3D Conceptualization and Numerical Model Analysis, and its Impact on Drawdown, in the Bulgarene Borefield, Port Hedland WA

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FRESH WATER THINKING WATER CORPORATION

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Water corporation Overview

Our services span over 2.6 million square kilometers.

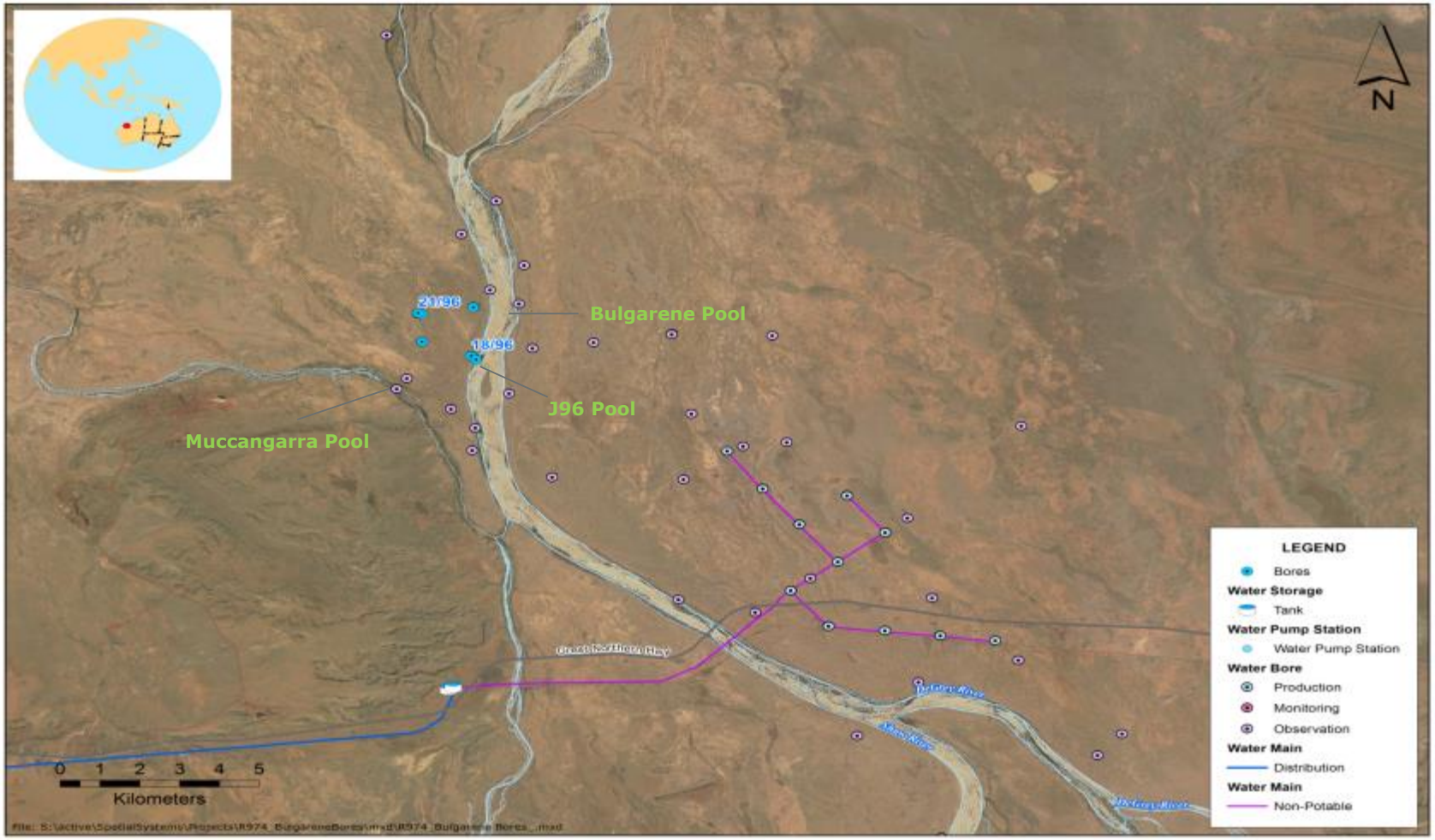
Water Supply

- 103 Dams
- 725 Production bores
- 456 pumping stations
- 277 Water treatment plants
- 33,562km of water mains

Wastewater

- 15,500km of sewer pipe
- 1.122 Pumping stations
- 106 treatment plants
- 2,850km of storm water drains

Site Description



Site Description

- The Bulgarene borefield is within the Degrey Scheme. The Degrey scheme is currently licensed to abstract 10 GL per year.
- It's a complex area with heritage, environmental, pastoralist and mining concerns all needing to be taken into account.
- Permanent and semi permanent water holes along the Degrey and Ridley Rivers having significant value to traditional owners.
- Muccangarra Pool on the Ridley River is a permanent pool which is particularly significant and potential impacts need to be investigated as thoroughly as possible.

Site Description

Site Description

Previous Work

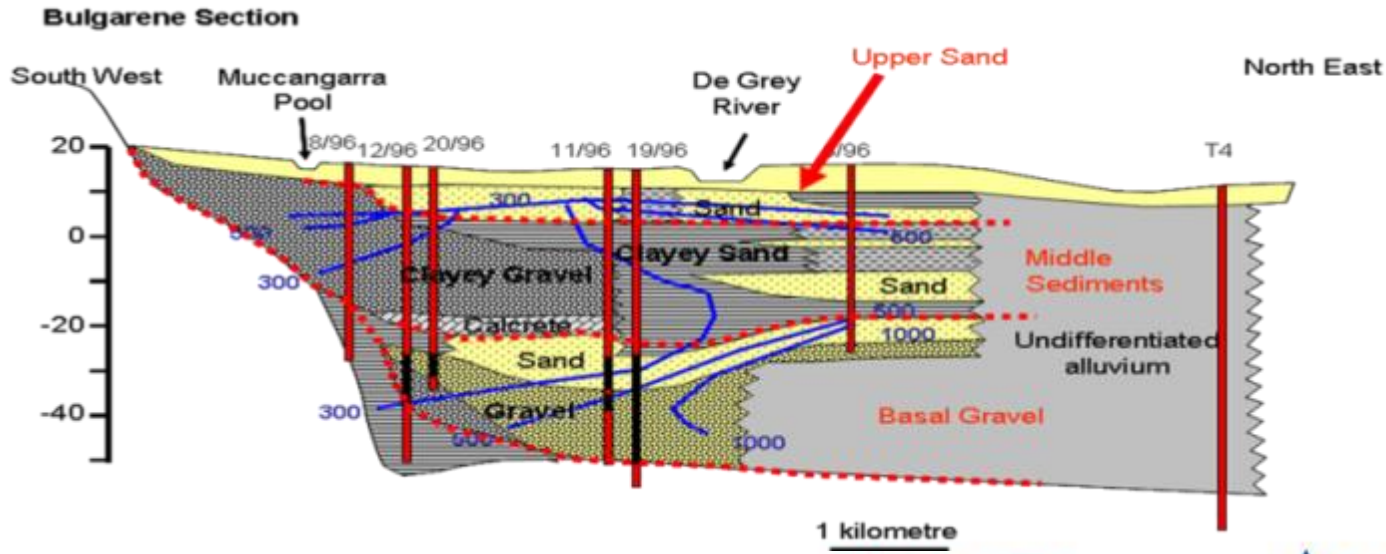
1996 Water Corporation Work

- 4 Production bores were drilled and pump tested at Bulgarene in 1996.
- The borefield was modelled and results indicated a potential for 3-6GL/yr. from Bulgarene.
- Although results indicated uncertainty regarding the impact on water levels in permanent and semi-permanent water holes along the Degrey and Ridley Rivers.

Previous Work

2004 Water Corporation

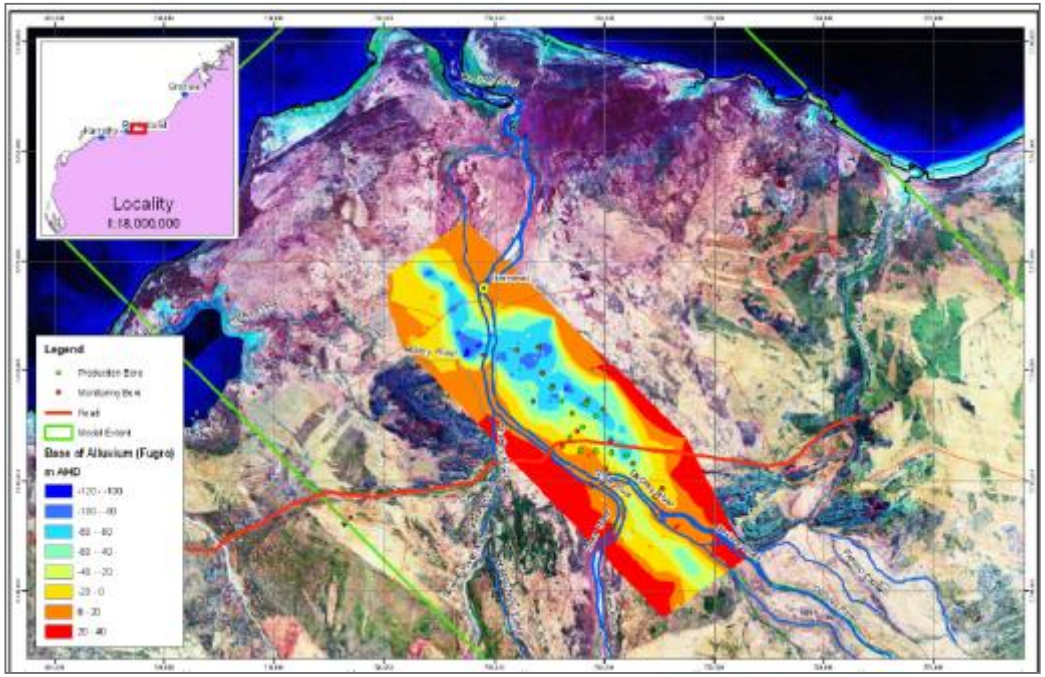
- Complex 3 layers
- Calcrete Confining Layer
- Modelling indicated Muccangarra drawdowns of up to 2.5m.



Previous Work

2009 Department of Water

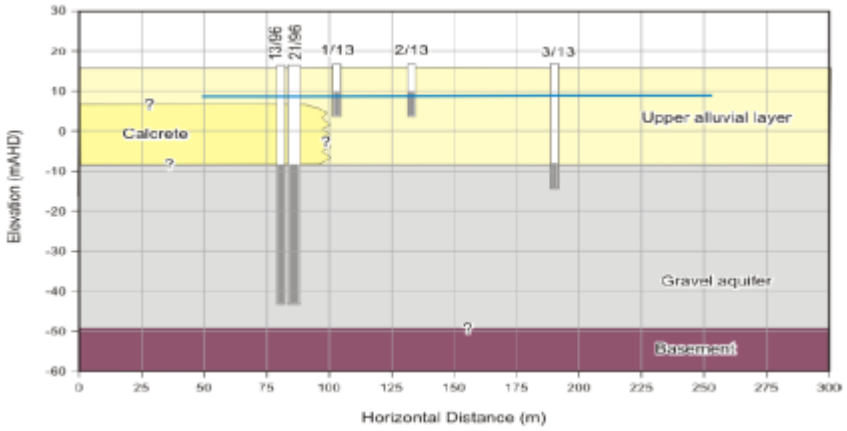
- AEM Survey assisted in better defining palaeochannel and updating of conceptualisation.
- New model indicated drawdowns of up to 2m at Muccangarra Pool.

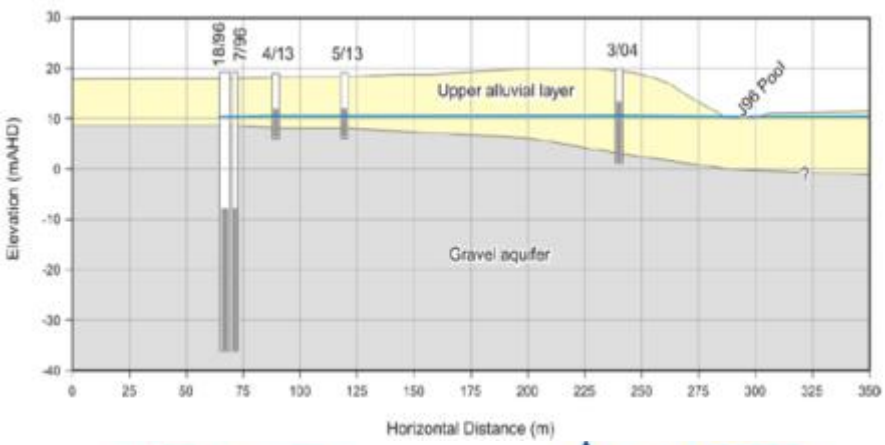


Previous Work

2014 Water Corporation

- Drilled 5 shallow monitoring bores to determine the extent of connection between aquifers during aquifer test.
- 2 separate 14 day 81l/s aquifer test in Production bore 18/96 and 21/96.
- Results from the 2014 field programme and subsequent numerical modelling indicate a potential 2-4 GL/annum with 0.2m of drawdown at Muccungarra Pool for all scenarios.





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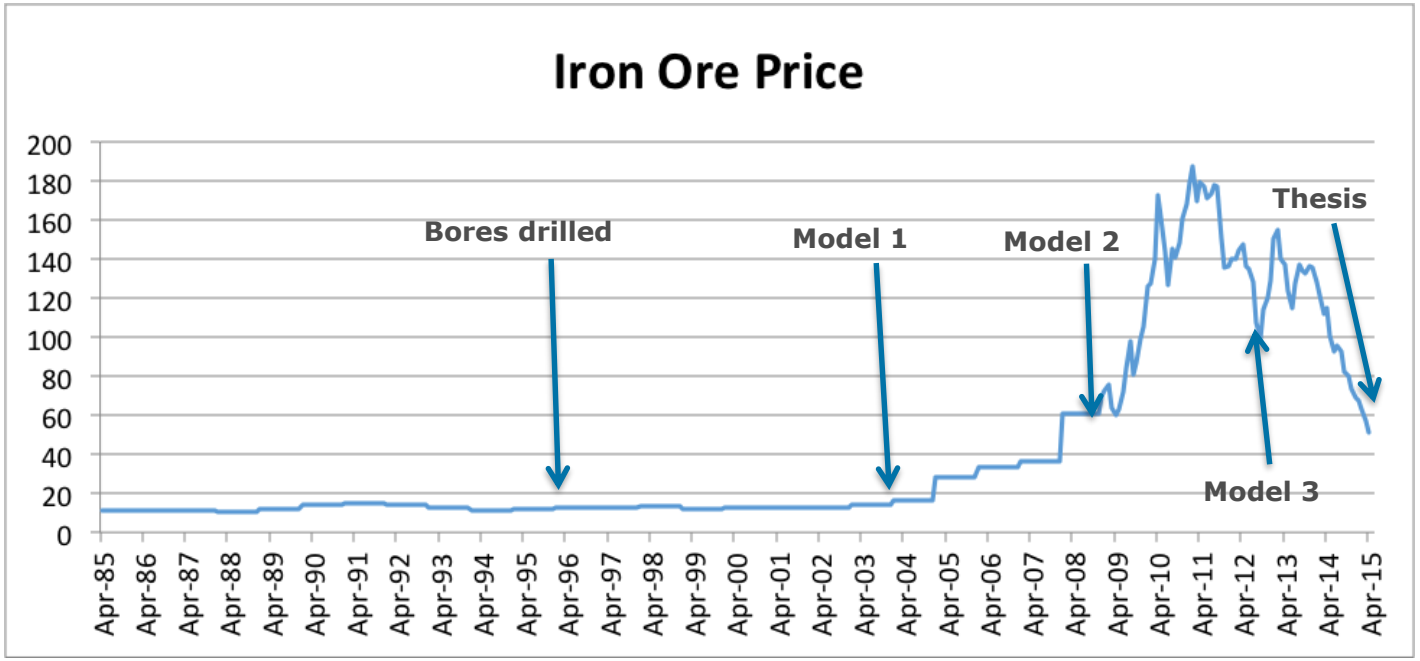
Next Step

- What Next?????
- We have 3 Numerical Models, but which one best represents the system?



Thesis Work

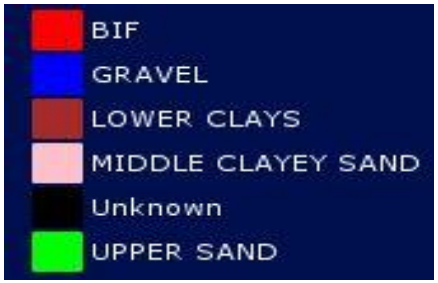
- Reviewed all of the existing data sets, including bore lithological logs, EM surveys, hydraulic testing data and previous 2D conceptual models.
- This information was then used to create 3D conceptual models using Leapfrog TM modelling software.
- These models will then be used to compare potential depositional environments used in the hydrogeological conceptualisation of the previous work undertaken

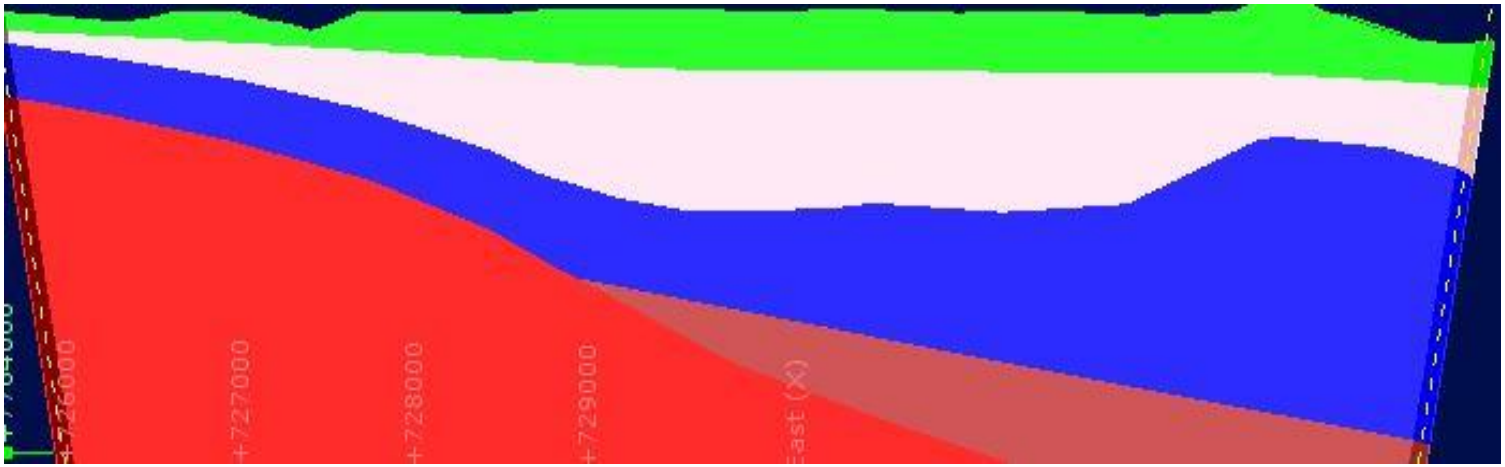
Thesis Work

- Comparing the three new 3D conceptual models with their corresponding 2D model.
- Analyse the numerical modelling parameter inputs selected for the three previous numerical models.
- Review the three previous conceptual models and their related numerical models and determine the reasons for the variation in drawdown results.

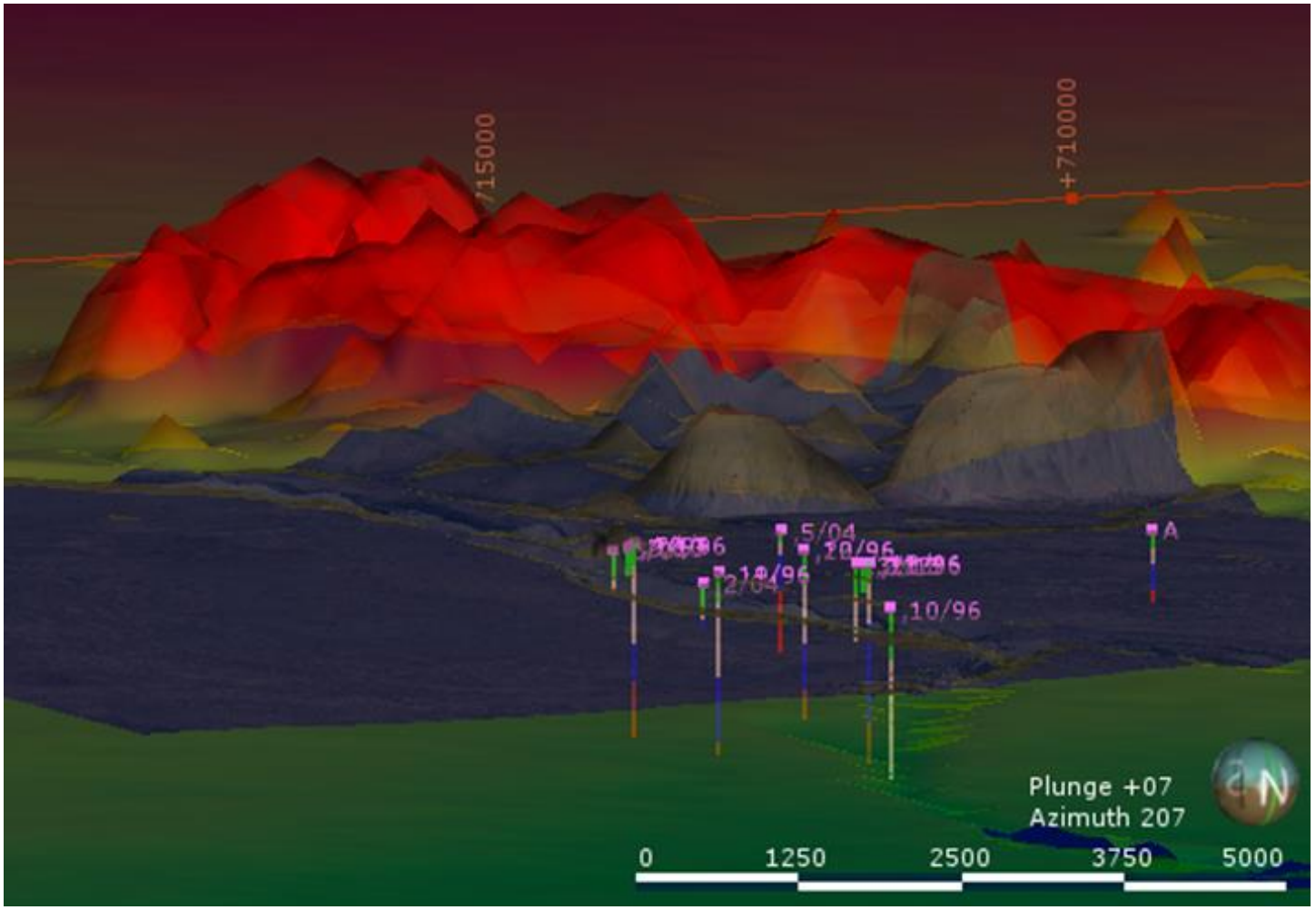
Findings

- Model 1 Conceptualization
- 5 layers.
- Confining layer between upper and lower aquifers.



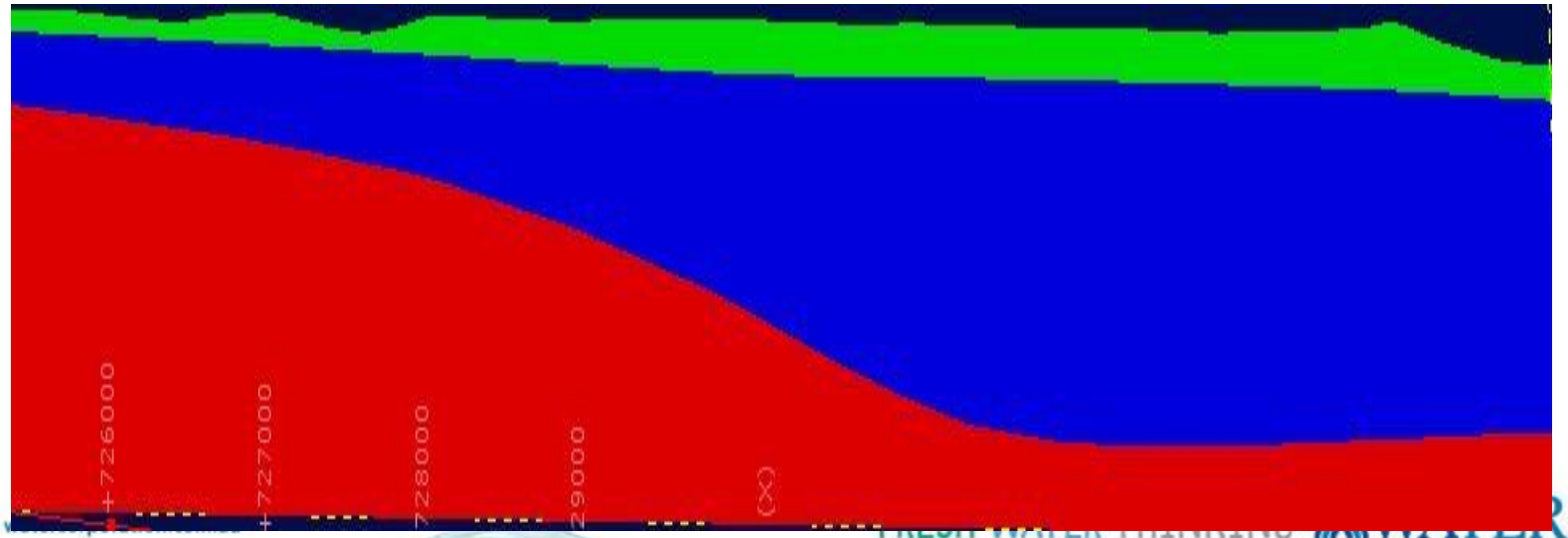


Findings – Model 1

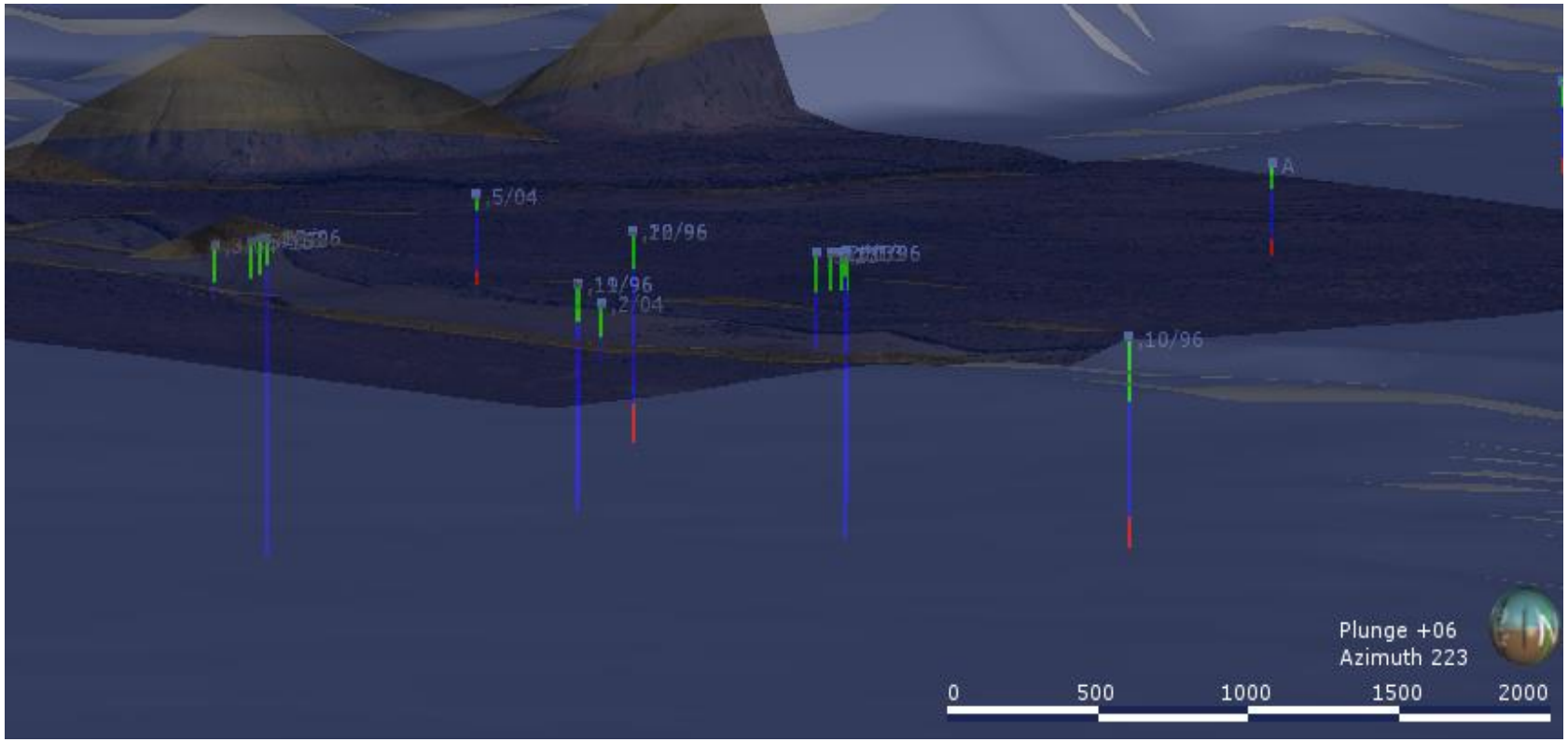


Findings

- Model 2 Conceptualization
- 3 layers

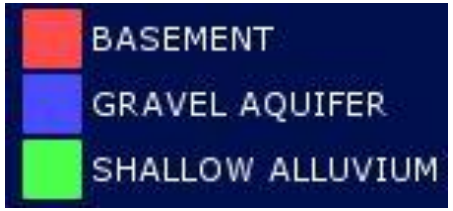


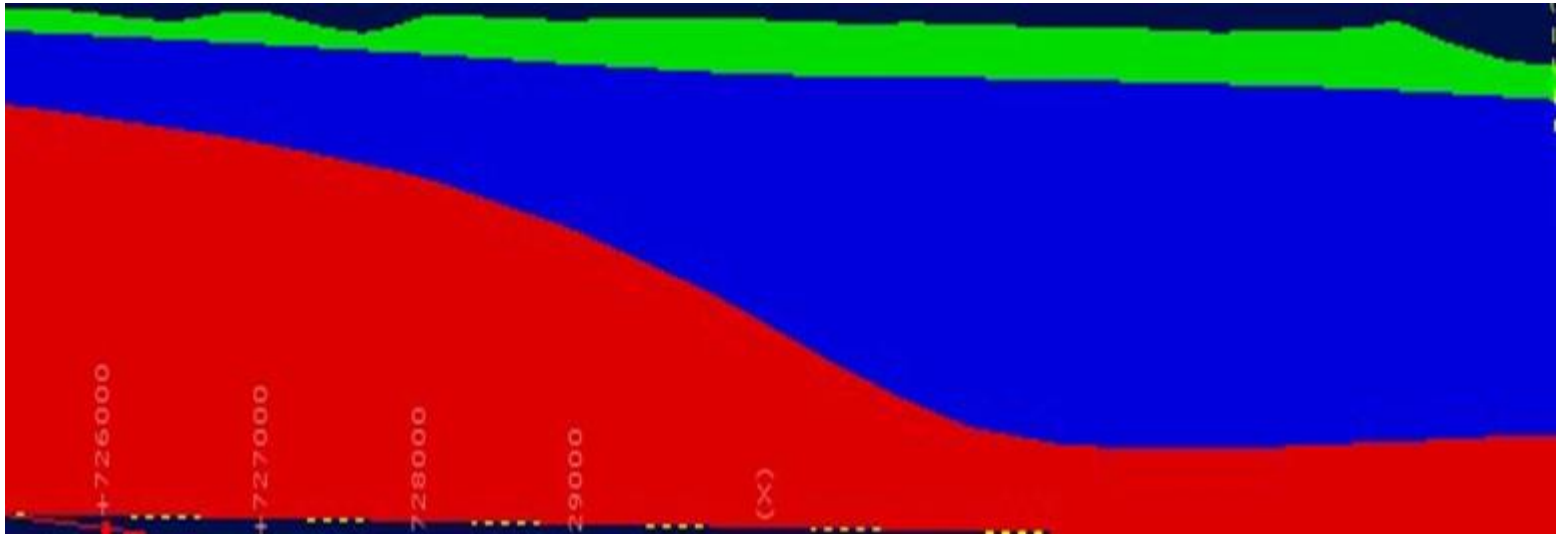
Findings – Model 2



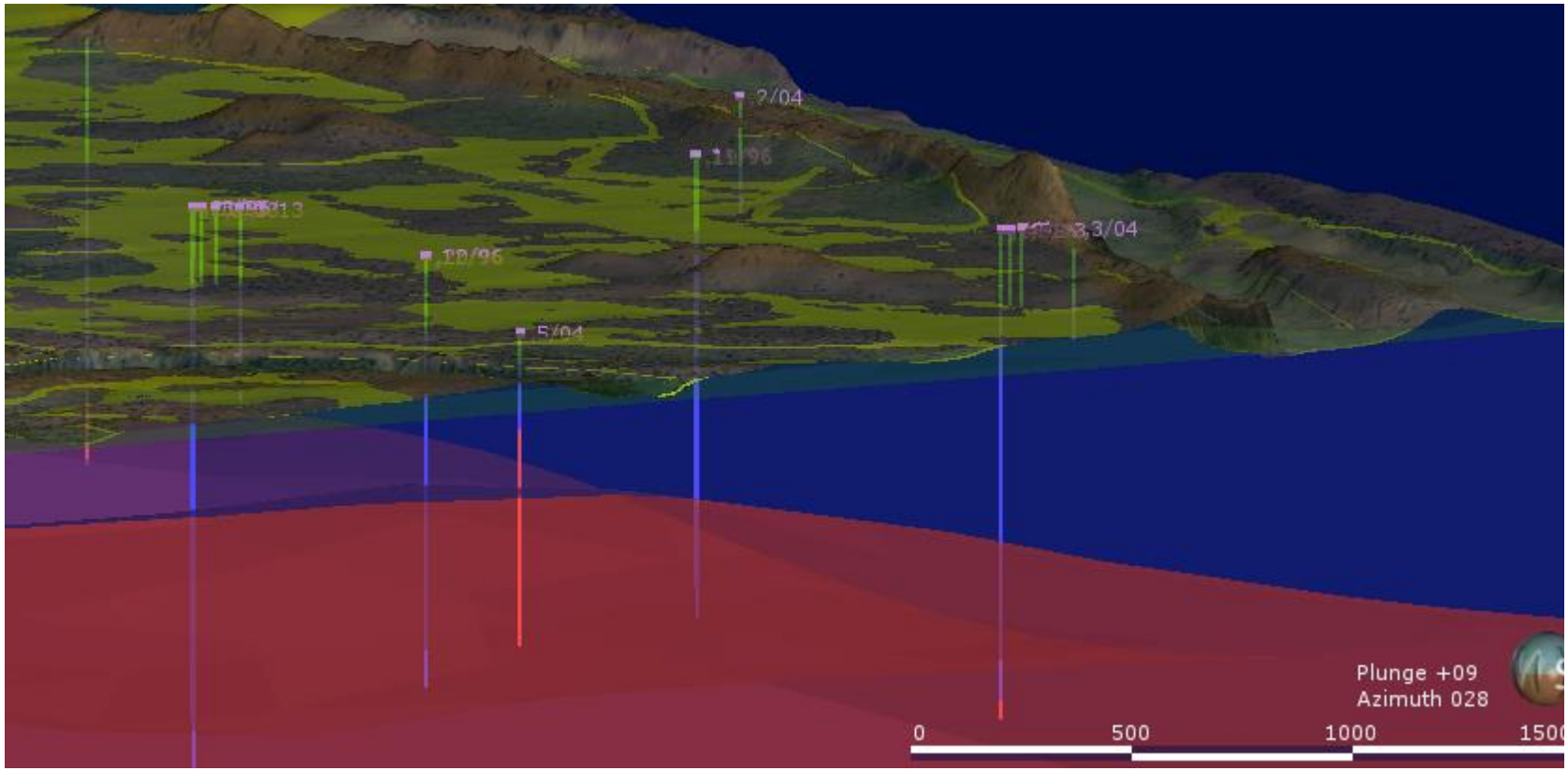
Findings

- Model 3 Conceptualization
- 3 layers





Findings – Model 3



Findings

Numerical Model Drawdown Estimates

- 3 numerical models have been undertaken on this scheme.
- Model 1 and 2 have very different conceptualization but showing substantial drawdowns.
- Model 2 and 3 have very similar conceptualization but showing conflicting drawdown results.

	Abstraction GL/yr	Drawdown Muccungarra (m)	Drawdown J/96 (m)
Model 1	6	1-2.5	4-5
Model 2	2	1	1-2
Model 3	2-4	0.08	1.2-2.44

Findings

Numerical Model Inputs

- Model Areas
- Boundary Conditions
- Rainfall Recharge
- River Recharge
- Evapotranspiration
- Calibration Period

- Didn’t vary much between the three numerical models as they all used the data from (Davidson, 1974).

Findings

1996 Pump Test Analysis

- Jacob constant rate Analysis
- 24 hour pump Test
- Total Drawdown 18/96- 4.96m
- Total Drawdown21/96- 5.76m

	Saturated Thickness (m)		Transmissivity (m2/d)		Hydraulic Conductivity (m/d)	
Borehole	Surficial Aquifer	Gravel Aquifer	Surficial Aquifer	Gravel Aquifer	Surficial Aquifer	Gravel Aquifer
18/96	N/A	47	N/A	3,669	N/A	78
21/96	N/A	51	N/A	6,115	N/A	121

Findings

2014 Pump Test Analysis

- Boulton Method Analysis
- 14 day pump Test
- Total Drawdown 18/96- 3.43m
- Total Drawdown 21/96- 2.24m

2014 Data	Saturated Thickness (m)		Transmissivity (m2/d)		Hydraulic Conductivity (m/d)	
Borehole	Surficial Aquifer	Gravel Aquifer	Surficial Aquifer	Gravel Aquifer	Surficial Aquifer	Gravel Aquifer
18/96	17	27	1.7	3,200	0.1	118
21/96	15	35	1.5	5,000	0.1	142

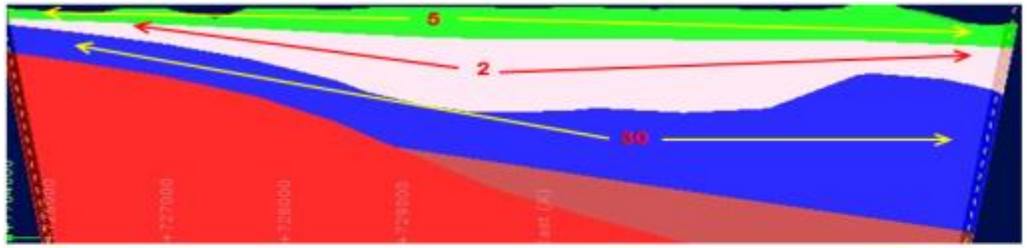
Findings

Calibrated numerical hydraulic parameters

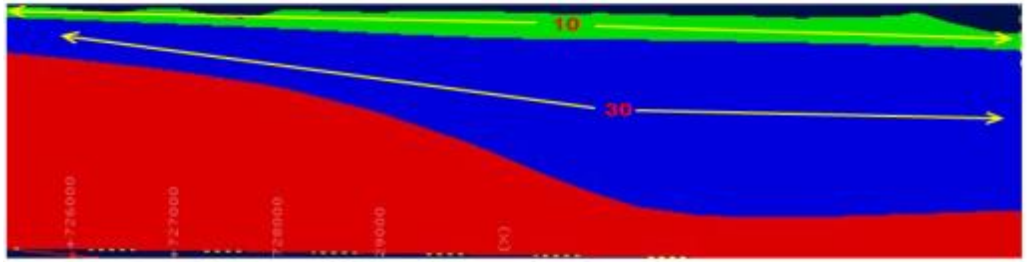
- All three models have much lower Kh values than the pump test results in the paleochannel alluvium.
- Model 3 has a higher Kh value than model 1 and 2.

	Surficial Alluvium Kh (m/d)	Surficial Alluvium Kz (m/d)	Confining Layer Kh (m/d)	Confining Layer Kz(only in borefield) (m/d)	Palaeochannel Alluvium Kh (m/d)	Palaeochannel Alluvium Kz (m/d)
Model 1	5	2	2	0.1	30	30
Model 2	10	1	N/A	N/A	30	5
Model 3	1	0.2	N/A	N/A	50	14

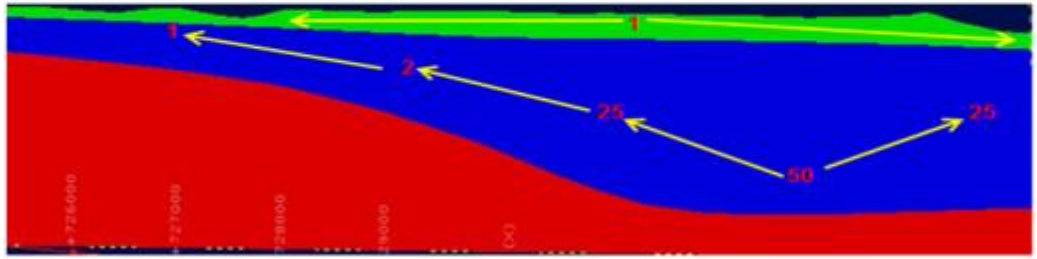
Summary



Model 1(a)

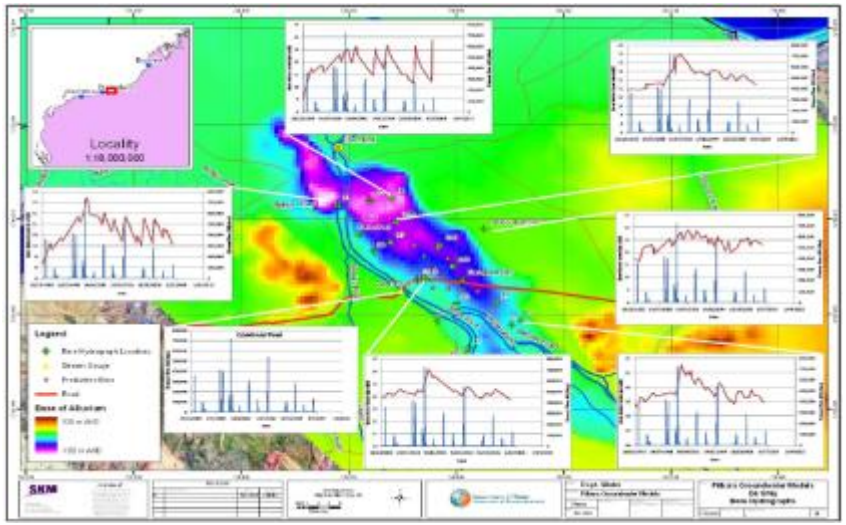


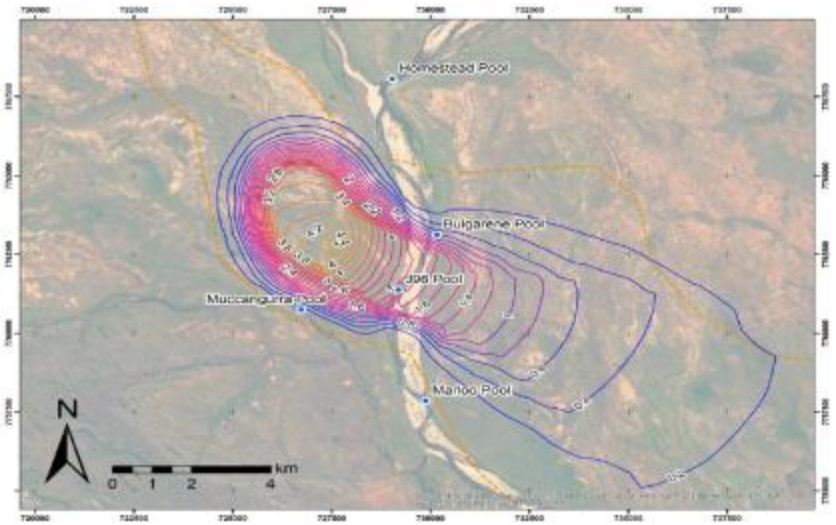
Model 2 (b)

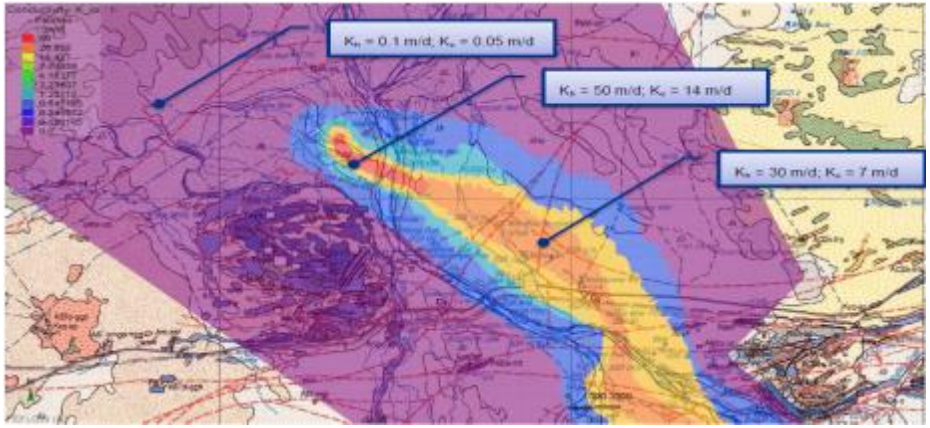


Model 3 (c)

Summary


Locality
Legend
SKM


Homestead Pool
Bulgarene Pool
Jane Pool
Muccanguma Pool
Mando Pool
N
0 1 2 4
km


K_h = 0.1 m/d; K_v = 0.05 m/d
K_h = 50 m/d; K_v = 14 m/d
K_h = 30 m/d; K_v = 7 m/d

Summary

- Model 1 conceptualization was based on things that hadn't been tested i.e. Kh and Kz values in upper sand confining layer.
- Model 2 had AEM survey data to increase understanding. But no other new information or data.
- Model 3 had the advantage of all previous data, plus newly acquired information. Which allowed for greater understanding of the aquifer. Shallow drilling and pump testing.

Summary

- Model 1 and Model 2 looked to have kept the Kh values at 30m/day which is in line with the 1970 investigations. And adjusted the other hydraulic parameters to calibrate their models.
- Model 1 and Model 2 have assumed the same Kh value across the entire gravel aquifer.
- Evidence suggests that the monitoring bores identified within the paleochannel are more responsive to river flow/recharge.
- So… It's a reasonable assumption to conclude the Kh values within the paleochannel area would higher than aquifer areas outside the paleochannel areas. As represented by Model 3.

Thanks