NORTHERN TERRITORY GOVERNMENT

DEPARTMENT OF
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File Ref:
TRIM No. DLR2014/0080-0001

The Hon Justice Rachel Pepper
Chair
Hydraulic Fracturing Taskforce
GPO Box 4396
DARWIN NT 0801

Dear Justice Pepper

RE: HYDRAULIC FRACTURING INQUIRY – INFORMATION REQUEST

In response to your information request of 21 August 2017, the Department of Environment and Natural Resources has prepared the attached Response to Request for Information.

Should you require any further clarification or information on the response please contact this office.

Yours sincerely

JOANNE TOWNSEND
Acting Chief Executive Officer

29 August 2017

Hydraulic Fracturing Inquiry – DENR Information Request

Comments from Water Resources Division

The karstic nature of aquifer development in Tindall Limestone/Gum Ridge/Montejinni Limestone Formations overlying the Beetaloo Sub-basin means that prediction of local scale groundwater movement is problematic. However, on a regional scale, groundwater movement will conform to laws governing flow through porous media (ie. Darcy's Law and the conservation of mass).

Assessments of groundwater systems in the region of the Beetaloo Sub-basin have been conducted at regional scale. The areas of study as reported by Bruwer and Tickell (2015), Yin Foo and Matthews (2001) and Bruwer and Tickell (2017) are as indicated in Appendix A, Figure 1 as Areas A, B and C respectively.

a) <u>Horizontal Flow Rates in the Cambrian Limestone Aquifer</u>

General Comment

Bruwer and Tickell (2015) reported that transmissivity was highly variable. Values determined from test pumping of a number of bores in the region ranged from 100 to above 30,000 m^2/d. This result is common in karstic aquifers where the transmissivity calculated from a cavity-rich zone may be orders of magnitude greater than an area with fewer cavities. The intersection of caverns and conduits is critical to the successful performance of bores in this aquifer, as well as in determining a value of transmissivity. The most appropriate method for determining such a value in karstic terrain is through groundwater modelling where system water balance and the continuity of flow is also taken into consideration. Hence, the groundwater model for Area A (Knapton, 2009) for example, applies transmissivity values in a narrower range from 2,000 to 5,000 m^2/d.

Area A

Cross-sections AB and CD in Tickell (2015), see appendix B, indicate variability in the basement topography along the groundwater flow path between Daly Waters and Mataranka. Across the flow path, the saturated formation thickness tapers from approximately 170m on its western margin, to 0m at its eastern extent. However, an average saturated formation thickness could be approximated to 80m for the sake of calculating flow cross-sec ton.

The *horizontal flow rate* calculations below emphasise the high degree of dependency on the value for transmissivity on this calculation.

- The horizontal flow rate calculated across a section north of Larrimah, between the 130 and 140m AHD water level contours, is about 12.2 ML/d (Tickell, 2016) assuming a value of transmissivity of 1,100 m^2/d, a width of flow of 40 Km and a gradient of 1:3600 (as measured between the contour lines).
- The horizontal flow rate calculated across a section south of Larrimah between the 140 and 150m AHD water level contours is about 7.3 ML/d (Tickell, 2016) assuming a value of

transmissivity of 1,100 m^2/d, a width of flow of 40 Km and a gradient of 1:6000 (as measured between the contour lines).

- An extraction of modelled data indicates the horizontal flow rate north of Larrimah is about 55 ML/d (the model used transmissivity values between 2,000 and 5,000 m^2/d).
- Applying much greater values of transmissivity (between 8,000 and 16,000 m^2/d), Yin Foo and Matthews (2000) derived an order of magnitude estimate of flow to be between 160 and 320 ML/d.

Area B

Yin Foo and Matthews (2001) determined that the aquifer across the Sturt Plateau is hosted in the remnant lower units of the Tindall Limestone. The surface of the underlying basalt upon which the limestone was deposited is featured by undulations which influence the groundwater flow regime.

Cross-section A-B (Yin Foo and Matthews, 2002) and Cross-section E-F (Daly Basin Aquifers, 2106) in appendix D, indicate that the aquifer across this region is thin, approximately 20m.

- The horizontal flow rate on the Sturt Plateau using a Water Level Contour map (Yin Foo and Matthews, 2002) is calculated to be approximately 5 ML/d. This volume is derived from a transmissivity value of 1,000 m^2/d (based on a proportion of the average modelled value of 3,500 m^2/d used for Area A), a flow width of 52 Km and a flow gradient of 1:11,000.
- Yin Foo and Matthews (2001) estimate the groundwater flow rate across the northern Wiso Basin to be between 64,000 and 128,000 ML/y (equating to between 175 and 350 ML/d). Much greater values of transmissivity were used in this calculation.

Area C

The Cambrian aquifers in this region include those developed in the Anthony Lagoon Formation and the Gum Ridge Formation. A lack of groundwater level data across this region does not permit the calculation of flow rates.

The Anthony Lagoon Formation exhibits water quality characteristics that enable it to be distinguished from the Gum Ridge groundwaters. These include high sulphate and high sodium chloride. The detection of these characteristics in the transition zone between Area A and Area C in the vicinity of Daly Waters suggests there is an (unquantified) flow regime northwards that mixes with the Gum Ridge aquifer (Yin Foo and Matthews, 2001), see appendix C.

Within Area C, recharge to the Gum Ridge Formation is low as opportunity is limited to the outcropping or sub-cropping areas delineated in Bruwer and Tickell (2017). This would suggest that horizontal flow rates in the Gum Ridge Formation are extremely low.

b) Vertical Flow Rates in the Cambrian Limestone Aquifers

Bruwer and Tickell (2017) provides groundwater monitoring data representing aquifers in the Anthony Lagoon and Gum Ridge Formations south of Dunmarra. This data indicates that the behavioural pattern for each aquifer is not congruent. Test pumping performed on bores constructed and isolated in each aquifer indicated that drawdown response was only detected in that aquifer. This suggests poor connectivity, if any, between these aquifers in this part of the system.

c) <u>The age of the groundwater in these aquifers</u>

Studies of groundwater age have been undertaken in Areas A, B and C using isotope Carbon-14 as the tracer. The data for Areas A and B presented in Yin Foo and Matthews (2000) indicate there is a variation in age from approximately 3000 to 5000 years.

In Area C, Gum Ridge groundwater has been dated in the order of 10,000 to 15,000 years in the recharge zone on its western margin. Towards the centre of the basin, its age increases to over 30,000 years (the upper limit of applicability of this dating method) but is consistent with the understanding that no recharge occurs in this part of the basin.

There has only been one analysis for an Anthony Lagoon aquifer indicating it was 10,000 years old.

d) <u>The likelihood and potential time for a spill of wastewater in the Beetaloo sub-basin to reach the aquifer, most easily transported through the soil profile, being sodium chloride.</u>

There have been no studies undertaken to quantify infiltration rates through the unsaturated zone in this region. However, the rate of infiltration is dependent on where the spill occurred, the nature of the sediments overlying the aquifer, the quantity of spillage and how persistent (or continuous) the spillage was.

- If a spill occurred in an area where the sediments overlying the karstic limestone were thin, or near a sinkhole, then infiltration could occur within days. This scenario is possible in parts of Area B.
- Where there is a thick overburden of Cretaceous sediments such as Area A, the infiltration could be over many years.
- In Area C, the most susceptible aquifers are those of the Anthony Lagoon Formation. Infiltration would not occur into the Gum Ridge Formation, unless in the recharge areas delineated in Bruwer and Tickell (2017)

<u>References</u>

Bruwer, Q. and Tickell, S. J., (2015). Daly Basin Groundwater Resource Assessment - North Mataranka to Daly Waters, Department of Land Resource Management, Water Resources Report Number 20/2015D

Bruwer, Q. and Tickell, S. J., (2017). Georgina Basin Groundwater Assessment - Daly Waters to Tennant Creek, Department of Environment and Natural Resources, Water Resources Report Number xx/2017D (unpublished)

Daly Basin Aquifers Map, 2016, Water Resources Division, Department of Land Resource Management, Darwin, 2016

Tickell, S.J. 2015, Investigation drilling in the south western Daly Basin, 2014, Water Resources Division, Northern Territory Department of Land Resource Management, Technical Report No. 3/2015D, Darwin, 2015

Tickell, S.J., 2016, Tindall Aquifer, King River to Daly Waters Hydrogeological Map, Water Resources Division, Department of Land Resource Management, Darwin, 2016

Yin Foo, D and Matthews, I. (2002), Hydrogeology of the Sturt Plateau, 1:250,000 Scale Map, Department of Infrastructure, Planning and Environment, Water Resources Division, 2002

Yin Foo, D and Matthews, I. (2001), Hydrogeology of the Sturt Plateau, 1:250,000 Scale Map Explanatory Notes, Department of Infrastructure, Planning and Environment, Water Resources Report Number 17/2000D

APPENDIX A

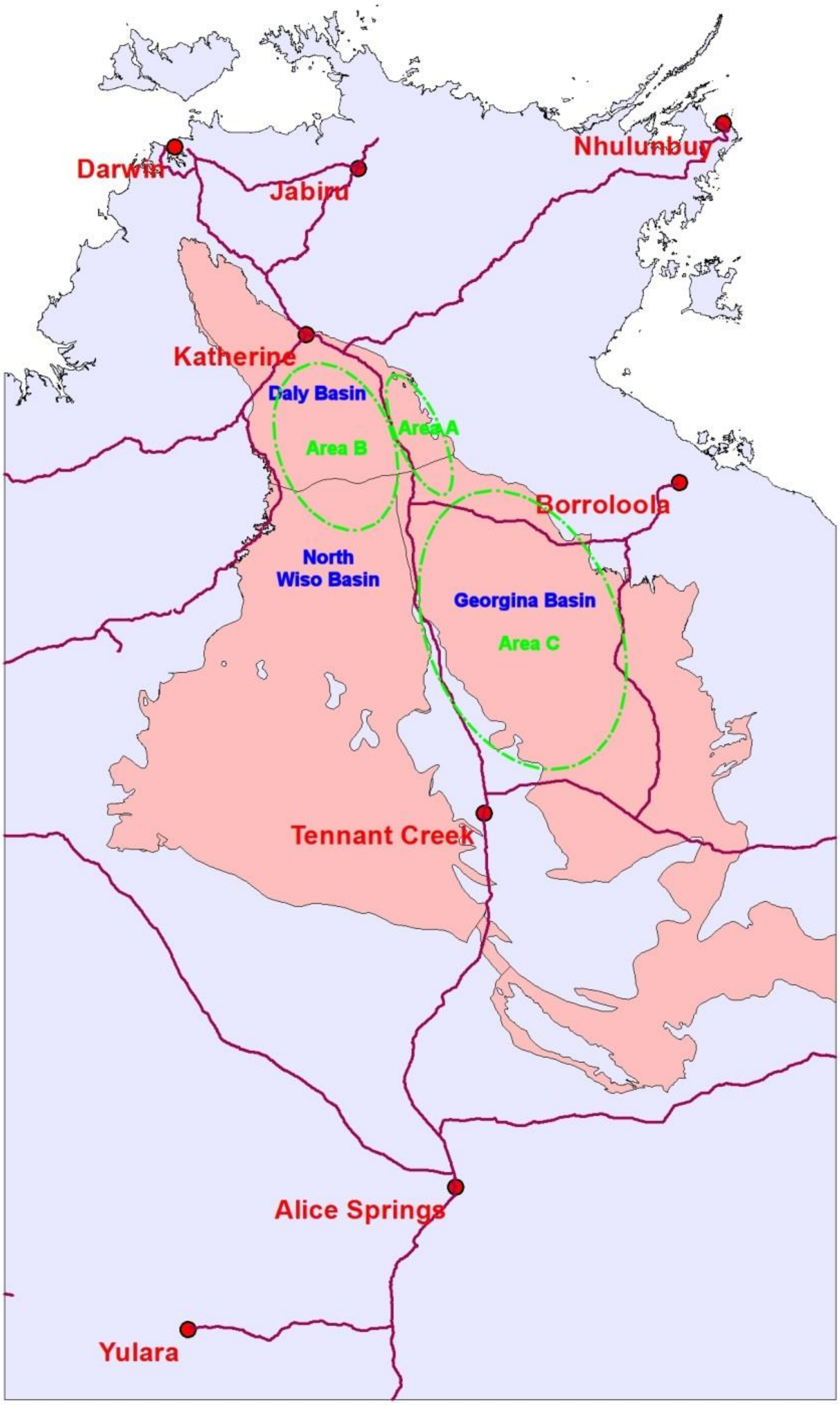

Figure 1 Groundwater Studies overlying the Beetaloo Sub-basin

APPENDIX B

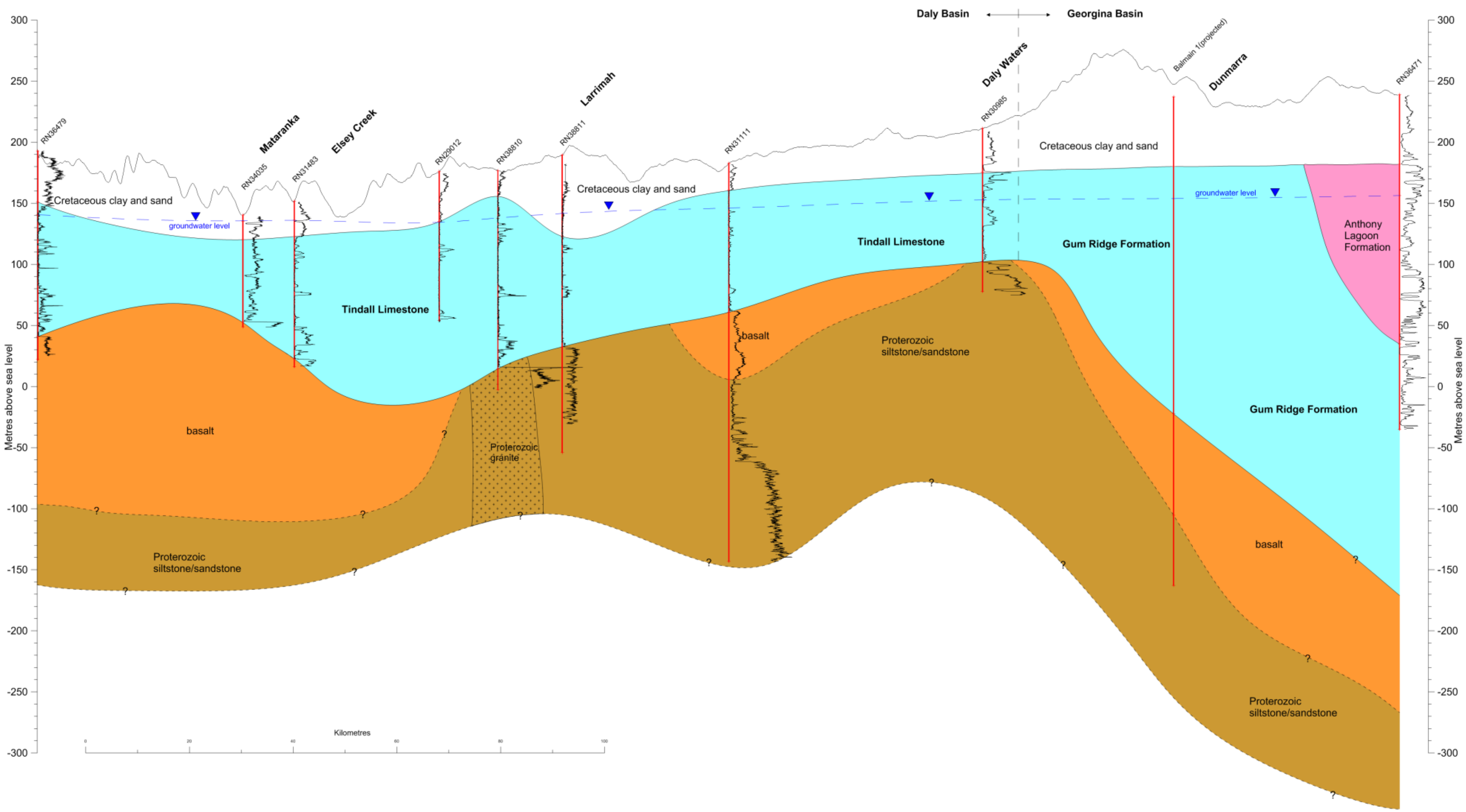

Figure 2 Cross section AB (from Tickell, 2015)

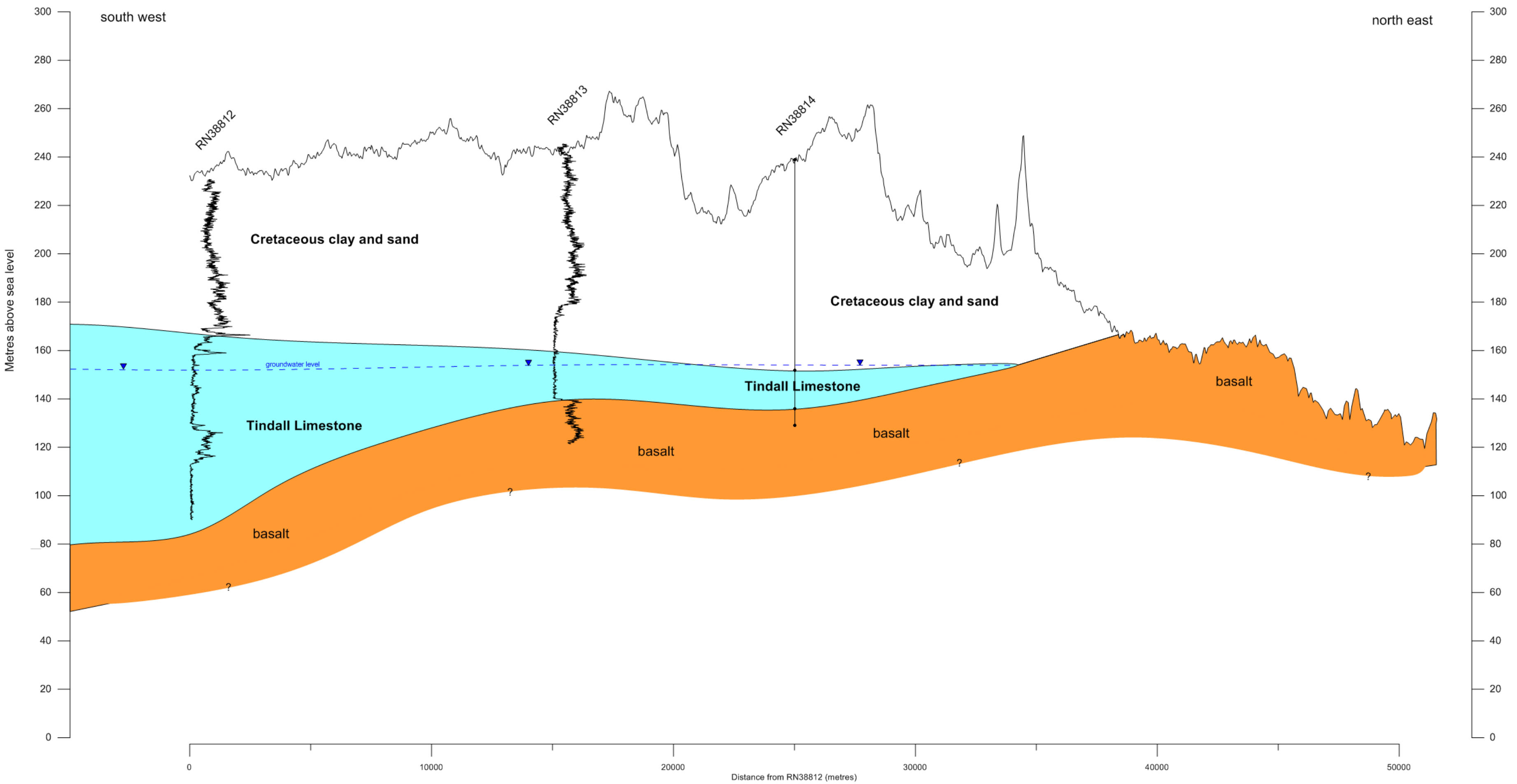

Figure 3 Cross section CD (from Tickell, 2015)

APPENDIX C

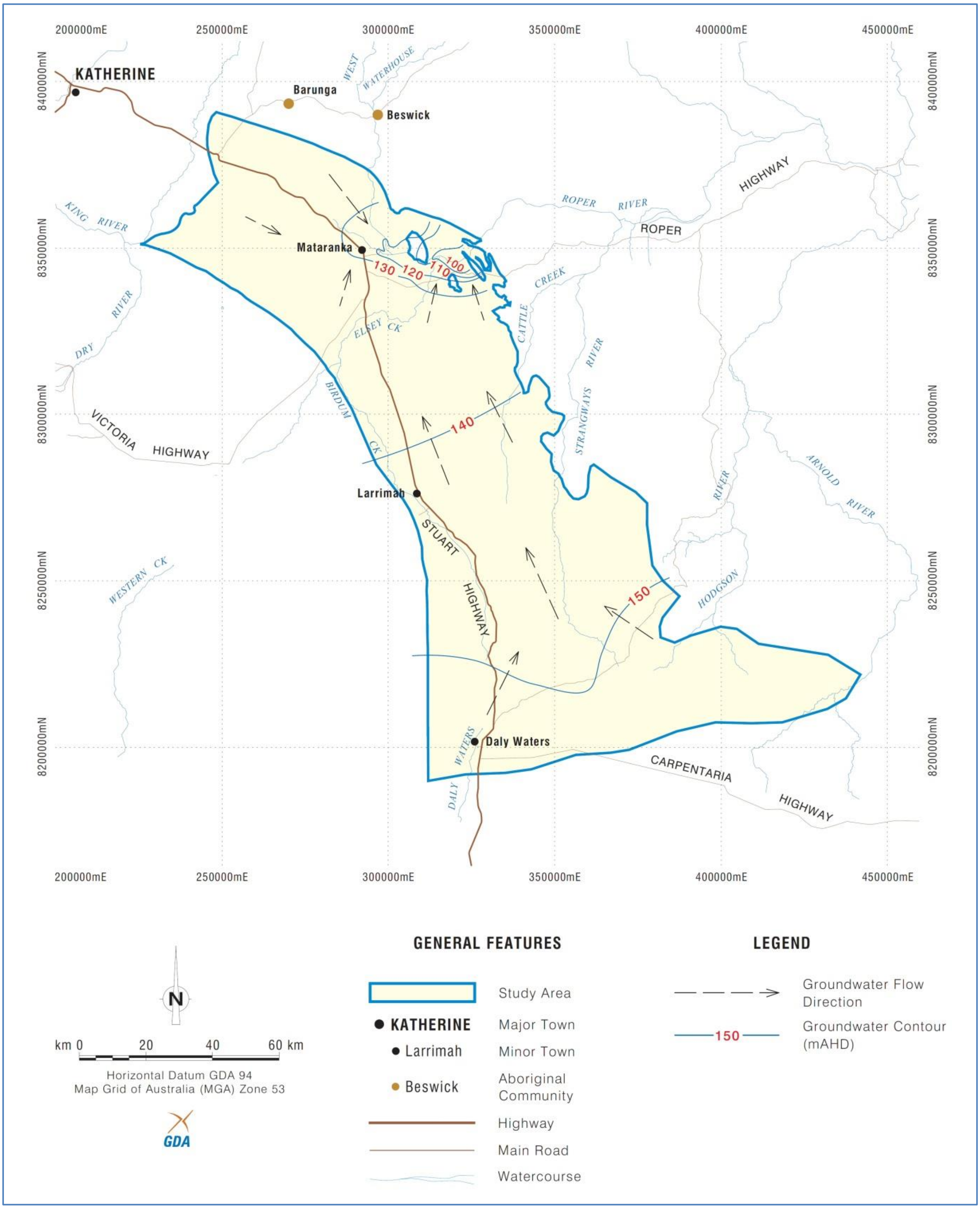

Figure 4 Groundwater Flow Direction, October 2015 (from Bruwer and Tickell, 2015)

APPENDIX D

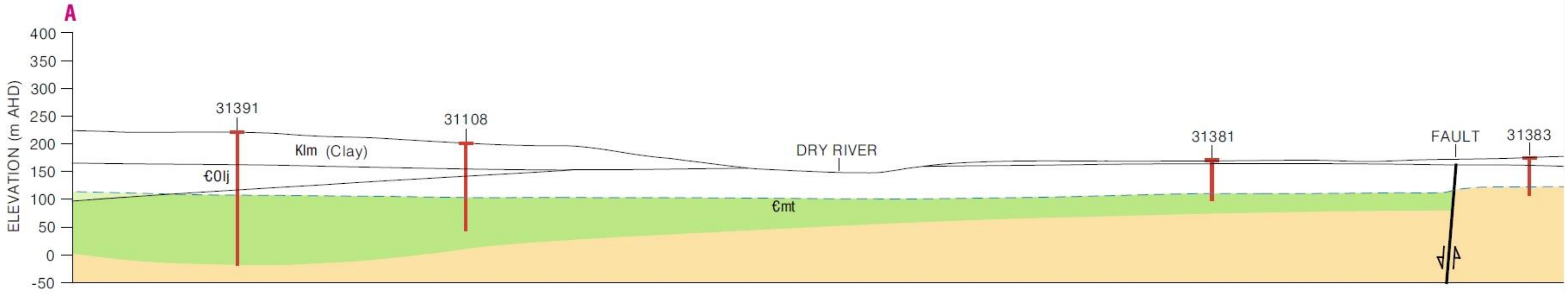

Figure 5 Partial Cross-Section A-B (from Yin Foo and Matthews (2000)

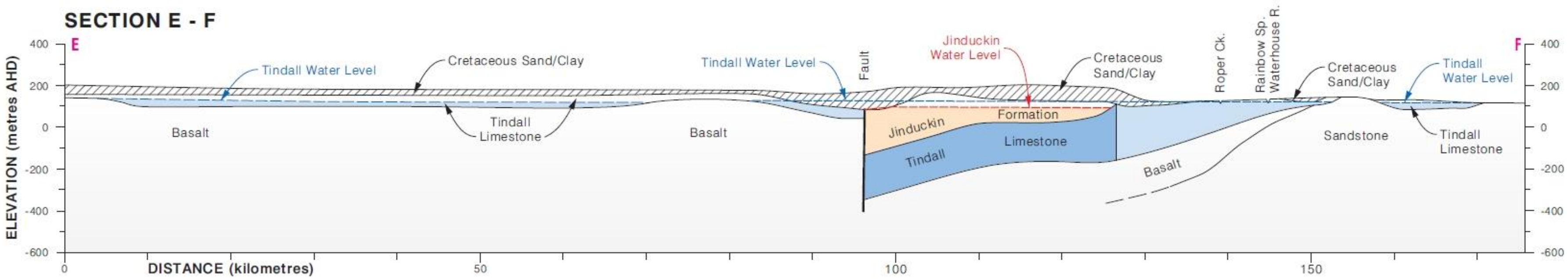

Figure 6 Cross-Section E-F (from Daly Basin Aquifers Map, 2016)