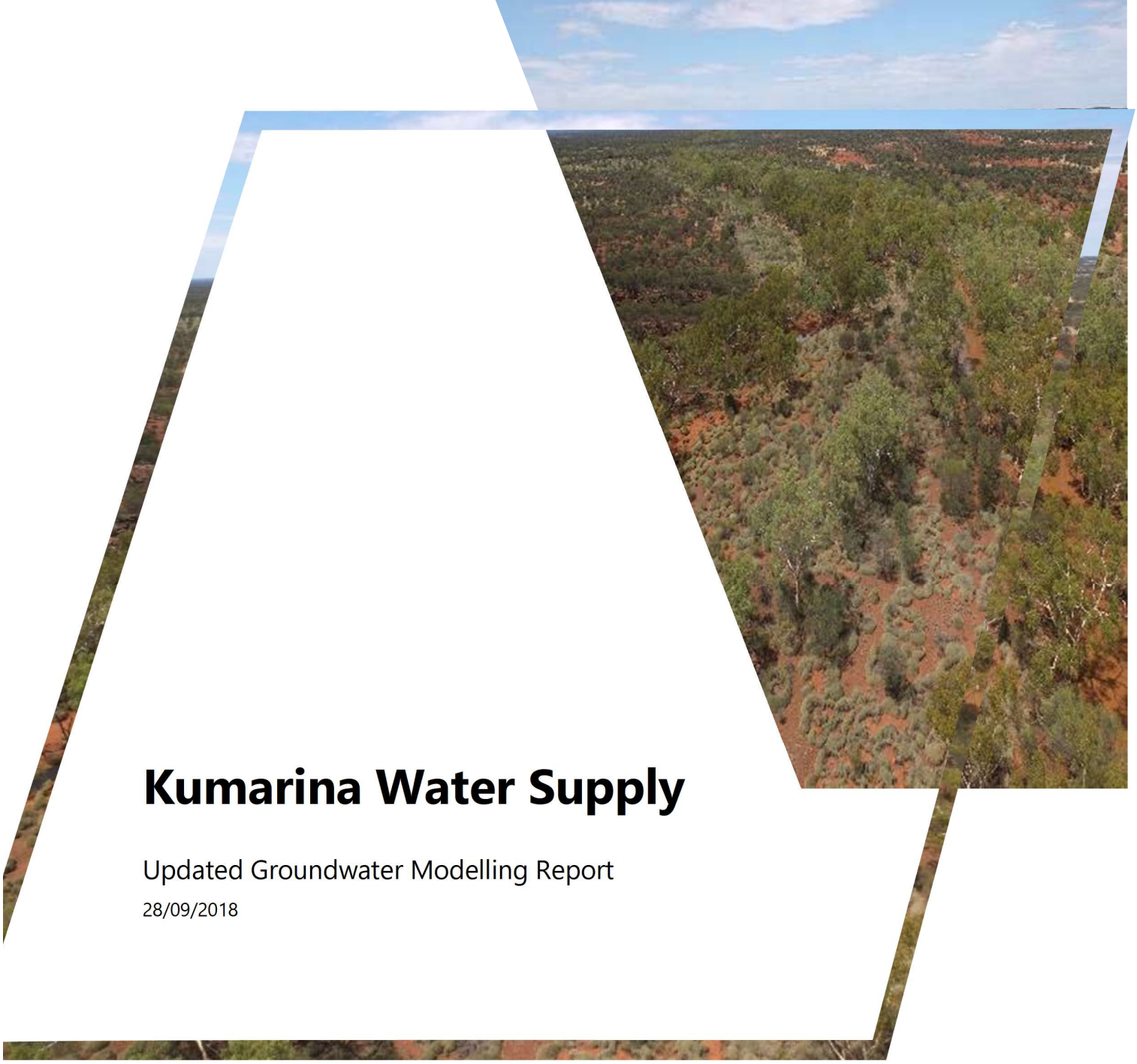

Kumarina Water Supply

Updated Groundwater Modelling Report

28/09/2018

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Project No: 201320-14624-Kumarina Water Supply: Updated Groundwater Modelling Report

Rev	Description	Author	Review	Advisian Approval	Date
Rev0	Issued	A Lloyd	L Siraz	C Chalmers	08/10/2018

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1 Introduction

Kalium Lakes Ltd (KLL) has recently completed a Bankable Feasibility Study (BFS) for the Beyondie Sulphate of Potash Project (BSOPP) in Western Australia. In order to refine the final SOP product and support operations, a process water supply is required of between 0.75 and 1.5 Gigalitres / annum (GL/a) of fresh to brackish water to meet the planned 82,000 to 168,000 tonne per annum SOP production.

Water supply assessments have been completed for three water supply borefields to meet the total water demand. The borefields are the Ten Mile South Borefield and Beyondie Borefield located within 30km of the process plant, and the Kumarina Borefield, located approximately 80km to the west along the project's main access road. Hydrogeological investigations and numerical modelling have been completed for all borefields and reported to H3 level guidelines. It is proposed to operate Ten Mile South as the priority borefield and Kumarina as a backup, there is limited plans for development of Beyondie due to the higher salinity of this aquifer.

1.1 Purpose of this Report

The Kumarina Borefield H3 report (Advisian 2018a) was completed in May 2018 and subsequently reviewed by the Department of Water and Environmental Regulation (DWER) in July 2018. The review advised that the rate of modelled drawdown of between 0.59 to 0.74 m/annum and magnitude of drawdown in excess of 5 m indicated a severe risk to potential groundwater dependent vegetation (GDV), according to Froend and Loomes (2004).

Since the submission of the Kumarina H3 Report, the Ten Mile South Borefield assessment (Advisian 2018b) has been completed and submitted to DWER which indicates that up to 1.5 GLpa is sustainable from this borefield in closer proximity to the Project site. This means that if Ten Mile South is granted 1.5 GLpa, then the Kumarina borefield will be used only as a backup borefield due to its distance from the Project site. Therefore, the abstraction volume from Kumarina can be managed to reduce its risk on GDV. The locations of Kumarina and Ten Mile South in relation to the Project site is presented in Figure 1. Further investigation work is required at Beyondie West to determine if sustainable process water supplies are available, however, no additional work is planned pending the approval of the Ten Mile South and Kumarina borefields.

This report summarises the revised hydrogeological modelling to reduce the rate of drawdown by reducing the rate of abstraction from the proposed Kumarina borefield.

1.2 The Kumarina Water Supply Project Area

The Kumarina Water Supply Project area is located on the Kumarina pastoral lease, approximately 80 km to the West of the BSOPP. It is located within the East Murchison groundwater area and the Egerton groundwater subarea. The township of Newman is approximately 150 km to the North along the Great Northern Highway, whilst Wiluna is approximately 240 km to the South. KLL has a pending application for a Miscellaneous Licence (L52/190 and L52/193) covering the Kumarina water supply project area and pipeline.

The Project plans to abstract fresh to brackish groundwater from the surficial sediments and calcrete associated with the Upper Gascoyne River and the weathe red and fractured bedrock zones associated with the Jaydinia Syncline. The project location, in relation to the greater BSOPP and other identified process water supply borefields is presented in Figure 1.

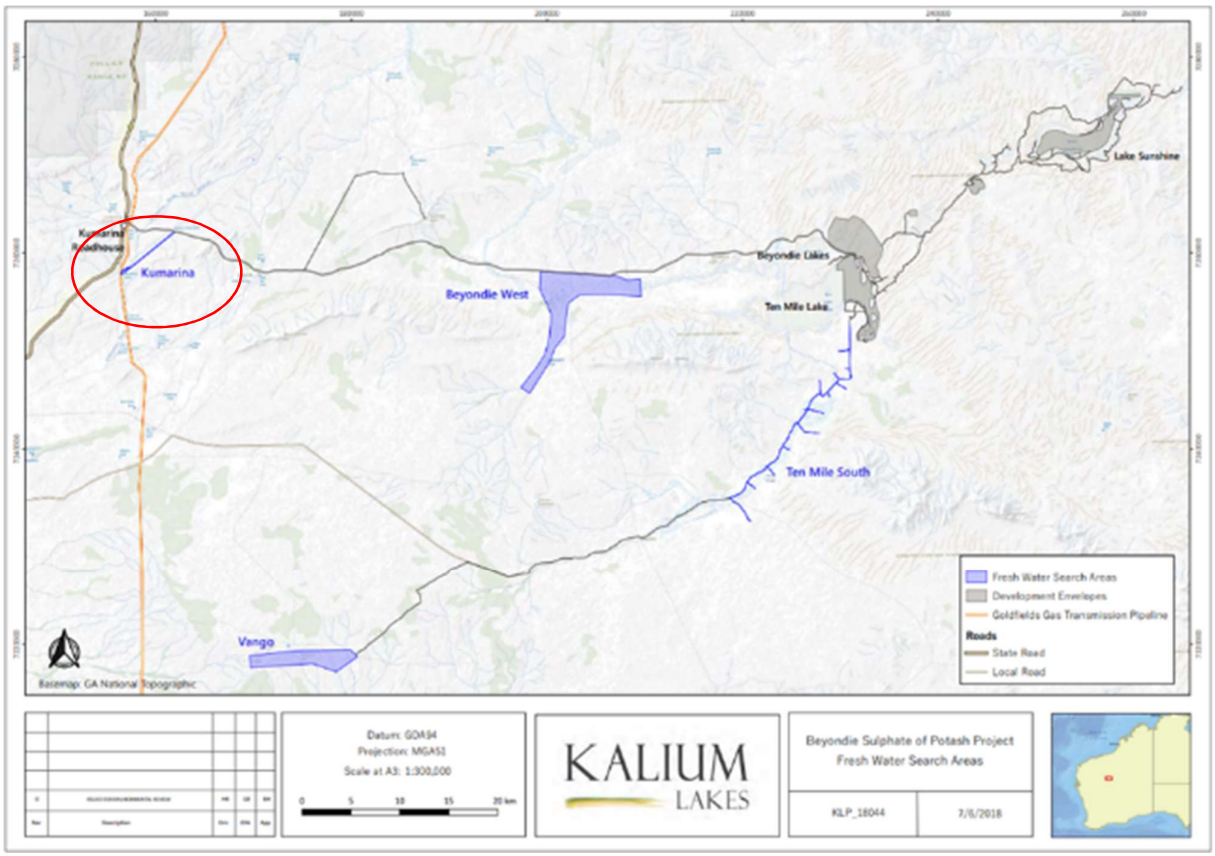

Figure 1: Project Location

2 Potential Groundwater Dependent Vegetation

Potential GDV are present along the creek channel as presented in Figure 2 and Figure 3 . Froend and Loomes (2004) suggest that the moderate risk category for phreatophytic vegetation where groundwater is between 6 and 10m below ground level is less than approximately 0.25m per annum and a magnitude of 2m, this is presented in Figure 4 below. The revised modelling will aim to be within this moderate risk category.

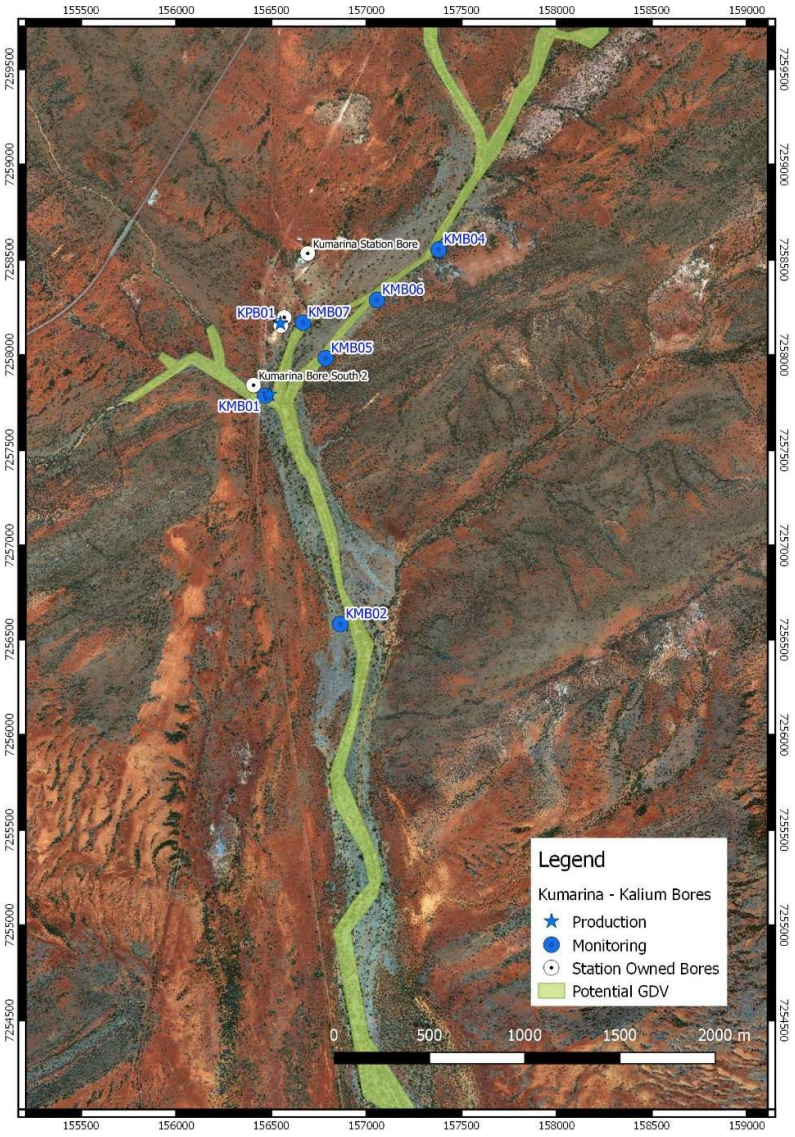

Figure 2: Potential Groundwater Dependent Vegetation – Region

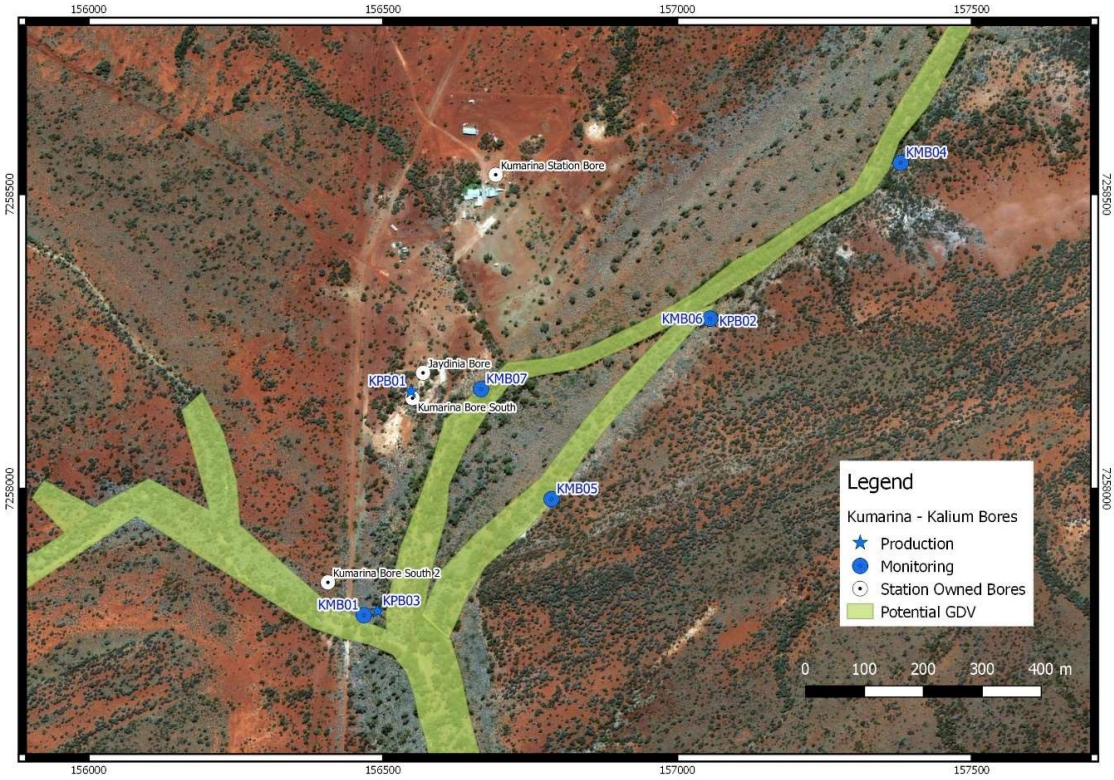

Figure 3: Potential Groundwater Dependent Vegetation – Borefield Area

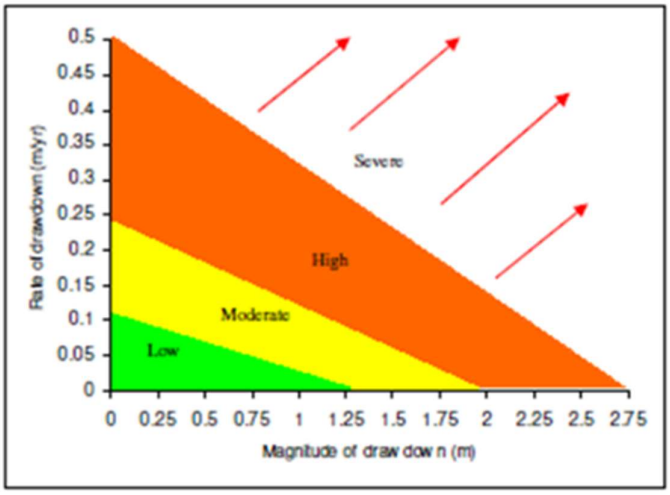

Figure 4: Risk categories for Phreatophytic Vegetation where Groundwater is between 6 and 10m below Ground Level, after Froend and Loomes (2004)

3 Revised Modelling

The groundwater model calibrated and presented in the H3 report (Advisian 2018a) was used for this update. Section 7 of the H3 Report describes the model construction and calibration. The sections below describe the updated predictive modelling to reduce the rate of drawdown within the zones of potentially GDV.

3.1 Predictive Modelling Scenario

Two additional scenarios were run where the abstraction rates were reduced by 30% and 60%. The abstraction reduction of 30% meant that three production bores were run at 5L/s each for 23 years (approximately 0.5 GLpa). The 60% reduction means that the three production bores were run at 2.5L/s for 23 years (approximately 0.25 GLpa). Episodic rainfall recharge represented by 5 year, 10 year and 20 year events and the periods in between, by an average 1% of rainfall recharge (as per Scenario 3, Advisian 2018a) was used in these model runs as this is considered to be more representative of naturally occurring conditions.

One additional monitoring bore (KMB07) has been proposed to specifically monitor drawdown in the direct location of potential GDV near KPB01. Other existing bores KMB01, KMB04 to KMB07 will also be used to monitor the drawdown in the vicinity of the potential GDV, as these are located on the fringes on the highly vegetated zones.

The drawdown results at the end of 5 years, 10 years and 23 year simulations are presented in Table 3-1.

The magnitude of drawdown at 0.5 GLpa over 23 years was still within the severe category according to Froend and Loomes (2004). However, the 0.25 GLpa abstraction was within the moderate zone over the life of the project.

Table 3-1: Simulated Drawdown Pumping at 5L/s (430 cubic metres per day (m3/d)) in Three Production Bores

Bore ID	Distance to KPB01 (m)	Distance to KPB02 (m)	Distance to KPB03 (m)	Drawdown (m) after 5 Years	Drawdown (m) after 10 Years	Drawdown (m) after 23 Years
KPB01	0	525	380	2.10	3.15	4.80
KPB02	525	0	750	2.45	3.50	5.20
KPB03	380	750	0	2.20	3.25	4.90

Bore ID	Distance to KPB01 (m)	Distance to KPB02 (m)	Distance to KPB03 (m)	Drawdown (m) after 5 Years	Drawdown (m) after 10 Years	Drawdown (m) after 23 Years
KMB01	390	775	25	2.00	3.05	4.70
KMB02	1615	1700	1265	0	0	0
KMB03	4175	4570	4115	0	0	0
KMB04	915	415	1170	1.65	2.65	4.30
KMB05	300	405	350	1.95	3.00	4.65
KMB06	520	5	775	2.10	3.15	4.80
KMB07	120	410	415	1.90	2.90	4.55
Kumarina Bore South 2	350	790	100	1.90	2.95	4.60
Kumarina Bore South	10	525	365	1.95	3.00	4.70
Jaydinia Bore	35	500	410	1.90	2.95	4.60
Kumarina Station	380	440	765	1.70	2.75	4.40
Johnny's Pool Bore	5170	5280	4790	0	0	0

Table 3-2: Simulated drawdown pumping at 2.5 L/s (215 m^3/d) in three production bores

Bore ID	Distance to KPB01 (m)	Distance to KPB02 (m)	Distance to KPB03 (m)	Drawdown (m) after 5 Years	Drawdown (m) after 10 Years	Drawdown (m) after 23 Years
KPB02	525	0	750	1.35	1.70	1.80
KPB03*	380	750	0	1.30	1.55	1.65
KPB01	0	525	380	1.25	1.45	1.60
KMB01	390	775	25	1.20	1.45	1.55
KMB02	1615	1700	1265	0	0	0
KMB03	4175	4570	4115	0	0	0
KMB04	915	415	1170	1.00	1.25	1.45
KMB05	300	405	350	1.20	1.45	1.60
KMB06	520	5	775	1.20	1.50	1.65
KMB07	120	410	415	1.10	1.35	1.50
Kumarina Bore South 2	350	790	100	1.15	1.40	1.50
Kumarina Bore South	10	525	365	1.20	1.40	1.55
Jaydinia Bore	35	500	410	1.15	1.40	1.55
Kumarina Station	380	440	765	1.00	1.30	1.45
Johnny's Pool Bore	5170	5280	4790	0	0	0

4 GDV Impact Assessment

Potentially GDV are considered to be present along the creek channel as shown in Figure 3. The rates of drawdown at monitoring points in the vicinity of these zones are presented in Table 4-1 and Table 4-2. Associated drawdown contours are presented in Figure 6 and Figure 5.

Table 4-1: Rate of Drawdown at Monitoring Bores in proximity to the GDV Zone from abstraction at 0.5 GLpa

Bore ID	Rate of Drawdown (m/yr) Year 1 to 5	Rate of Drawdown (m/yr) Year 5 to 10	Rate of Drawdown (m/yr) Year 10 to 23	Average Rate of Drawdown Year 1 to 23 (m/year)
KMB01	0.42	0.32	0.20	0.2
KMB04	0.33	0.27	0.18	0.2
KMB05	0.39	0.30	0.20	0.2
KMB06	0.42	0.32	0.21	0.2
KMB07	0.37	0.29	0.20	0.2

Table 4-2: Rate of Drawdown at Monitoring Bores in proximity to the GDV Zone from abstraction at 0.25 GLpa

Bore ID	Rate of Drawdown (m/yr) Year 1 to 5	Rate of Drawdown (m/yr) Year 5 to 10	Rate of Drawdown (m/yr) Year 10 to 23	Average Rate of Drawdown Year 1 to 23 (m/year)
KMB01	0.24	0.14	0.07	<0.1
KMB04	0.20	0.13	0.06	<0.1
KMB05	0.24	0.15	0.07	<0.1
KMB06	0.24	0.15	0.07	<0.1
KMB07	0.22	0.14	0.07	<0.1

The tables above show that the drawdown rate is greatest within the first five years for both scenarios and that the average drawdown rate for the 0.5 GLpa scenario would be approximately 0.2 m/year and for the 0.25 GLpa scenario would be less than 0.1 m/year.

These average rates of drawdown put the abstraction in the low to moderate risk zone for rate of abstraction but the overall drawdown of between approximately 4.5 and 5 m after 23 years would suggest severe impacts over the life of the project at 0.5 GLpa according to Froend and Loomes (2004). At an abstraction rate of 0.25GLpa over 23 years the overall drawdown is between 1.5 and 1.8 m which would put the total abstraction in the moderate risk category according to Froend and Loomes (2004).

Froend and Loomes' (2004) paper is based on the Swan Coastal Plain ecosystems and groundwater regime and may or may not be applicable to how the vegetation have adapted to the drier seasonal regime. Therefore, direct application of Figure 4 may not be entirely applicable, however, due to the limited data available on the groundwater dependence of the vegetation community, a conservative approach has been adopted to manage the risks.

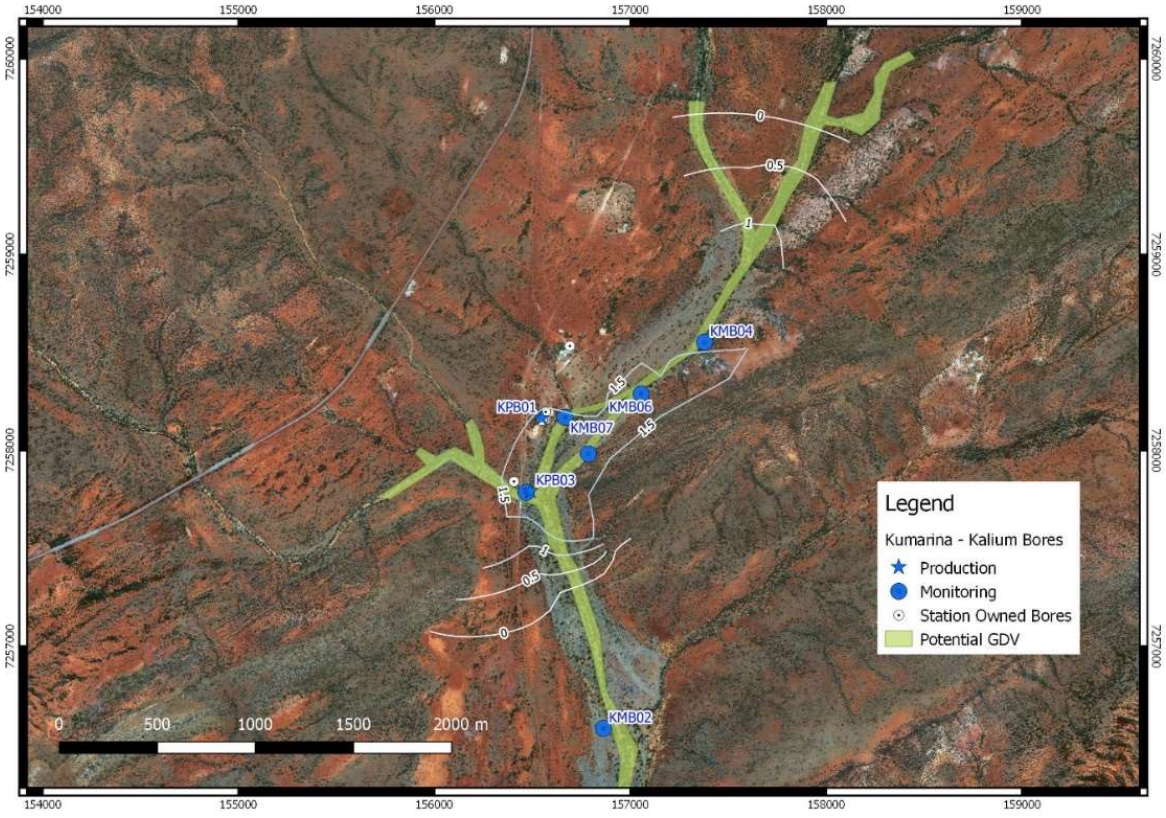

Figure 5: 0.25 GLpa drawdown contours after 23 years

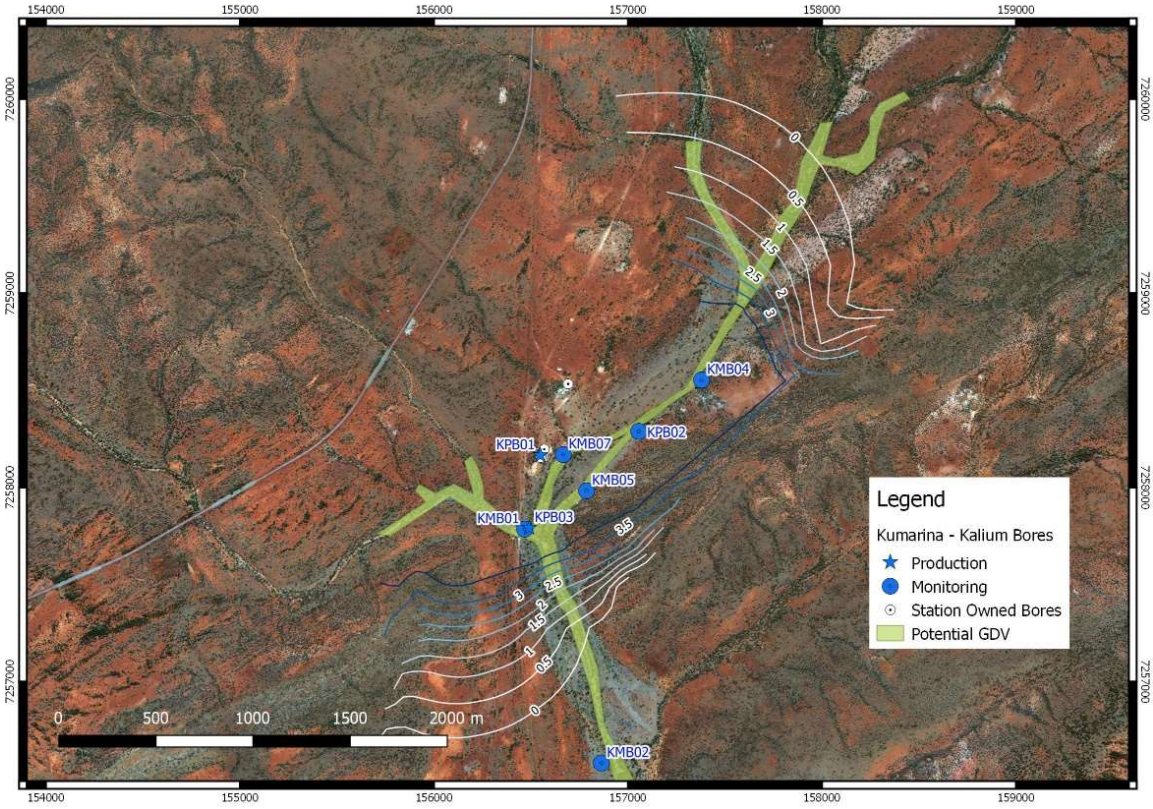

Figure 6: 0.5 GLpa drawdown contours after 23 years

5 Summary

The aim of this report was to reduce the rate of water level drawdown by reducing the abstraction of groundwater from the Kumarina borefield so that the rate and magnitude of water level drawdown is within the moderate risk zone to GDV according to Froend and Loomes (2004).

Two abstraction rates were modelled, 0.5 GLpa and 0.25 GLpa over 23 years. The results suggest that the average rate of drawdown over the 23 years of the project is within the moderate risk zone for both abstraction rates, however the magnitude of the 0.5 GLpa Scenario puts this abstraction rate within the severe risk category, whilst the 0.25 GLpa abstraction is within the Moderate category.

There is currently little available information on the potential GDV community in the vicinity of the borefield. Therefore, the Froend and Loomes (2004) risk categories derived for Swan Coastal Plain are the only referable source to characterise potential impacts to the potential GDVs. The 0.25 GLpa abstraction is considered to have a moderate risk to GDVs in the vicinity to the borefield over the 23 years period.

Further work to characterise the potential GDV and determine their reliance on groundwater is required to understand the potential impacts at higher rates of abstraction.

6 References

Advisian 2018a, Kumarina Water Supply Project, H3 Level Hydrogeological Assessment, Report for Kalium Lakes Ltd, June 2018.

Advisian 2018b, Ten Mile South and Beyondie Water Supply Project, H3 Level Hydrogeological Assessment, Report for Kalium Lakes Ltd, July 2018.

R. Froend and R. Loomes 2004, Approach to Determination of Ecological Water Requirements of Groundwater Dependent Ecosystems in Western Australia, A report to the Department of Environment, December 2014.

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