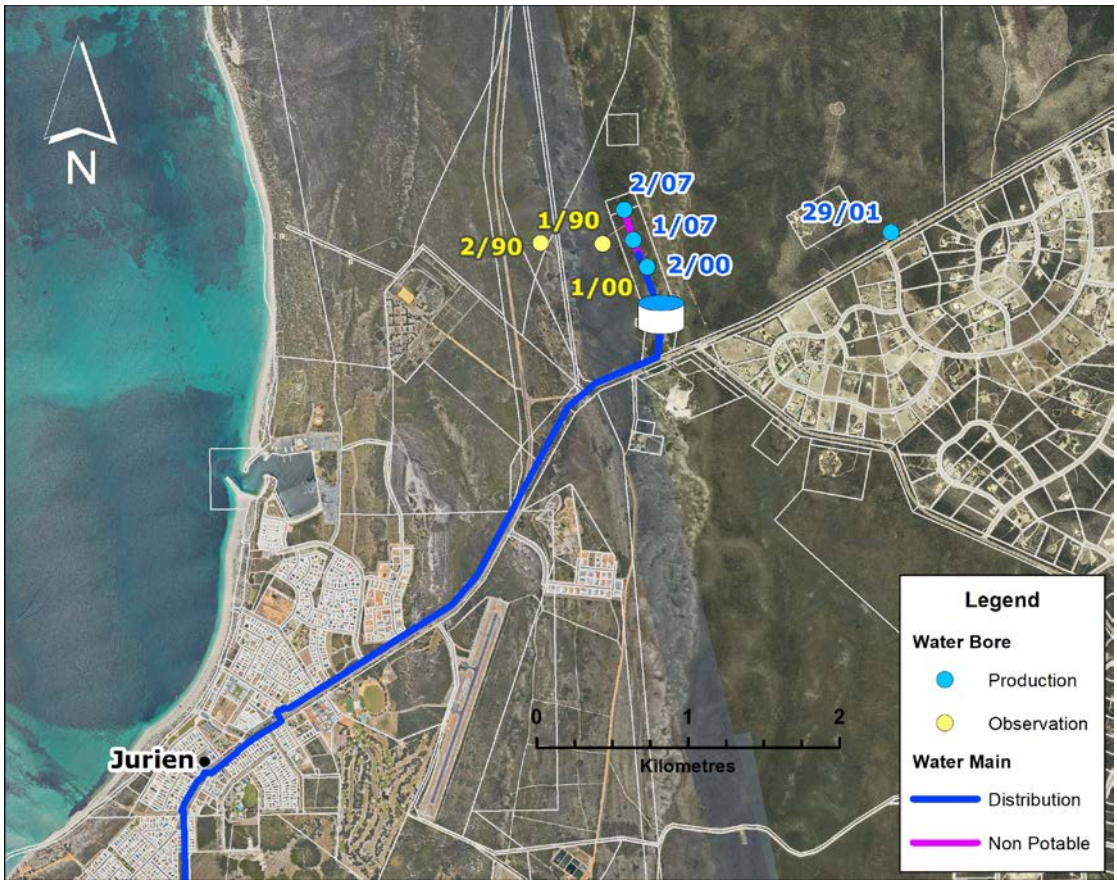

Figure 1. Satellite image with production and monitoring bores, and water infrastructure.

The Jurien Bay is situated in the northern Perth Basin, and the geological cross section (Figure 2) is taken from Baddock and Lach (2003) and description of geology and hydrogeology are after, Baddock and Lach (2003) and Lowry (1975). The Jurien Bay production borefield is primarily located in the Quaternary Tamala Limestone, which is underlain by the Early to Mid-Triassic Woodada Formation. Eolian sands are present at surface in some areas and to the east of the production borefield. Other shallow units include the Bassendean Sands and the Guildford Formation. Woodada Formation is conformably underlaid by Early Triassic Kockatea Shale. The Kockatea shale does not outcrop and has only been intersected in offshore drilling in this area. The Woodada Formation is a fine grained sandstone and siltstone and is has low transmissivity and considered an aquiclude. The Kockatea Shale is also a low transmissivity saline formation with shale siltstone and minor sandstone.

The borefield is to the west of the interpreted Beagle Fault. To the east of Beagle Fault the Late Triassic Lesueur Sandstone is present unconformably below the surficial formations. Significantly further east (~10 km inland) the Cattamarra Coal Measures outcrop to the east of the Lesueur Fault.

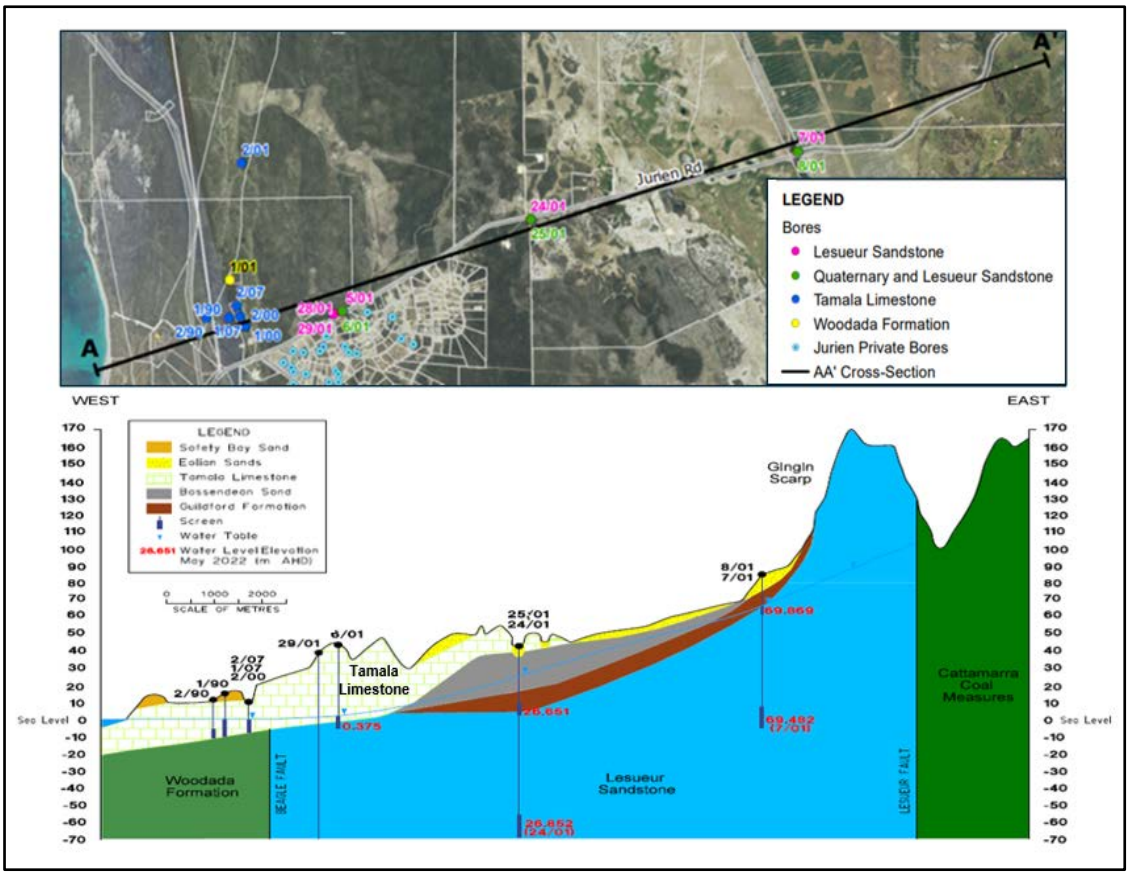

Figure 2. Top; satellite image location of geological section, with bores and the aquifer the bores are screened in. Bottom; Hydrogeological cross section of Jurien Bay Area with bore location and water levels (modified from Baddock and Lach, 2003).

AIRBORNE ELECTROMAGNETICS RESULTS

AEM inversion show significant contract in conductivities within the data and these have been interpreted to represent the geological and hydrogeological features of interest. The data set that has been used primarily for interpretation is the SkyTEM™ contractor supplied spatially constrained inversion processed in Aarhus Workbench software. The inversion are interpreted to be of good quality, the inversion is not constrained by drilling, but correlates well with it which is used to validate the quality and reliability of the inversion.

The interpretation will be discussed using the exemplar section of line 100701 as shown Figure 3, this section is an exemplar as all of the main hydrogeological units are interpreted and there is significant drilling data? for correlation. Figure 3 shows the highly conductive saline water interface (SWI) mapped shallow depths on the west of the section and validated by the monitoring bore 2/90.

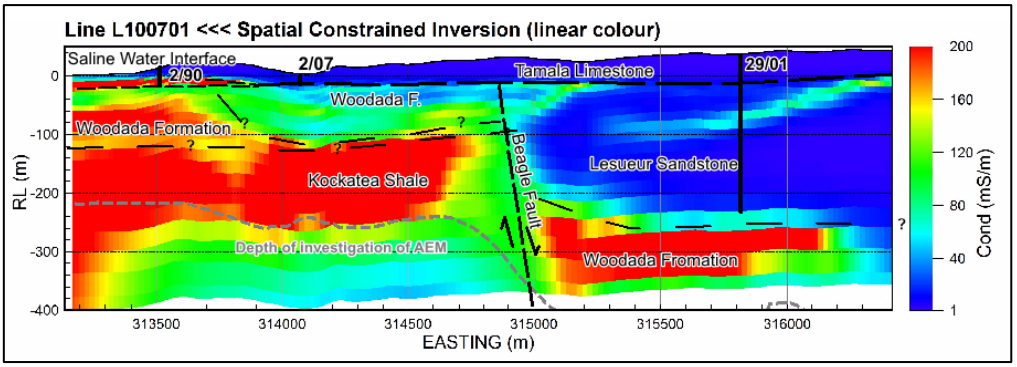

Figure 3. SkyTEM™ Spatially constrained inversion section of line 100700, location of section shown in Figure 1 and 4, the section starts approximately section extends from the edge of town area, approximately in the west light lines in black and bore locations. Coordinates are in GDA94 MGA zone 50.

Production bore 2/07 is located approximately 300m east of the edge of the SWI and is within the resistive Tamala limestone freshwater aquifer. Bore 2/07 ends just above the interpreted moderately conductive, brackish, Woodada Formation. The survey was undertaken after the influx of winter rains so it is expected that this bore has low salinity at the time of the survey. A significant increase in conductivity is present at depths of approximately 100m under Bore 2/07 and continuing to the interpreted Beagle Fault. This change in conductivity is interpreted as potentially a change in lithology from Woodada formation to Kockatea Shale but at this stage this has not been confirmed by drilling and could also potentially represent a more conductive part of the Woodada Formation.

The Beagle Fault is interpreted as the distinct break between the more conductive units to the west and the resistive units to the east. The resistive, Lesueur Sandstone is a significant freshwater aquifer and underlies the shallow Tamala limestone, confirmed by drilling of bore 29/01 and surrounding adjacent monitoring bores such as 5/01 and 28/01 (Figure 2). A conductive unit is present underlying the Lesueur Sandstone at depths of approximately 250 m to 300m, this unit is interpreted as the Woodada Formation which unconformably underlies the Lesueur Sandstone in this area. The Beagle Fault was interpreted from sections and plan maps and is shown in plan view in Figure 4. The plan view map also shows that monitoring bore 2/90 is known to be west of the SWI, with existing monitoring and operational production bores located 250m -300m east of the interpreted SWI. It is interesting to note that the location of the saline water interface appears to have a very similar shape to that of the interpreted Beagle fault (Figure 4). The SWI is closest to the coast in the south of the survey area ~2km inland from the coast and extends significantly further inland ~4km in the north of the survey area.

Tamala Limestone and Lesueur Sandstone are both resistive units and it is not possible to detect the boundary between these units from the spatially constrained inversion, it has instead been inferred from drilling information. The location of the water table in the freshwater aquifers is also not able to be detected in the AEM inversion as there is very little conductivity contrast between the saturated or unsaturated limestone. These features are well understood from drilling and were always expected to have low contrast so and lack of contrast in the conductivity was expected.

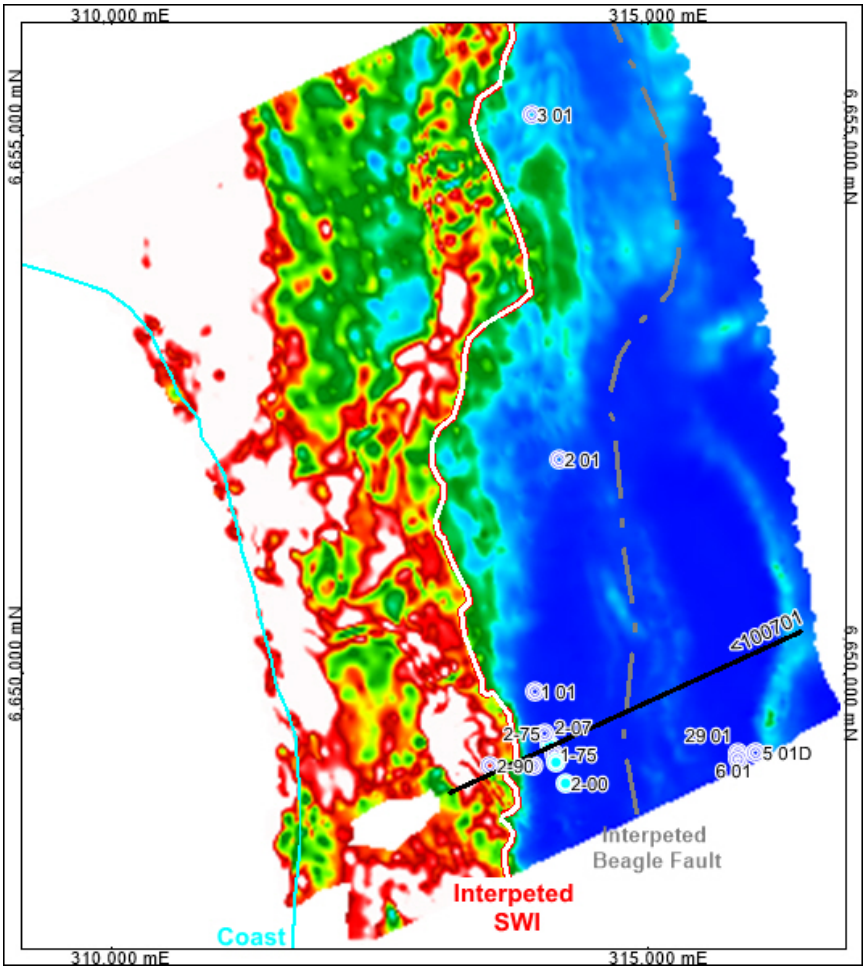

Figure 4. SkyTEM™ Spatially constrained inversion 10m AHD depth section, non-linear image, with interpretation of Saline water interface (SWI), Beagle Fault, flight line 100701, and bore locations. Coordinates are in GDA94 MGA zone 50.

There are two moderately conductive feature that are not well understood both seen in the inversions, within in the interpreted Lesueur Sandstone. One moderately conductive feature below the Tamala Limestone is close to the Beagle Fault and the other is at the western extent of the line section (Figure 3), it is possible that both features represent a higher conductivity lithology, such as units with increased clays, the feature could be related to increased salinity.

CONCLUSIONS

The AEM survey has determined that the increase in salinity detected in the production bore field from 2020 onwards is caused by up-coning of the underlying brackish groundwater from the Woodada Formation. The SWI is located approximately 250 m – 300m west of the production borefield and as such is very unlikely to be causing any impact at present in these bores. The AEM results have significantly improved the understanding of the hydrogeology of the area. The understanding gained from the interpretation of the depth for the Tamala Limestone and the location of the SWI all indicated that future expansion of the Jurien town water supply should be to the east of the Beagle Fault where significant fresh groundwater is present in the Lesueur Sandstone Aquifer. This information has been used to support an application to the Western Australian Department of Water and Environment Regulation for a 250 ML per annum licence for the unequipped bore 29/01 in the Lesueur Sandstone.

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