Appendix C

Groundwater Assessment

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OREBODY25 (Pit 3) HYDROGEOLOGICAL INVESTIGATIONS

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EXECUTIVE SUMMARY

The main objectives of this investigation were to assess the feasibility of dewatering Orebody25 (Pit 3), in conjunction with the planned dewatering of nearby Orebody 23 (OB23), and the short and longer term impacts of mining below the water table on local and regional groundwater resources.

The investigation comprised a data collection phase (including a review of all available background information and site specific field investigations) to provide input data for predictive groundwater flow and dewatering modelling.

Six scenarios were modelled, one base case scenario with no dewatering and five active dewatering scenarios covering various water supply pumping schemes to maintain water supplies to Newman and the Satellite Orebodies. The model predicted the dewatering requirements for OB25 (Pit 3) and OB23, for the five dewatering scenarios (including sensitivity to wet and dry rainfall sequences) and the potential long-term impacts of the final voids at the completion of mining. This included one scenario where the OB25 pit void is infilled to above the pre-mining water table.

A conservative, one dimensional mass balance model was used to estimate the development of salinity within the mine void lake at OB23 and for the lake at OB25 for the infill scenario.

The key results of the investigation are as follows:

Dewatering Rates

It is anticipated that three in-pit dewatering bores and up to four ex-pit, shallow dewatering bores will be required to achieve target dewatering water levels. The in-pit bores are anticipated to be high yielding, with a maximum yield of 4,000 kL/d. The ex-pit bores will be shallow and their effectiveness may be short-lived. Should these bores be decommissioned as water levels decline, it is anticipated that they may be recommissioned in the wet seasons when recharge from the Homestead Creek will increase water levels in this area. As the ore is dewatered, the reduced thickness of saturated aquifer and the associated reduced transmissivity will also result in bore yields declining. Thus, as the pit approaches its maximum depth, the effectiveness of the in-pit bores will decline and it is anticipated that they will be replaced with in-pit sumps.

Total predicted dewatering requirements for OB25 (Pit 3) range from 14,800 kL/d in the early years to approximately 9,400 kL/d at the end of mining (assuming a seven year mine life). The combined total dewatering requirements for OB25 (Pit 3) and OB23 range between 39,600 and 51,800 kL/d.

It is proposed that a reticulation system will be installed such that the dewatering discharge can be used for process water at OB25 or fed into the Ophthalmia E Line for either use at Mt Whaleback (Newman Hub) or discharge to Ophthalmia Dam (ie if production is in excess of water supply requirements). Water balance calculations for the dam suggest that excess water from OB23 and OB25 will not result in overflow from the dam.

Impacts During Active Dewatering

Water Levels

The precise impact of dewatering on water levels will be dependent on the climatic conditions at the time of dewatering. The worst-case (dry conditions), predicts drawdown (ie greater than 10 m) extending approximately 4.5 km upstream and downstream of OB25 (Pit3) and OB23 respectively and maximum predicted drawdowns at Ophthalmia Dam of approximately 5 m.

Water Quality

Active dewatering is not expected to have any impact on groundwater quality. Active groundwater recharge processes will replenish depleted groundwater storage and, if anything, groundwater quality might improve. That is, older groundwater will be abstracted and replaced by recharge that might have otherwise run off.

We also understand that mineral exploration to date has not encountered pyritic shales at OB25 (Pit 3). This being the case, it is not anticipated that acid rock drainage (ARD) as a result of runoff over pit walls or drainage through lower pit walls will be a problem.

Flora and Fauna

Drawdowns in response to dewatering and water supply pumping may have some localised impact on phreatophytic vegetation, which is concentrated within the main drainage courses, and stygofauna species, which are known to inhabit the calcrete / gravel valley fill sediments within the main drainages.

Predicted drawdowns of 5m at the end of dewatering extend 3km to the west of OB25 beneath Homestead Creek, 1.5km to the east of OB23 beneath Shovelanna Creek and 1km north of OB23 beneath the Fortescue River. Drawdowns in excess of 20m are restricted to a narrow zone beneath Whaleback Creek and extend no more than 500m upstream of OB25 or downstream of OB23. Predicted drawdowns in excess of 40m are restricted to the immediate vicinity of each pit.

The potential impacts of these predicted drawdowns have been specifically addressed in parallel investigations.

Post Dewatering Impacts

Water Levels

Following dewatering, the water levels at OB25 (Pit 3) are predicted to recover irrespective of the water supply scenario for Newman and the Satellite Orebodies. Assuming that the pit is left open, the model simulations suggest that water levels in the vicinity of the pit will have recovered to within 20 m of the pre-mining levels (ie 85% recovery) 19 years after the cessation of dewatering with aquifer drawdowns in excess of 10m being restricted to an area within 2km of OB25 (and negligible drawdown around OB23).

Assuming that OB25 is infilled to above the pre-miming water table, groundwater levels are predicted to have recovered to within 2 metres of pre-mining levels by Year 35 (ie 9 years after the cessation of water supply pumping and approximately 28 years after the cessation of dewatering).

Water Quality

Given the absence of pyritic shale, the only potential impacts of mine closure on groundwater quality are related to the potential salinity increases in the pit lake due to evaporative concentration of salts if the pits are left as is.

Groundwater modelling results indicate that, once full recovery of water levels is complete, there will be some groundwater outflow from OB25 (Pit 3). This groundwater outflow will limit the long-term development of salinity within the pit lake (as it results in a net export of salt). The mass balance model predicts that the pit lake salinity will be at around 12,000 mg/L after around 1,000 years and will still be increasing (ie steady sate conditions will not be reached for at least 2,000 years). However, the impacts of such outflows (low flow rates at elevated salinity) would likely have negligible impact on down-gradient groundwater quality due to blending and dilution with the much higher rates of fresh throughflow in the paleovalley aquifer. Measurable impacts would be expected to be limited to the immediate vicinity of the pit, where groundwater outflows remained within the Brockman Iron Formation.

Notwithstanding the above, BHPBIO have committed to backfilling OB25 (Pit 3) to just above the pre-mining water table. As a result, there will be no daylighting of groundwater and there will be no increased salinity due to the evaporative concentration of salts in a pit lake. As such, there should be no long-term impact on groundwater quality within or outside the pit area.

Flora and Fauna

In relation to phreatophytic vegetation and stygofauna habitats, the predicted long term drawdowns around each pit are minimal (refer Figure 16), and are expected to have no impacts.

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

Appendix A	Composite Borelogs
Appendix B	Test Pumping Plots
Appendix C	Source Reliable Outputs
Appendix D	Water Quality Data
Appendix E	Model Features & Calibration
Appendix F	OB23 Modelled Prediction Plots
Appendix G	Predicted Impact on Selected Elements of the Modelled Water Balance

SECTION 1 - INTRODUCTION

1.1 BACKGROUND

Orebody 25 (OB25) is situated on Eastern Ridge, to the south of the Ophthalmia Range, some 13 km east-north-east of Mt Whaleback. Three mining pits have been developed at OB25: Pit 1 and Pit 1 Extension which are currently in production; Pit 2 which has been mined out; and Pit 3 which has been mined to the water table with mineralisation still extending to approximately 140 m below the current level. Mining below water table at Pit 3 (and also at Orebody 23 to the east of Pit 3) is presently scheduled to begin during YEJ06 / YEJ07 and will require dewatering ahead of mining.

Aquaterra Consulting Pty Ltd (Aquaterra), in their role as the BHPBIO Hydrogeology Group, were tasked to conduct hydrogeological investigations at OB25 (Pit 3) in February 2004.

This report details these investigations and presents the findings. It is intended that the report will provide supporting documentation to the Environmental Impact Assessment and regulatory approvals documentation relating to mining below the water table at OB25 (Pit 3).

1.2 OBJECTIVES

The main objectives of the investigation were to assess the feasibility of dewatering OB25 (Pit 3), in conjunction with the planned dewatering of nearby Orebody 23 (OB23), and the short and longer term impacts of mining below the water table on local and regional groundwater resources. The aims were to predict the following:

1. The groundwater abstraction requirements for dewatering at OB25 (Pit 3);
2. The short-term (ie mining phase) impacts on groundwater levels associated with the combined dewatering of OB25 (Pit 3) and OB23;
3. The longer-term (ie post mining) impacts on ground water levels and water quality associated with the closure (pit voids) of OB25 (Pit 3).

1.3 TECHNICAL APPROACH

Investigations were conducted in three main phases.

1. Initial Desktop Study: Assessment of the existing geological and hydrogeological data at OB25 (Pit 3) and planning of the field investigations;
2. Field Investigations: Comprising exploration drilling, the installation of observation bores and the installation and hydraulic testing of trial dewatering bores to determine the aquifer parameters and potential bore yields.
3. Modelling: Expansion and upgrading of the existing OB23 groundwater model to cover OB25 (Pit 3) and the more extended regional area to assess the combined impact of dewatering the two orebodies and to undertake closure predictions. Initial modelling covered a number of operational scenarios where the final pit void was left open at mine closure. Follow-up modelling covered the most likely operational scenario, but for a case where the pit void was infilled to above the pre-mining water table. As part of a separate investigation, the model was also designed to be used to assess the optimisation of the Newman water supply system. Development of a conservative one-dimensional mixing model to estimate the development of salinity within the mine void lakes at both OB23 and OB25 assuming no infill of the final voids.

1.4 HYDROGEOLOGICAL BACKGROUND

1.4.1 Regional Geology

The topography of the extended area of investigation is dominated by the Ophthalmia Range which, in places, rises 100m above the surrounding gently undulating terrain. The mineralisation of the satellite orebodies in this area (OB23, OB24 and OB25) is located within the Dales Gorge Member of the Brockman Formation which is part of the Early Proterozoic Hamersley Group.

The Hamersley Group is underlain by the Fortescue Group and older Archean granitic rocks which outcrop in places to the south and southeast of the investigation area.

Long term erosion has incised deep valleys into the Archean and Proterozoic basement rocks, which were subsequently infilled with sediments during the Tertiary period. These sediments reflect periods of intermittent fluvial and lacustrine sedimentation. The older, deeper sediments and more recent, shallow sediments are fluvial with the development of extensive calcrete horizons within the shallow sediments.

1.4.2 Local Geology

Orebody 25, located on Eastern Ridge, comprises a faulted outlier of the Brockman Iron Formation bounded to the far north-west by the Whaleback Fault and to the far east by the Fortescue River Fault. A large F2 anticline dominates the structure of the area, with Pits 1 and 2 developed on the southern limb / anticlinal crest area and Pit 3 in the overturned north limb (Kneeshaw, 2002). Ore is mined from both the Dales Gorge (D2) and Joffre Members and is M-G (martite-goethite) high phosphorous type.

At Pit 3, the orebody is flanked to the south by siltstones, shales and BIF of the Mt McRae Shale and Mt Sylvia Formation which is overlain by Tertiary alluvial sediments, known as the Tertiary Detritals (TDs). At OB25, the Tertiary Detritals comprise a sequence of surficial silty BIF scree (TD3) underlain by mixed gravels, clays and calcrete horizons (TD2). The oldest Tertiary unit (TD1) does not appear to be present. In comparison to the alluvial sequence at OB23 which is up to 100m in places, the sequence adjacent to OB25 appears to be much thinner (approximately 30m thick) and less permeable having a high clay content and only a thin horizon(s) of calcrete.

1.4.3 Hydrology

The Newman (and Orebody 25) area is located within the subtropical rainfall zone, with typically hot summers with periodic heavy (sometimes cyclonic) rainfall and mild winters with occasional rainfall. Average annual rainfall at Newman is 352 mm with an average of 58 raindays per year. All creeks in the region are intermittent and flow only after major rainfall. The Fortescue River and its main tributaries coalesce prior to cutting through the Ophthalmia Range at Ethel Gorge (adjacent to OB23).

Ophthalmia Dam impounds the Fortescue River upstream of Ethel Gorge as part of an aquifer recharge scheme (refer below). Surface water flow in the main Fortescue River channel results from dam overflow and/or release, leakage and run-off generated in catchments not impounded by the dam. One such catchment (Homestead Creek) extends westwards from the dam area, with the main creek passing some 500 m to the south of OB25 (Pit 3).

1.4.4 Hydrogeology

Two main aquifer types have developed in the region as follows:

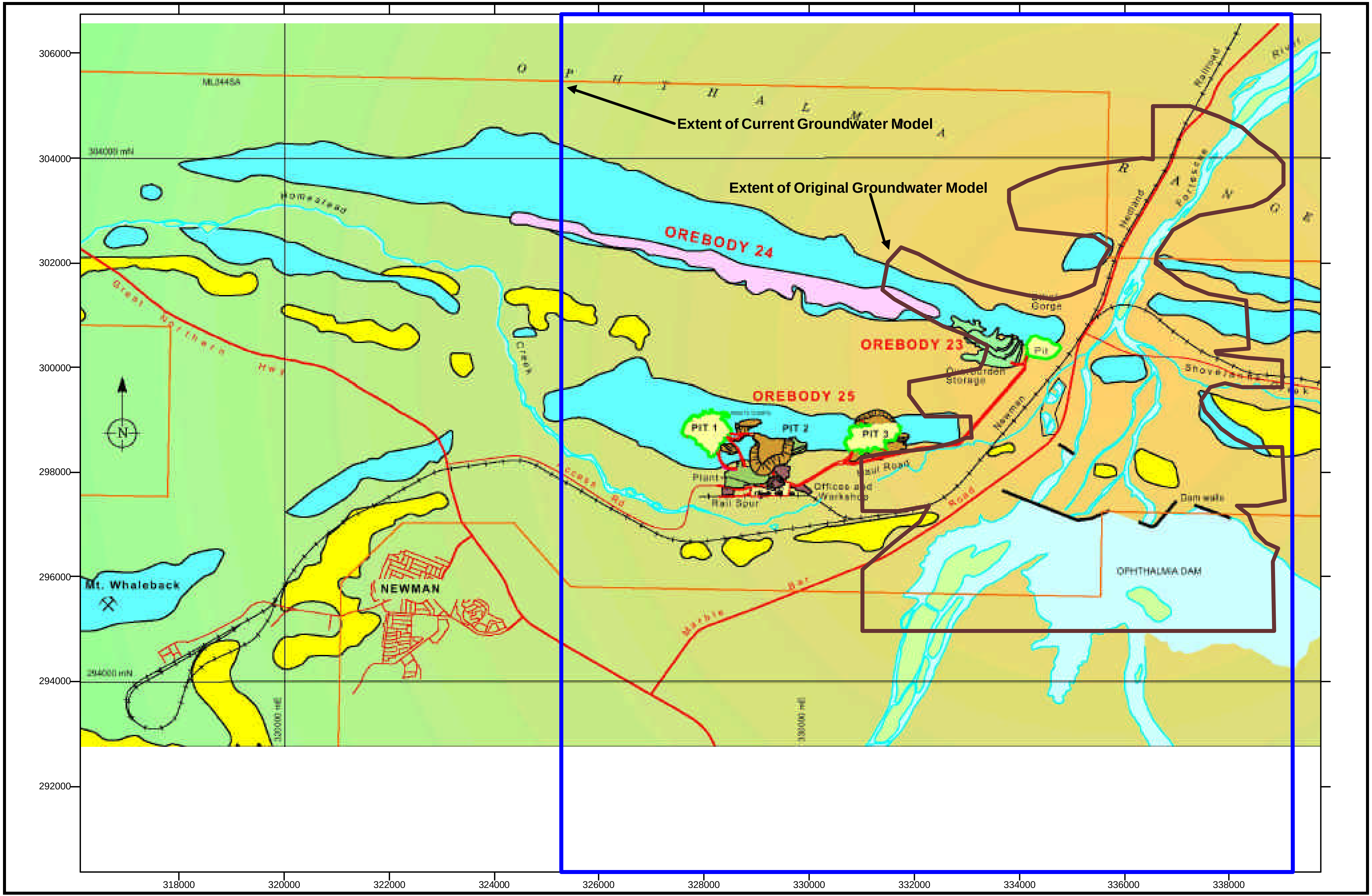
- Basement Aquifers – The main orebodies form major aquifer systems. These are generally unconfined aquifers as a result of secondary permeability and porosity associated with mineralisation. At OB23 and OB25, the main orebody and aquifer is associated with the Dales Gorge Member. The aquifers are elongated along the east-west strike of the Dales Gorge Member, with the higher permeabilities being limited by the extent of mineralisation. The aquifers are bound to the north by the hanging wall sequence (Whaleback Shale, Joffre member and Weeli Wolli Formation) and to the south by the footwall sequence (Mt McRae Shale and Mt Sylvia Formation) and overlying valley fill sediments. Recharge occurs through direct infiltration of rainfall and by leakage from surrounding alluvium. In places beneath the main sections of the valley fill sequences, a confined aquifer has also developed within the Paraburdoo (dolomite) Member of the Wittenoom Formation.
- Valley Fill Aquifers – Permanent, semi-confined to unconfined aquifers have developed within the valley fill sediments associated with primary granular permeability and porosity in sands and gravels and with secondary weathering features within the calcretes. Recharge occurs through infiltration of runoff, particularly beneath the main creek channels and has also, in the past, been recharged by the planned release of water from Ophthalmia Dam into recharge basins (refer below). Local perched aquifers may also develop when sandy creek bed deposits are saturated during creek flow events and before leakage to the deeper water table.

1.4.5 Historical Water Resource Usage

Key water resource features in the area are the Ophthalmia Dam and the Ophthalmia Wellfield (see Figure 1). The dam (commissioned in December 1981) controls a catchment area of approximately 4,200 km^2 and intercepts stream flows from the Fortescue River, Warrawanda Creek, Whaleback Creek and a small tributary of Shovelanna Creek. The total storage capacity at full supply level (RL 513.5 mASL) is approximately 31 GL, covering a surface area of 16 km^2. The dam was constructed as part of an aquifer recharge scheme in the early 1980's when it was recognised that abstraction from the Ophthalmia Wellfield was exceeding the sustainable yield of the aquifer. The recharge scheme also includes four excavated recharge ponds, two river basins and an open earth canal (as shown on Figure 1), which can be flooded as required from the dam.

The Ophthalmia Wellfield currently provides both potable and raw water to the town of Newman, OB25 and the Mt Whaleback mining operations (supplementing water available from the Mt Whaleback mine dewatering activities and a nearby water supply bore). As the dewatering at OB25 (and OB23) will have an impact on the Ophthalmia Wellfield area, the water supply and dewatering requirements are closely associated and cannot be considered independently.

The Ophthalmia Wellfield currently comprises eighteen production bores and a wide network of monitoring bores, the locations of which are presented in Figure 1. The production bores generally intersect the alluvial aquifer, with some intersecting underlying weathered dolomite of the Wittenoom Formation (Hamersley Group).



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Location Plan and Model Extent

Figure 1

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Wellfield production is reticulated via three pipelines. The E and H pipelines reticulate water to the potable water treatment plant at Newman. Water supplies for the OB25 mining operation are sourced from the H Line. The K pipeline reticulates water into the Mt Whaleback mine raw water supply system. Production bore prefixes generally designate which pipeline the bores primarily discharge into (ie. H10 pumps into the H line). However, due to interconnecting reticulation, some bores can be reticulated into more than one line.

Groundwater was first produced from the Ophthalmia Dam Wellfield in 1969 with abstractions increasing steadily throughout the 1970s. Although, more recently, the availability of large volumes of mine dewatering production from the Whaleback Pit has reduced the demand on the Ophthalmia Wellfield, water requirements for both the Newman townsite and local mining activities (Newman Hub, OB23, OB24 and OB25) are proposed to increase again with BHPBIO's plans for expansion.

SECTION 2 - FIELD INVESTIGATIONS

2.1 DRILLING AND BORE INSTALLATION

2.1.1 Drilling Contracts

The drilling and installation of observation and production bores was undertaken by Nudrill Pty Ltd (Nudrill) under direct contract to BHP Billiton (BHP-03-138). The drilling took place between 5th March and 16th April 2004. Drilling was carried out using a Drilltech DH1 rig, and involved both mud-rotary drilling and conventional (direct circulation) down-the-hole hammer drilling.

2.1.2 Exploration Drilling & Observation Bores

Exploration drilling was conducted both within the Pit 3 orebody and along its southern boundary at five locations and a total of eight observation bores were installed. Although it had been intended to drill exploration holes using conventional down-the-hole-hammer techniques (to achieve measurements of airlift yields whilst drilling), the unstable nature of both the ore and the alluvium resulted in hole collapse as soon as the rods were pulled, and preventing the completion of the holes as observation bores to total depth. As a result, although the first exploration hole (WP25-1) was drilled using conventional hammer methods, mud-rotary drilling was used for the remainder of the exploration drilling.

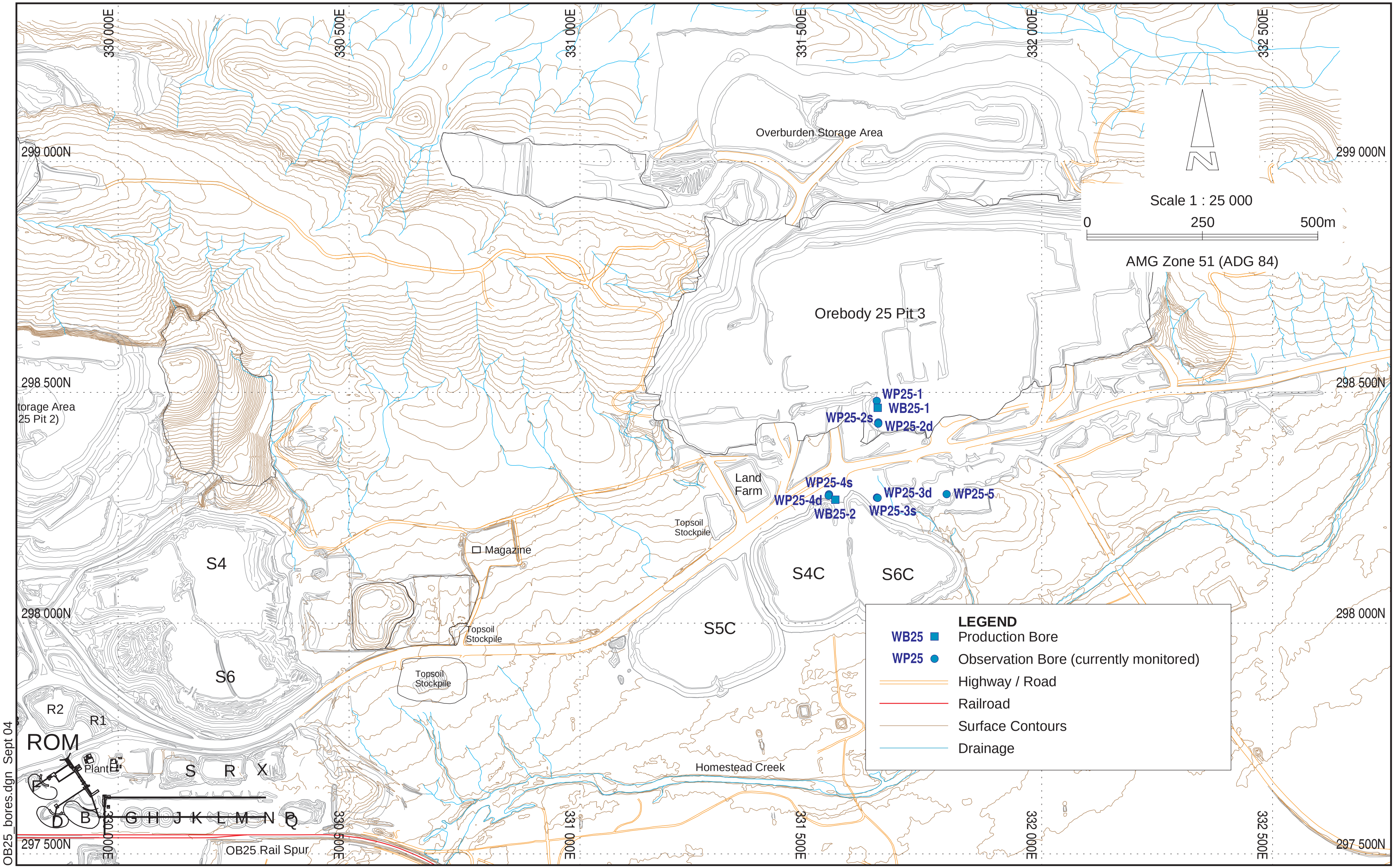
Each hole was drilled at 6” diameter and completed with 50 mm CL9 PVC, with six meters of slotted casing (longitudinal slots) installed and against the lower portion of the targeted aquifer. Observation bores were generally installed in pairs with one deep and one shallow bore at each selected monitoring location. Deep bores were completed to monitor groundwater heads within bedrock units, whereas the shallow bores were completed to monitor groundwater levels within the overlying alluvium. The annulus of each bore was backfilled with gravel pack to the top of the slotted interval and cement grout seals were installed above the slotted sections in selected observation bores. Bore locations are shown on Figure 2 and bore details are summarised in Table 2.1. Composite bore logs are presented in Appendix A.

2.1.3 Production Bores

Two test production bores were constructed, one in the orebody (WB25-1) and one in the Tertiary valley fill sediments to the south of the proposed pit boundary (WB25-2). Both production bores were drilled to at 14” diameter using mud-rotary techniques.

Both production bores were completed with 250 mm ND steel casing (9.4 mm WT for WB25-1 and 6.4 mm WT for WB25-2) with in-line stainless steel screens and slotted steel casing adjacent to the target aquifer unit. The annulus between the production casing and borehole wall in each bore was backfilled with graded gravel pack (1.6 to 3.2 mm) to surface. Upon completion, the bores were developed for approximately six hours by airlifting and surging until the discharge was substantially clear and free of suspended sediment.

Bore locations are shown on Figure 2, and bore details are summarised in Table 2.1. Composite bore logs are presented in Appendix A.



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OB25 (Pit 3) - Bore Locations
Figure 2

Table 2.1
OB25 (Pit 3) Location and Construction Summary for Recently Drilled Observation and Production Bores

Bore	Location Data[1]			Drilling Data						Construction Data			Geology[4]
	Northing (m)	Easting (m)	Elevation (mRL)	Date Drilled		Drilled Depth (mbgl)	Water Level (mbtoc)	Date of WL Reading	Drill Method	Total Cased Depth (m)	Slotted Interval (mbgl)	S/S screen (mbgl)	Slotted Units
				Started	Finished								
Observation Bores													
WP25-1	331142.6	298481.5	514.715	5/03/04	6/03/04	110	5.46	6/03/04	CH	54	48-54	-	BIF (D2)
WP25-2d	331145.9	298432.3	514.667	9/03/04	11/03/04	125	5.27	15/03/04	MR	125	119-125	-	BIF (D2)
WP25-2s	331146	298434.9	514.736	11/03/04	11/03/04	18	5.13	15/03/04	MR	18	12-18	-	TD3
WP25-3d	331144.5	298271.4	523.065	12/03/04	13/03/04	72	13.32	15/03/04	MR	72	66-72	-	Clay (McRae S.)
WP25-3s	331143.1	298272	523.156	14/03/04	14/03/04	30	13.90	15/03/04	MR	30	24-30	-	TD2
WP25-4d	331038.5	298276.3	524.348	15/03/04	16/03/04	60			MR	60	54-60	-	Clay (McRae S.)
WP25-4s	331039.2	298279.1	524.164	30/03/04	30/03/04	30			MR	30	24-30	-	TD2
WP25-5	331294.2	298279.5	519.628	31/03/04	31/03/04	47			MR	47	41-47		McRae Shale
Production Bores													
WB25-1	331144.8	298466.6	514.478	1/04/04	10/04/04	~120			MR	~119	~17-89	~89-113	BIF (D2)
WB25-2	331053	298267.4	523.816	12/04/04	16/04/04	46			MR	41.5	35.5-41.5	29.5-35.5	TD2

Notes: 1 – Newman Mine Co-ordinates
CH – Conventional Hammer
MR – Mud Rotary
BIF (D2) – Banded Iron Formation; D2 unit of the Dales Gorge Member (Brockman Formation)
TD2 = Tertiary Detrital 2 (Eocene/Oligocene-including Pisolite)

2.2 TEST PUMPING

2.2.1 Test Pumping Contract

Testing pumping of the production bores WB25-1 and WB25-2 was undertaken by Gorey & Cole Drilling Pty Ltd (Gorey & Cole) under contract to BHPBIO (PO 5200654690). Testing was completed between the 14th to 22nd July 2004.

2.2.2 Test Procedures

Test pumping was carried out using a Warman 200 DH pump at Bore WB25-1 and a Lowara Z64212 pump at WB25-2. Discharge rates were measured using a flow meter. Water levels were recorded in the test bore and observation bores.

Testing comprised a multi-rate (or step discharge) test and a constant rate test. Following pump shutdown after the multi-rate and constant rate tests, the recovering water levels were generally monitored at the pumping bore for a period of 60 minutes.

A summary of the pumping test schedules are given in Table 2.2, and test pumping plots are presented in Appendix B.

Table 2.2
Summary of Pumping Test Schedules

Test Bore	Obs Bores	Testing Dates		Test Duration (mins)			Constant Rate Test	
							Discharge	
		Start	Finish	Step Test	Constant Rate	Recovery	kL/d	L/s
WB25-1	WP25-1 WP25-2d/s WP25-3d/s WP25-4d/s WP25-5	20/07/04	22/07/04	4 x 100	1800	60	3456	40
WB25-2	WP25-1 WP25-2d/s WP25-3d/s WP25-4d/s WP25-5	14/07/04	19/07/04	4 x 100	6100	60	690	8

2.2.3 Data Analysis

The test data were analysed using standard graphical analysis techniques, including the Jacob, Theis, and Walton Methods. The results of analyses of all test data are listed in Table 2.3.

From the test pumping of both the production bores, drawdowns were observed in monitor bores installed in the ore, the alluvium and the shale to the south of the pit. This indicates hydraulic connection between each of the units.

During the test on WB25-1 (ore bore), the discharge from the test recirculated back into the aquifer resulting in recharge to the water table. The test data show the obvious effects of this recharge in all but very early time data. In most of the bores there were insufficient early time data (ie before the effects of recharge induced a flattening of drawdown slopes) to derive reliable estimates of aquifer transmissivity. An aquifer transmissivity of 300m^2/d was adopted based on selected early time data.

The test data on WB25-2 (valley fill alluvium bore) do not appear to be affected by delayed drainage or leakage (very late time data), although the rates of drawdown in many of the observation bores appear to reflect some incomplete hydraulic connection with the pumping bore.

This is not uncommon in multi-layered aquifers even when there is a good hydraulic connection between the layers. Later time data from the pumping bore and all data from the monitor bores can be influenced by leakage processes taking place between the various aquifer horizons. A transmissivity of 180m^2/d was adopted based on the mid to late time data from the pumping bore.

Table 2.3
Estimates of Aquifer Parameters

Bore	Constant Rate Test		Test Data	Estimated Aquifer Parameters	
	Discharge (L/s)	Duration		Storativity (S)	Transmissivity (T) (m^2/d)
WB25-1	40	1800	WB25-1	-	60 to 80
			WP25-1 WP25-2d	3.4×10^{-6}	3100 to 3600 320 to 4370
WB25-2	8	6100	WB25-2	-	180
			WP25-3d WP25-4d WP25-3s WP25-4s	2.7×10^{-2} 1.6×10^{-2} 1.8×10^{-3} 1.1×10^{-3}	350 to 400 500 to 600 350 to 550 500

2.3 SUSTAINABLE BORE YIELDS

The reliable output from a groundwater source (Source Reliable Output – SRO) is dependent on both:

- Aquifer Sustainability, (ie. how much water can the aquifer supply) which is related to aquifer parameters and groundwater storage.
- Installed Capacity, (ie. how much water can physically be removed from the ground with the installed system) which is related to the hydraulic performance and physical design parameters of each bore.

Theoretically, either of these factors may impose the ultimate limit on the bore yield (SRO).

The multi-rate data were used to assess the hydraulic performance of the trial dewatering bores WB25-1 and WB25-2. This information, combined with the estimated aquifer parameters in Table 2.3 were used to determine the pumping capacity for the bore.

The SROs for the two bores are presented in Appendix C. Assuming that other adjacent dewatering bores will be operational simultaneously, it is estimated that Bores WB25-1 and WB25-2 should be capable of initial yields of 4,000 kL/d and 600 kL/d respectively, although these yields will decline as the aquifers are dewatered.

2.4 WATER QUALITY ANALYSIS

Water samples were collected from the two test dewatering bores at the end of the constant rate tests. All samples were analysed by a NATA registered laboratory for major ions, total dissolved solids, pH and electrical conductivity.

Laboratory reports from the analyses are presented in Appendix D and summarised in Table 2.4.

Table 2.4
Summary of Water Quality Analysis

	Units	Australian Drinking Water Guidelines (NHMRC, 1996)	WB25-1	WB25-2
Date of Sample			22/7/04	19/7/04
pH	pH Units	6.5 to 8.5*	7.3	7.6
EC @ 25°C	µS/cm		1400	1700
TDS	mg/L	500*	**880**	**1100**
TSS	mg/L		<5	<5
Total Alkalinity (as $CaCO_3$)	Mg/L		370	330
Hardness (equiv $CaCO_3$)	mg/L	200*	**560**	**700**
Sodium (Na)	mg/L	180*	95	110
Potassium (K)	mg/L		7.6	7.5
Calcium (Ca)	mg/L		83	100
Magnesium (Mg)	mg/L		86	110
Soluble Iron (Fe)	mg/L	0.3*	<0.1	<0.1
Chloride (Cl)	mg/L	250	180	**300**
Sulphate (SO_4)	mg/L	500 (250*)	100	160
Nitrate (NO_3)	mg/L	50	5.8	**96**
Bicarbonate (HCO_3)	mg/L		460	400
Carbonate (CO_3)	mg/L		<1	<1
Aluminium (Al)	mg/L	0.2*	<0.1	<0.1
Arsenic (As)	mg/L	0.007	<0.001	0.001
Manganese (Mn)	mg/L	0.5 (0.1*)	0.01	<0.01
Zinc (Zn)	mg/L	3.0*	0.08	0.16
Chromium (Cr)	mg/L	0.05	<0.01	<0.01
Nickel (Ni)	mg/L	0.02	<0.01	<0.01
Mercury (Hg)	mg/L	0.001	<0.0005	<0.0005
Copper (Cu)	mg/L	2.0 (1.0*)	<0.01	<0.01
Lead (Pb)	mg/L	0.01	<0.005	<0.005
Cadmium (Cd)	mg/L	0.002	<0.001	<0.001

Notes
* Aesthetic Guideline value.
Where no guideline is indicated, none exists.
Bold indicates Australian Drinking Water Guidelines Exceeded

The water sample analysis indicates that the water is slightly alkaline and fresh with respect to total dissolved solids (TDS). The water from both bores exceeds the aesthetic limits of the Australian Drinking Water Guidelines for TDS and hardness but is within the health-based limits for these analytes. The sample from WB25-2, however, has concentrations of chloride and nitrate which exceed health-based guidelines.

SECTION 3 - MODELLING

3.1 BACKGROUND

3.1.1 Existing Groundwater Model

A numerical groundwater model for the area was developed in 1997 as part of the OB23 Dewatering Investigation (Woodward-Clyde, 1997). The model was set-up and calibrated to a long term pumping test at OB23. Regional parameters for the model were based on a previous finite element model (Rust PPK, 1996). The model was subsequently used to design the OB23 dewatering borefield layout, to determine the timing sequence required to achieve satisfactory dewatering ahead of mining, and to predict the impacts of active dewatering and the final mine void on local / regional groundwater levels.

3.1.2 Model Objectives

The overall objective of the current modelling was to:

- Assess dewatering requirements for OB25 (Pit 3) and reassess previous requirements predicted for OB23.
- Predict the impact on groundwater (in terms of drawdown and water balance) of the simultaneous dewatering of both OB25 (Pit 3) and OB23 in accordance with the mining schedule for the two deposits.
- Complete mine closure predictions of the final water level in the two pits and the impact of the pit lake on the regional groundwater system assuming that both final voids were left open after mine closure.
- Complete predictions of aquifer water levels for the case where OB25 was infilled to above the pre-mining water table.
- Provide input to parallel investigations relating to the optimisation of the Newman water supply system (ie potentially sourcing the required water supply from OB23 / OB25 both during and after dewatering).
- Conduct salinity modelling to estimate the development of salinity within the mine pit lakes at both OB23 and OB25.

3.1.3 Refinement of Existing Model

The existing model has been refined and expanded to allow it to be used to assess dewatering and mine closure predictions for OB25 (Pit 3). The model has been expanded to the west to include OB25 and to the south to include the Ophthalmia Wellfield. Figure 1 shows the area covered by the extended groundwater model.

3.2 MODEL SET-UP

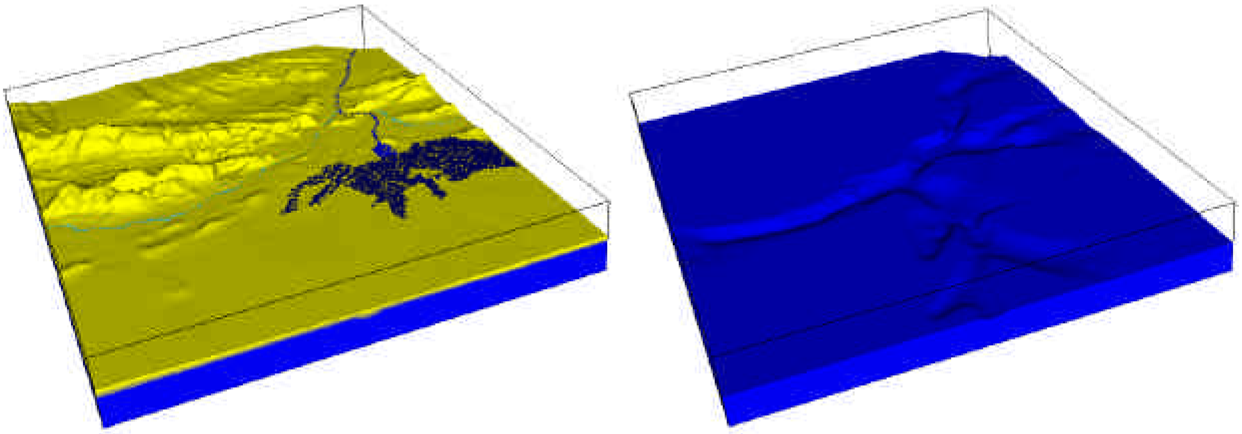
3.2.1 Conceptual Model

The conceptual model was largely based on the existing groundwater model. The model has six layers to represent:

- Shallow alluvial calcretes, deep palaeochannel alluvials, basement and ore (Layers 1 to 5).
- Basement comprising the orebody aquifer locally (ie at OB25 Pit 3 and OB23) and low permeability units more regionally (Layer 6).

Geological logs from bores drilled as part of the Newman Water Supply System (Tahal, 1981) were used to assign model layers and aquifer parameters where the existing model was expanded to the east and south. In addition, the results of the recent drilling programme (Section 2), together with geological data from mineral exploration drilling (BHPBIO) were used to assign model layers and aquifer parameters to the model over the OB25 (Pit 3) area. Figure 3 below shows the adopted elevations for the top of Layer 1 (ie topographic surface) and the base of Layer 3 (base of the valley fill alluvium).

Figure 3



MODEL ELEVATION

BASE OF ALLVIUM (LAYER 3)

3.2.2 Model Grid and Boundary Conditions

The industry-leading MODLFOW Package designed by the US Geological Survey (McDonald and Harbaugh, 1988) was used for this work, operating under the PMWin Pro graphical user interface (version 7.0.10, Webtech360 Inc., 2002-2003).

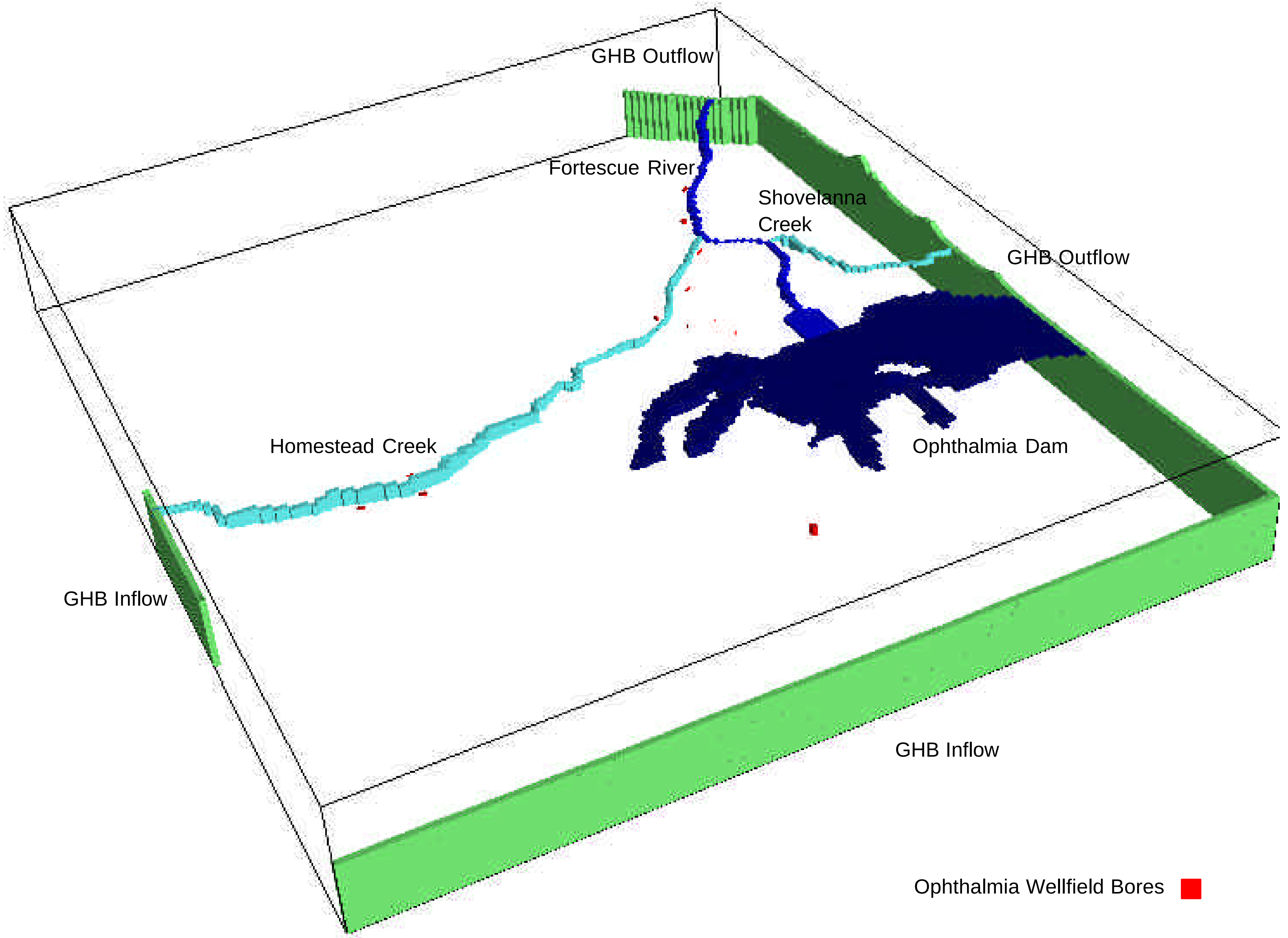
The finite difference grid consists of 226 rows x 220 columns, covering an area of approximately 16 km by 14 km. The grid has been refined to cell size of 25 m square in the vicinity of the two orebodies (OB23 and OB25), where substantial curvature of the water table is expected, and a 100 m square cell size has been adopted for the remainder of the regional model.

The General Head Boundary (GHB) Package has been used to represent head-dependent inflow and outflow from the groundwater model. Details of the model boundaries are described below:

- West: Inflow boundary through the Homestead Basin (following Homestead Creek).
- South: Inflow boundary representing regional inflow from the Fortescue Basin towards Ophthalmia Dam.
- East: Outflow boundary, mainly due to seepage from the Ophthalmia Dam.
- North: Outflow boundary representing outflow across the Ethel Gorge Basin.

3.2.3 Model Features

A summary of all the main model features are presented in Figure 4 and detailed in Appendix E.



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Summary of Model Features
Figure 4

3.3 CALIBRATION

The calibration process involves running the model numerous times and varying model parameters (within acceptable ranges based on site specific data and typical data for the region where site specific data are absent) until an acceptable match between predicted and observed water levels is achieved.

Calibration is a two step process, with steady state calibration to long-term average data to achieve the appropriate assignment of regional parameters to the model, and transient calibration against shorter-term data to improve model reliability in simulating dynamic aquifer processes.

3.3.1 Steady State Calibration

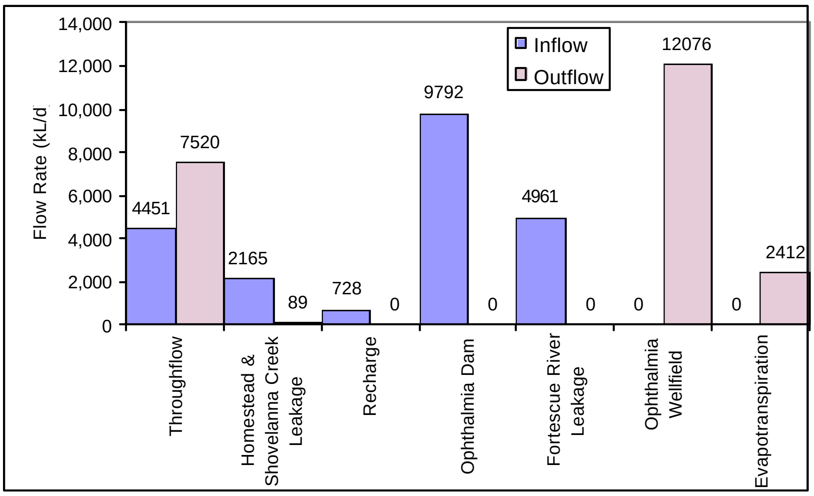
The groundwater model was calibrated in steady state mode to the average observed groundwater levels between 1991 and 2004, using the following observed average stresses between 1991 and 2004.

- Abstraction from the Ophthalmia Wellfield: 12,076 kL/d.
- Rainfall recharge: 4.8 x 10^{-6} m/d (0.5% of annual average rainfall of about 350 mm/yr).
- Evapotranspiration rate: 2 x 10^{-3} m/d (25% of annual average of 3 m/yr pan evaporation); extinction depth of 2m.
- Ophthalmia Dam water level: 511.5 mAHD.
- Ophthalmia Dam overflow: 180,000 kL/d.
- Homestead and Shovelanna Creek stage level: 2m above base of river.

The water balance for the final simulation of the steady state calibration is summarised in Figure 5 below:

Figure 5
Steady State Calibration Water Balance

Component	Rate (kL/d)
Inflow	
Groundwater Inflow	4,451
River Leakage	4,961
Stream Leakage	2,165
Recharge	728
Ophthalmia Dam	9,792
Outflow	
Groundwater Outflow	7,520
River Leakage	0
Stream Leakage	89
Ophthalmia Wellfield	12,076
Evapotranspiration	2,412



The above water balance varies significantly from the previous model (Woodward-Clyde, 1997) due to the expansion of the model area, the incorporation of additional model features and some changes to the model boundary conditions (applied to more reliably simulate groundwater flow processes). A comparison between the current steady state water balance and that from the original modelling study is presented below.

Table 3.1
Comparison of Steady State Water Balance Between Original and Refined Models

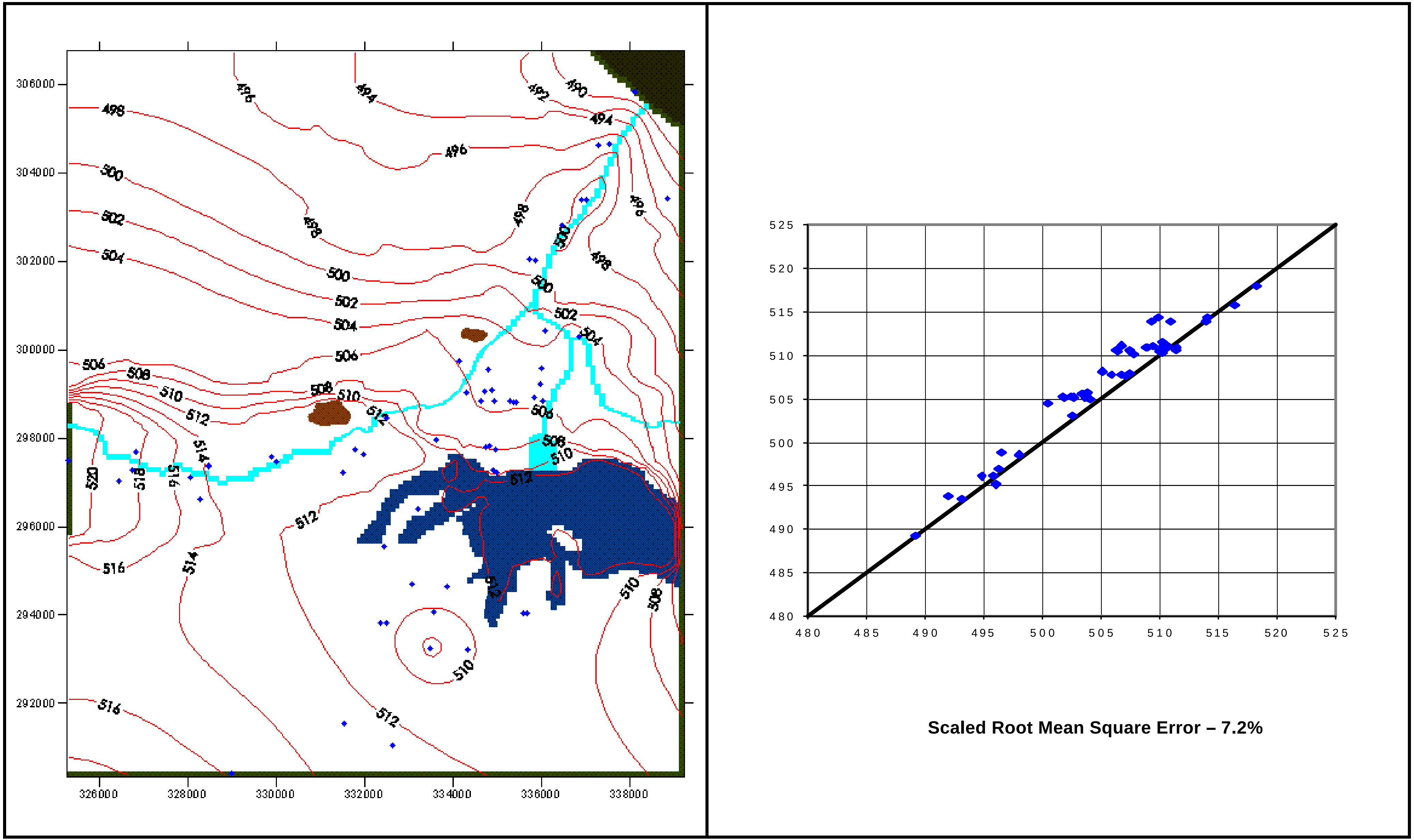
Component	Original Model (kL/d)	Current Model (kL/d)
Total Inflow	***25,200***	***22,097***
Groundwater Inflow	1,480	4,451
River Leakage	Not Modelled	4,961
Stream Leakage	Not Modelled	2,165
Recharge	Not Modelled	728
Ophthalmia Dam Leakage	23,720	9,792
Total Outflow	***25,200***	***22,097***
Groundwater Outflow	6,800	7,520
River Leakage	Not Modelled	0
Stream Leakage	Not Modelled	89
Ophthalmia Wellfield	8,700	12,076
Evapotranspiration	9,700	2.412

The main area of groundwater outflow in the previous model was to the west, towards the Ophthalmia Wellfield (see Figure 1). The current model has, however, been expanded further west to include these abstraction sources. The main sources of boundary outflow in the new model are to the north following the Fortescue River and to the east due to seepage in the area of the Ophthalmia Dam. The only source of groundwater inflow in the previous model was from the south (ie Ophthalmia Dam). In the revised model, there is inflow from the west from the Homestead Creek basin and from the south.

The interaction between the creeks and the aquifer was not simulated in the previous study. At the time a higher rate of leakage from the Ophthalmia Dam was adopted in the previous model to account for total recharge from surface water sources to balance the abstraction from the wellfield. The rate of abstraction from the wellfield specified in the previous model is also significantly less than that in the revised model. The abstraction rates used previously reflected abstraction rates at the time of transient model calibration. The rate adopted for the new model is based on the average over the period of steady state calibration.

An acceptable match was achieved between the observed average heads and the simulated steady state heads. Figure 6 presents a scatter plot of predicted heads, together with the range in observed heads. A scaled root mean square (SRMS) error of 7.2% was obtained between the predicted and average observed water levels. This is considered to be acceptable given the highly variable nature of streamflow recharge in the Pilbara region which makes it very difficult to identify a steady state condition for the model, and a good starting point for transient model calibration.

A contour plan of the steady state water level in the model area is also presented in Figure 6. Bores used in the steady state calibration are shown on the figure.



Scaled Root Mean Square Error – 7.2%

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Steady State Calibration
Figure 6

3.3.2 Regional Transient Calibration

The groundwater model was calibrated in transient mode to observed water levels in the alluvial aquifer. Further details of the calibration are presented below.

Period of Calibration

The period of transient model calibration was between March 1991 and February 2004, with quarterly stress periods (March to May, June to August, September to November and December to February) being adopted.

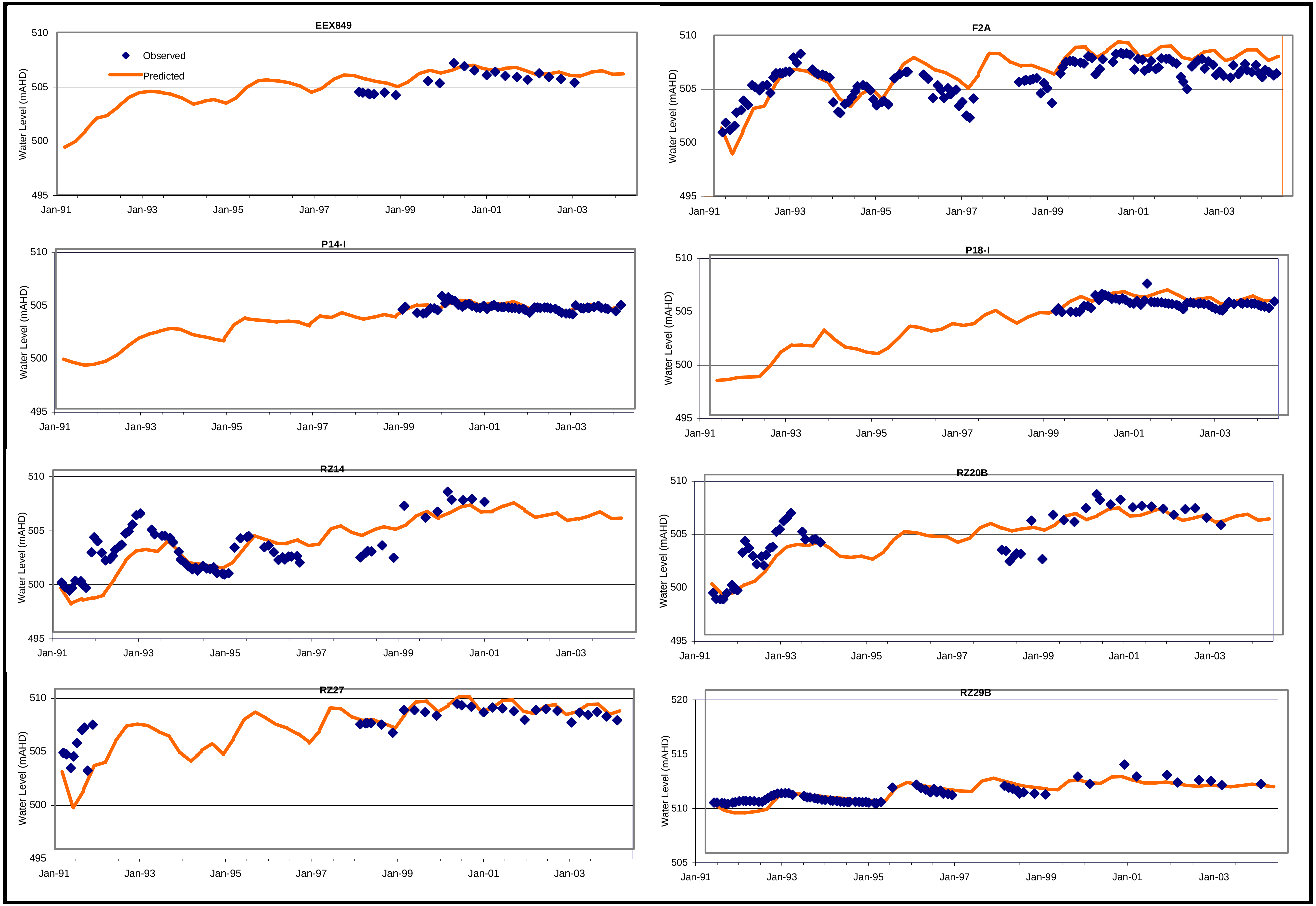
Calibration Hydrographs

Figures 7(a) and 7(b) present selected hydrographs of observed and predicted water levels over the calibration period. Figures E5 to E13 (Appendix E) show all the modelled and measured hydrograph plots used in the calibration. In general, there is a good fit between observed and predicted water levels across the model area. Aquifer parameters for the alluvial aquifer derived from the calibration are summarised in Section 3.3.4.

The elevation at the general head boundary which controls inflow into the model from the Homestead Creek basin was varied quarterly during the transient calibration, based on measurements in Bore W013 which is located on the boundary. The water level in Bore W013 responds strongly to high flow events along the creek as a proportion of the flow recharges the alluvial aquifer, resulting in an increase in water level. Monitoring data over the calibration period shows the water level at this bore varying between about 512 and 522 mAHD. The variation in the specified head at this location directly represents processes further upstream which are not being modelled. Homestead Creek is simulated using the River Package based on data collected from the downstream section of Homestead Creek, slightly upstream of the confluence with the Fortescue River. The actual water level in the upstream section of Homestead Creek is likely to differ from that gauged further downstream (due to losses from the stream to the alluvial aquifer). The observed water levels in bores along Homestead Creek near OB23 and OB25 have been well simulated by the model.

Fluctuations in water levels in some bores located upstream of Ophthalmia Dam (eg. W09) are not able to be reproduced as the variability along streams feeding Ophthalmia Dam has not been modelled. An average water level over the period of simulation has been simulated in these bores. The net influence of stream inflows into Ophthalmia Dam on the groundwater flow system has been simulated through leakage from the dam.

In some observation bores (eg W091 – refer Appendix E) that are located very close to pumping bores, water levels are strongly influenced by the abstraction and it is not possible to accurately predict the full extent of drawdown as both the observation and pumping bores are within a 100 x 100m cell (ie the model averages drawdown over the cell). However, the general pattern of water level drawdown and recovery during periods of high and low pumping has been reproduced.



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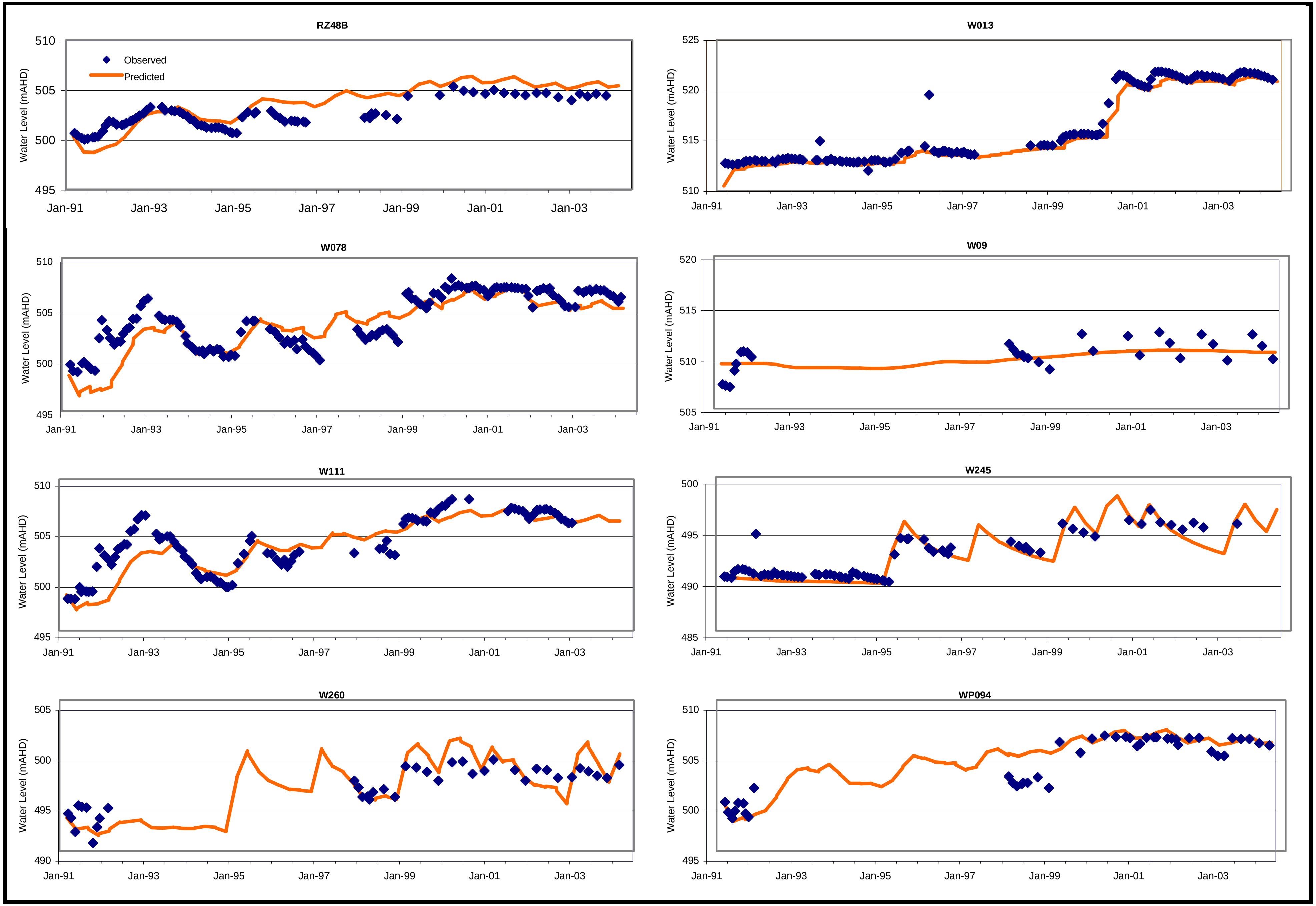
Calibration Hydrographs
Figure 7a



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Calibration Hydrographs
Figure 7b

Transient Model Water Balance

The water balance over the period of the regional transient calibration is presented in Figure 8 and summarised in Table 3.2. The ranges of inflows and outflows over the calibration period are presented in the table with the averages noted in brackets. Key aspects of the water balance are discussed below.

Table 3.2
Summary of Water Balance over Transient Calibration Period

Component	**Inflow (kL/d)**	**Outflow (kL/d)**
Throughflow	4,499 - 16,400 (5,970)	5,299 - 22,126 (11,932)
Recharge	5 - 6,564 (977)	-
Evapotransiration	-	6.3 - 20,030 (4,556)
Fortescue River Leakage	0 - 28,456 (5,276)	0 - 4,881 (1017)
Homestead & Shovelanna Creek Leakage	3,363 - 9,218 (7,336)	0 -16 (0.6)
Seepage from Ophthalmia Dam	137 – 77,490 (18,208)	0 - 1,619 (332)
Ophthalmia Wellfield Abstraction	-	6,209 - 17,795 (12,018)

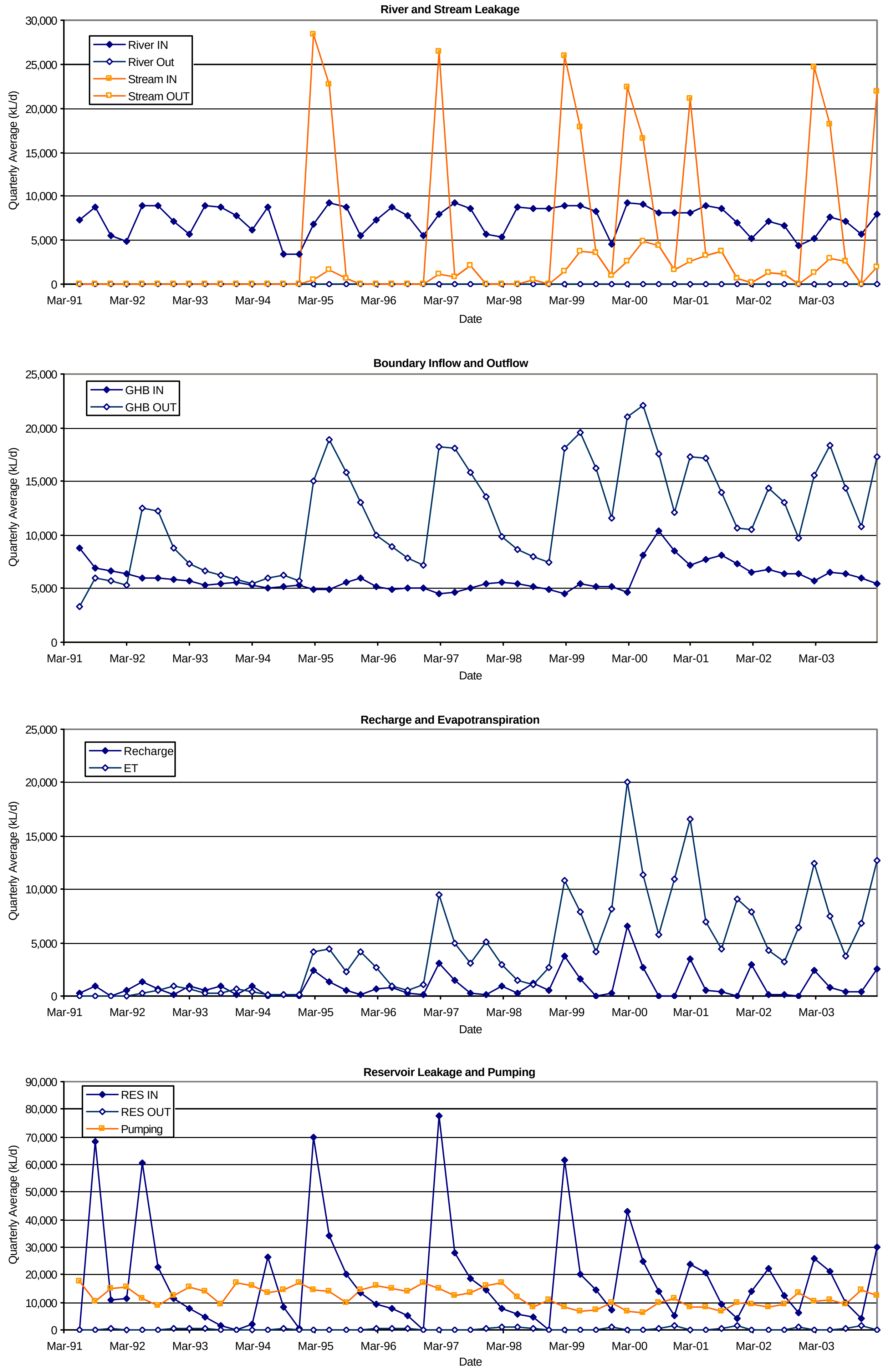
Simulated groundwater inflow and outflow across the specified head boundaries is largely controlled by streamflow and high recharge events. Groundwater inflow increases when the specified head at the inflow boundary (from the Homestead Basin) is increased. The average rate of groundwater inflow is about 5,970 kL/d. Rates of groundwater outflow (ranging between 5,300 and 22,130 kL/d) increase in response to spill events from Ophthalmia Dam, which flows down the Fortescue River.

There is simulated leakage from Homestead and Shovelanna Creeks into the alluvial aquifer, which varies seasonally in response to the water level in the creeks. The rate of leakage typically ranges between 3,300 and 9,200 kL/d. There is also simulated leakage of streamflow into the alluvial aquifer along the Fortescue River during dam overflow events. During some periods, there is leakage of groundwater from the aquifer into the river (ie baseflow). This is typical during periods of high groundwater levels following high rainfall and streamflow events. Rates of simulated leakage along the Fortescue River following dam overflow events typically ranges between 21,000 and 28,500 kL/d.

Simulated rates of evapotranspiration (ET) are also higher during high rainfall and streamflow events due to a higher predicted water table. The rate of ET across the model area was as high as 20,000 kL/d in early 2000 due to high rainfall and streamflow events between 1999 and 2001.

Simulated seepage from Ophthalmia Dam to the alluvial aquifer varies seasonally in response to the dam water level. Over the calibration period, the average rate of simulated seepage from the dam was about 18,000 kL/d, with a peak rate of about 77,500 kL/d.

Average abstraction from the Ophthalmia Wellfield was about 12,000 kL/d over the calibration period. There was a significant reduction in the abstraction from the wellfield in mid 2001 from about 17,000 kL/d to less than 10,000 kL/d. Abstraction for the remainder of the calibration period averaged about 10,000 kL/d.



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Transient Model Calibration - Water Balance Summary

Figure 8

3.3.3 Transient Calibration to Long Term OB23 Pumping Test

The groundwater model was also calibrated in transient mode to the long term (82 days) pumping test carried out at OB23 in November 1995. Two bores screened in the orebody aquifer were pumped at rates up to 1,577 kL/d each (average total rate of 2,300 kL/d) over the first 62 days of the test. A number of monitoring bores located in the orebody aquifer and the alluvial aquifer were monitored during the test, and for a 20 day recovery period following completion of the test.

Figure E14 (Appendix E) presents the results of the calibration to this pumping test. A good fit was achieved in most of the monitoring bores. The calibration was found to be mainly sensitive to the horizontal conductivity of the orebody aquifer and the rate of leakage from the overlying alluvial aquifer. Aquifer parameters derived from both the 82 day pump test model and 13 year calibration model are summarised below in Section 3.3.4.

3.3.4 Calibrated Aquifer Parameters

The final set of adopted aquifer parameters for the model was based on the results of the transient calibrations discussed above.

The alluvial aquifer was divided into a number of zones, similar to that described in Tahal (1981). These zones were used to distribute aquifer parameters for the alluvial aquifer. The distribution of each of these zones is shown in Figure 9.

A summary of the calibrated aquifer parameters is presented in the table below.

Table 3.3
Calibrated Model Aquifer Parameters

Unit	Horizontal Conductivity (m/d)	Vertical Conductivity (m/d)	Specific Yield (Sy)	Confined Storage (S)
Alluvial Aquifer (Layers 1 to 3)				
Homestead Zone	20	20	0.06	1×10^{-4}
Fortescue Zone	3	3	0.06	1×10^{-4}
Shovelanna Zone	30	30	0.06	1×10^{-4}
Ethel Gorge Zone	10	10	0.1	1×10^{-4}
Other Zone	7	7	0.06	1×10^{-4}
Basement (1)	0.01 to 0.05	0.01 to 0.05	0.005	1×10^{-5}
Orebody Aquifer				
OB23	0.2 to 4	0.2 to 4	0.05	1×10^{-4}
OB25	1 to 4	1 to 4	0.05	1×10^{-4}

(1) Basement outcrop in Layer 1 is specified a slightly higher hydraulic conductivity than basement in Layer 2-6.

As described earlier, recharge was applied across the model area (except in areas of basement outcrop) at a rate of 0.5% of quarterly rainfall. Evapotranspiration rate was applied at the pan evaporation rate using a pan factor of 0.5 and an extinction depth of 2m.

	Zone	Description
🟧	Homestead Zone	Around Homestead Creek
🟦	Fortescue Zone	Upstream of and area underlying Ophthalmia Dam.
🟥🟫	Shovelanna Zone	Around Shovelanna Creek and Fortescue River downstream of Ophthalmia Dam.
🟧🟩	Ethel Gorge Zone	Downstream of the confluence between Homestead Creek and Fortescue River.
🟩	Other Alluvium	Other areas of shallow alluvium away from the creeks and river.
⬛	Basement	Basement outcrop.
◼	OB 25 Zone	Alluvium south of Ore body 25 ore zone.
🟨	Ore	Ob 25 and 23 Ore zone area.

Distribution of Aquifer Parameters
Figure 9

The above aquifer parameters are of the same order as that used in the previous model. Parameters for OB25 were based on analysis of data collected from the pumping tests completed in June 2004. Aquifer parameters for the orebody and basement in the vicinity of OB23 were based on the results of the transient calibration to the long term pumping test.

Additional parameters to define open channel flow for the Fortescue River (ie Manning's n, stream slope and width etc) downstream of Ophthalmia Dam were also specified in the model. A Mannings n of 0.035 (at typical value for 'major rivers') was specified in the model. The stream width ranged between 60 and 700m, and the stream slope between 0.0005 and 0.005.

3.4 MODEL PREDICTIONS

The calibrated groundwater model was used to predict dewatering requirements for OB25 (Pit 3), with OB23 dewatering taking place simultaneously, and to assess the impacts of the dewatering both during and after mining.

As the Ophthalmia Wellfield supplies water to both the town of Newman and the nearby mining operations (ie Mt Whaleback and the Satellite Orebodies), a constraint was adopted to model predictions to ensure that these water supplies are maintained. To optimise water use, it is assumed that all dewatering volumes will be used for process water supplies wherever possible and only excess water will be discharged either into the Ophthalmia Dam or the major creeks. At this stage, it is assumed that all potable water will be sourced from the H Line bores, located approximately 2 km to the southwest of OB25 (Pit 3).

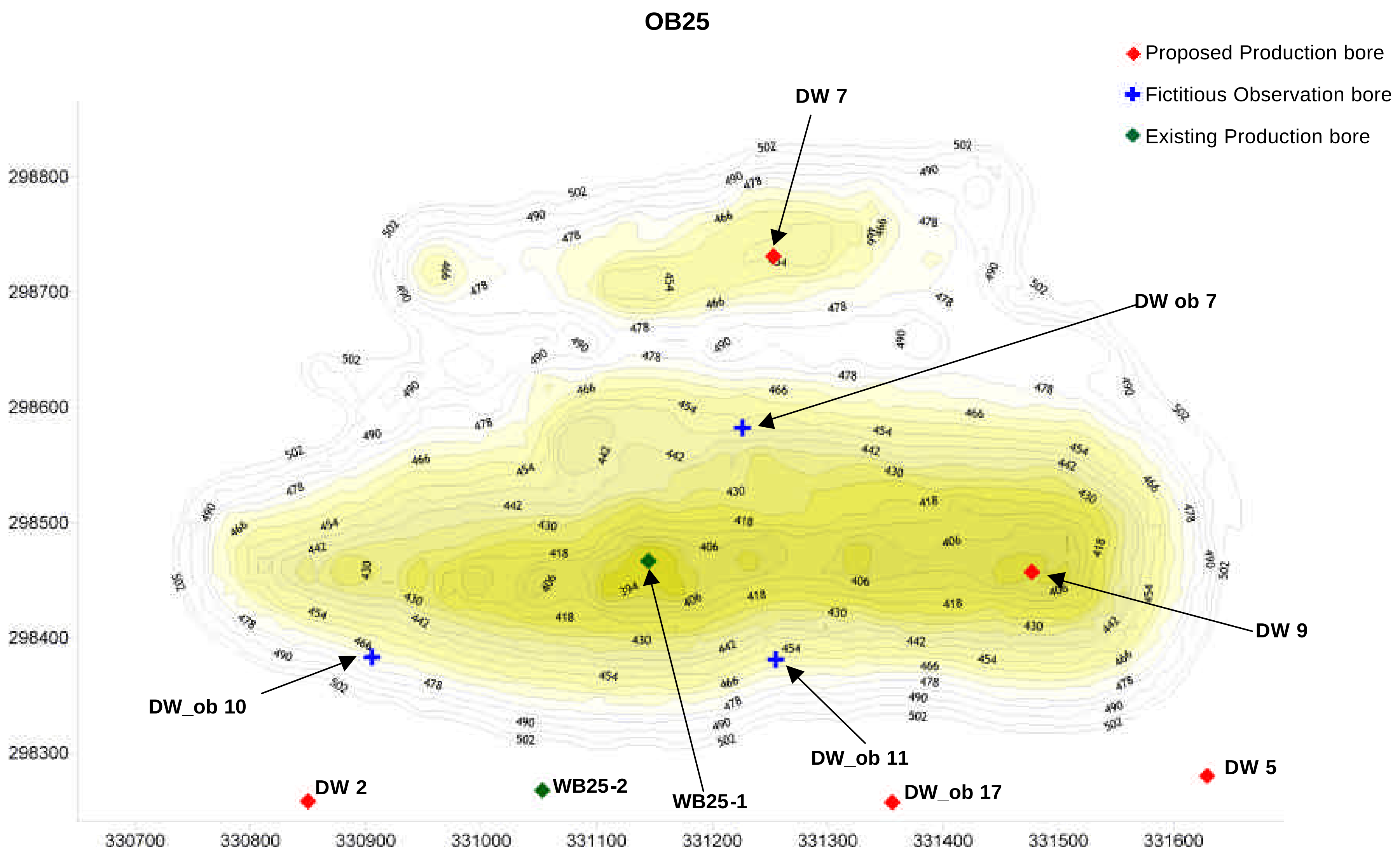
3.4.1 Pit Design and Mine Schedule

The pit design for OB25 (Pit 3) is presented in Figure 10. The pit is proposed to extend to a depth of approximately 394 mRL over a five year mining period.

It is currently proposed that the mining of OB23 will commence at the same time as the OB25 (Pit 3) operations. Details of the pit development for both OB25 (Pit 3) and OB23 are summarised in Table 3.4 and Figure 11.

3.4.2 Model Set-up and Features for Dewatering Simulations

As rainfall and streamflow both recharge the alluvial aquifer, causing water levels to rise, and therefore increasing dewatering requirements, dewatering predictions were made for two climate cases. A "Dry" or Lower Bound prediction was made using data collected between 1991 and 1995 and a "Wet" or Upper Bound dewatering prediction was made using data collected between 1997 and 2001. Measurements of rainfall, evaporation, water levels and overflows for Ophthalmia Dam and levels for Homestead and Shovelanna Creeks which were recorded during these periods were specified in the model. Abstraction from OB25 (Pit 3), OB23 and the Ophthalmia Wellfield was modelled using a combination of the Well Package and Evapotranspiration Package. Dewatering abstraction was specified at maximum rates, consistent with anticipated bore capacities (Section 2.3 for OB25 (Pit 3) and Woodward-Clyde, 1997 for OB23) such that once water levels are drawn down to a specified level, the "pumping" rate decreases to zero.



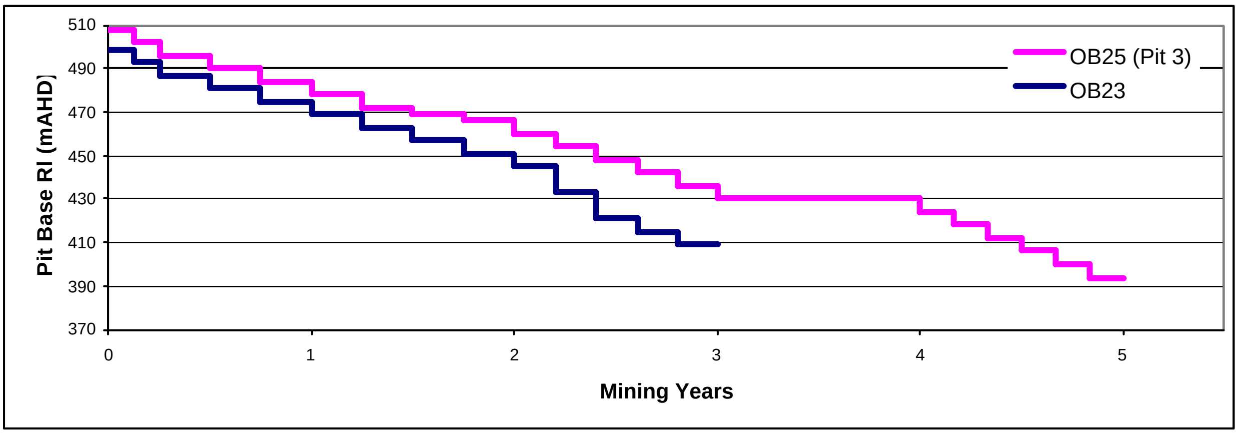
Pit Design for OB25 (Pit 3)
Figure 10

Table 3.4
Pit Development Schedule

OB23				OB25 (Pit 3)			
Year	**Months**	**Benches**	**RL**	**Year**	**Months**	**Benches**	**RL**
1	12	5	499	1	3	2	508
			493				502
			487		3	1	496
			481		3	1	490
			475		3	1	484
2	12	4	469	2	6	2	478
			463				472
			457		6	1	466
			451	3	12	5	460
3	12	7	445				454
			439				448
			433				442
			427				436
			421	4	12	1	430
			415	5	12	6	424
			409				418
							412
							406
							400
							394

(Provided by BHPBIO)

Figure 11
Rate of Mine Development – OB25 (Pit 3) and OB23



3.4.3 Model Set-up and Features for Closure Simulations

Pit closure predictions were made assuming the same climatic conditions as for the transient calibration. These are referred to as “normal” case conditions. For OB23 and the cases where OB25 was to be left open, aquifer parameters over the pit areas were adjusted for the closure predictions to reflect voids. Both the horizontal and vertical hydraulic conductivities were changed to 10,000 m/d in the pit areas and the specific yield was given a value of 0.99. Pit void parameters were implemented at OB23 from Year 3.25 onwards and Year 5.25 onwards for OB25.

Evaporation from the open water bodies (pit lakes) that develop in the mined out voids was simulated using the ET Package and adopting an evaporation rate equivalent to 50% of Pan Evaporation (typical value applied to Pilbara pit lake modeling). Whereas in the dewatering scenario, 0.5% of the recorded recharge in the area was assumed to recharge the water table, 100% of the recorded recharge was set over the pit void areas for the closure predictions, to simulate the direct incident rainfall to the open water surface. In addition, extra recharge to the pit voids was also added due to runoff from the surrounding pit catchment. A recharge volume was estimated from the local catchment areas surrounding the pit voids and a rate of 20% of the total catchment volumes was added to the pit void in addition to the direct recharge estimate.

For the cases where OB25 was to be infilled above the pre-mining water table, it was assumed that the aquifer parameters of the infill material were similar to the material mined.

3.4.4 Initial Prediction Scenarios

Initially, four prediction scenarios were modelled to determine both the dewatering requirements for OB25 (Pit 3) and the drawdown impacts associated with the dewatering and the on-going water supply requirements for Newman (town and Mt Whaleback) and the Satellite Orebodies (ie OB23, OB24 and OB25). Table 3.5 below summarises the four scenarios. Scenario D is the base case (with no dewatering) whilst Scenarios A, B, and C cover different water supply scenarios after mining of OB25 (Pit 3). It was assumed that Scenario A would be adopted as it is operationally the simplest water supply scheme to run and probably the most cost-effective. Only the dry climatic cases for Scenarios B and C have been simulated as these would be the worst-case scenarios in terms of water supply impacts.

It is assumed that dewatering will commence 3 months (0.25 years) prior to mining. Therefore, for the 5 years of OB25 (Pit 3) mining, there will be 5.25 years of dewatering. Based on this, Years 0 to 5.25 represent the period of dewatering and Years 5.25 to 50 represent the pit closure prediction period. It is assumed that all mining operations (ie dewatering and water supply abstraction) will cease after Year 24. Figures E15 and E16 (Appendix E) tabulate the scenarios in more detail.

3.4.5 Subsequent Prediction Scenarios

Following discussions with BHPBIO, two additional prediction scenarios were modelled to assess alternative post-mining options for OB25 (Pit 3). Table 3.5 also summarises these additional prediction runs and Figures E17 and E18 (Appendix E) tabulate the scenarios in more detail.

Scenario E assumes that, after dewatering, all water supply would be sourced from the pit lakes if possible, as opposed to using any Ophthalmia bores (with the OB23 pit lake as the priority target and the rest from the OB25 pit lake). Previous model runs (ie Scenario A) had a maximum abstraction from OB23 of 16,000 kL/d, as opposed to the full water demand of 18,000 kL/d.

Scenario F assumes that OB25 (Pit 3) is backfilled to just above the pre-mining water level at the completion of mining. In this scenario, the water supply requirements are primarily sourced from the OB23 pit lake, with the Ophthalmia bores used only if required.

For these two scenarios (Scenarios E and F), both “dry” and “wet” climatic scenarios were run for the mining period and the following changes were made to the previous mining / water supply assumptions:

- Whereas previously a five year mine life was assumed for OB25 (Pit 3), it was now assumed that mining would be conducted over a seven year period. As mine schedules for the seven year development were not available at the time of the recent modelling, the previous five-year plan was used with water levels maintained at the pit base for an additional two years to simulate the longer mine plan.
- The mining at OB24 was deferred until after the end of the modelled period and therefore the OB24 water demand was no longer required to be met within the prediction scenario.

Table 3.5
Prediction Scenarios Summary

Scenario	Case	Climate	Description	Years from Dewatering Commencement
A	1	Dry	• OB25 (Pit 3) dewatering from years 0 to 5.25. • OB23 dewatering from years 0 to 3.25 and then continued abstraction from the pit lake for on-going water supply to Newman Hub and SOBs. • Potable water supply for Newman and SOBs from H-Line throughout period.	0 to 5.25
	2	Wet		0 to 5.25
	3	Normal		5.25 to 24
	4	Normal	• No dewatering and no water supply abstraction after Year 24.	25 to 50
B	1	Dry	• Dewatering at OB25 (Pit 3) and OB23 as above. • Only the water supply for SOBs is abstracted from pit lakes after dewatering. • Newman Hub water supply is sourced from the Ophthalmia Wellfield (E and K line Bores). • Potable water supply for Newman and SOBs from H-Line throughout period.	0 to 5.25
	3	Normal		5.25 to 24
C	1	Dry	• Dewatering at OB25 (Pit 3) and OB23 as above. • No abstraction from pit lakes after dewatering. • Newman Hub and SOBs water supplies are sourced from the Ophthalmia Wellfield (E and K line Bores). • Potable water supply for Newman and SOBs from H-Line throughout period.	0 to 5.25
	3	Normal		5.25 to 24
D (Base Case)	1	Dry	• No dewatering at OB23 and OB25 (ie all pits are above the water table). • Newman Hub and SOBs water supplies are sourced from the Ophthalmia Wellfield (E and K line Bores). • Potable water supply for Newman and SOBs from H-Line throughout period.	1 to 5.25
	2	Wet		1 to 5.25
	3	Normal		5.25 to 24
	4	Normal	• No dewatering and no water supply abstraction after Year 24.	25 to 50
E	1	Dry	• OB25 (Pit 3) dewatering from years 0 to 7.25. • OB23 dewatering from years 0 to 3.25. • Water supply to Newman Hub and SOBs sourced from the OB23 and OB25 pit lakes after mining and Ophthalmia bores, if required. • Potable water supply for Newman and SOBs from H-Line throughout period.	0 to 7.25
	2	Wet		0 to 7.25
	3	Normal		7.25 to 24
	4	Normal	• No dewatering and no water supply abstraction after Year 24.	25 to 50

Scenario	Case	Climate	Description	Years from Dewatering Commencement
F	1	Dry	• OB25 (Pit 3) dewatering from years 0 to 7.25. • OB23 dewatering from years 0 to 3.25. • OB25 (Pit 3) back-filled to pre-mining water level after mining. • Water supply to Newman Hub and SOBs sourced from the OB23 pit lake after mining and Ophthalmia bores, if required. • Potable water supply for Newman and SOBs from H-Line throughout period.	0 to 7.25
	2	Wet		0 to 7.25
	3	Normal		7.25 to 24
	4	Normal	• No dewatering and no water supply abstraction after Year 24	25 to 50

Normal Climate = climate from calibration period
SOBs = Satellite Orebodies (OB23, OB24 and OB25) – no water demand at OB24 for Scenarios E and F.

3.5 PREDICTION RESULTS

3.5.1 Predicted Dewatering Requirements

The predicted abstraction rates to maintain water levels below the mining levels are presented in Table 3.6 and presented in Figure 12. The predicted water levels at nominal bore locations are plotted in Figure 13. Please note that the model also simulates dewatering at OB23 and details of the OB23 mine schedule, proposed pit and dewatering requirements are presented in Appendix F.

In summary, it is anticipated that three in-pit dewatering bores and up to four shallow, ex-pit dewatering bores will be required to achieve water levels below the base of mining at OB25 (Pit 3) - refer to Figure 10 for bore locations. The in-pit bores are anticipated to be high-yielding, with maximum abstraction rates of approximately 4,000 kL/d. The out of pit bores will intersect the alluvial aquifer and have maximum yields of approximately 600 to 700 kL/d. As water levels decline, the ex-pit bores will be decommissioned and the effectiveness of in-pit bores will decrease. It is anticipated that in-pit sumps will replace the bores as mining approaches the ultimate pit base.

Table 3.6
Predicted Dewatering Abstraction Rates

Time (Years)	OB25 (Pit 3)		
	Bench Level (mRL)	Dewatering Abstraction Dry Scenario (kL/d)	Dewatering Abstraction Wet Scenario (kL/d)
0 → 0.25	-	14800	14800
0.25 → 0.38	508	14800	14800
0.38 → 0.5	502	14800	14800
0.38→0.75	496	14800	14800
0.75→1	490	14800	14800
1→1.25	484	14800	14800
1.25→1.5	478	14800	14800
1.5→1.75	472	14800	14800
1.75→2	469	14800	14800
2→2.25	466	14260	14660
2.25→2.45	460	13240	14000
2.45→2.65	454	13730	14250
2.65→2.85	448	12530	13550
2.85→3.05	442	11440	12700

Time (Years)	OB25 (Pit 3)		
	Bench Level (mRL)	Dewatering Abstraction Dry Scenario (kL/d)	Dewatering Abstraction Wet Scenario (kL/d)
3.05→3.25	436	11720	12350
3.25→4.25	430	9840	11750
4.25→4.42	424	10100	12180
4.42→4.59	418	10100	12470
4.59→4.75	412	10100	12450
4.75→4.92	406	10100	12390
4.92→5.09	400	10100	12330
5.09→5.25	394	9720	12420

3.5.2 Predicted Drawdown Impacts

Figures 13 and 14 present the predicted hydrograph plots for Scenarios A, B and C during the dewatering and pit closure periods at OB25 (Pit 3). Refer to Figure 10 for bore locations. Hydrographs for bores near OB23 are presented in Appendix F.

The predicted maximum drawdown at OB25 (Pit 3) is approximately 130m (ie water levels at 380 mRL), with predicted water levels recovering to pre-mining levels 45 years after dewatering ceases (irrespective of the various water supply scenarios).

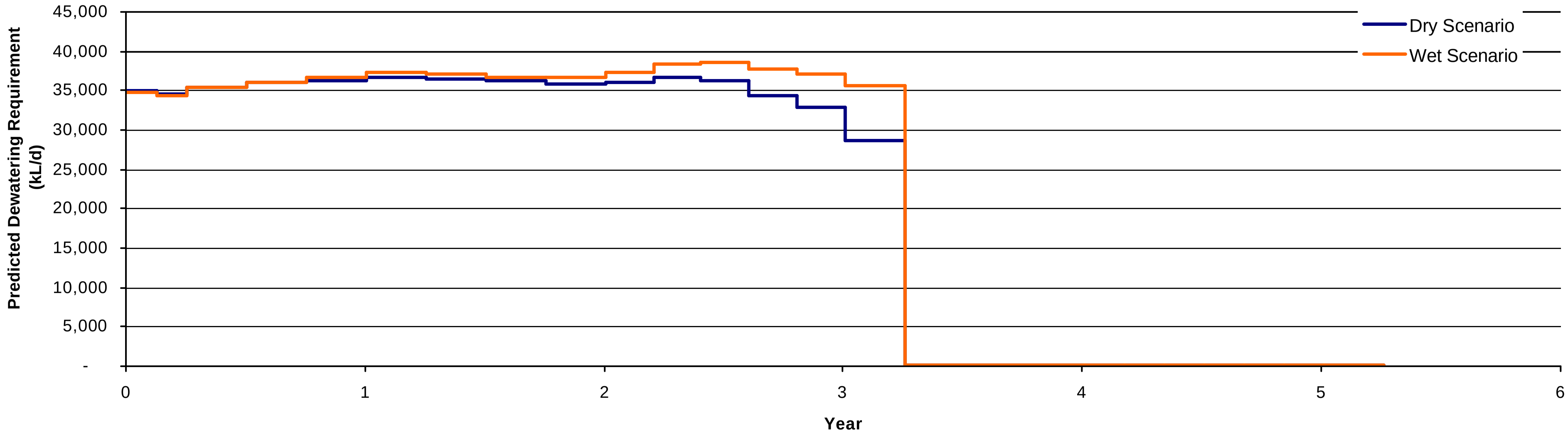
Contours of predicted groundwater drawdown after various stages of mining are presented in Figures 15 to 20 for Scenarios A, B, C, E and F.

Predicted drawdowns for Scenario A (Dry ie worst case) extend regionally to the model boundaries (see Figure 15), with drawdown focused along the alluvial aquifer system (ie following the major creek lines). Predicted drawdowns in excess of 10 m extend a maximum of approximately 4.5 km upstream and downstream of OB25 (Pit3) and OB23 respectively. The predicted drawdown at Ophthalmia Dam reaches a maximum of approximately 5 m.

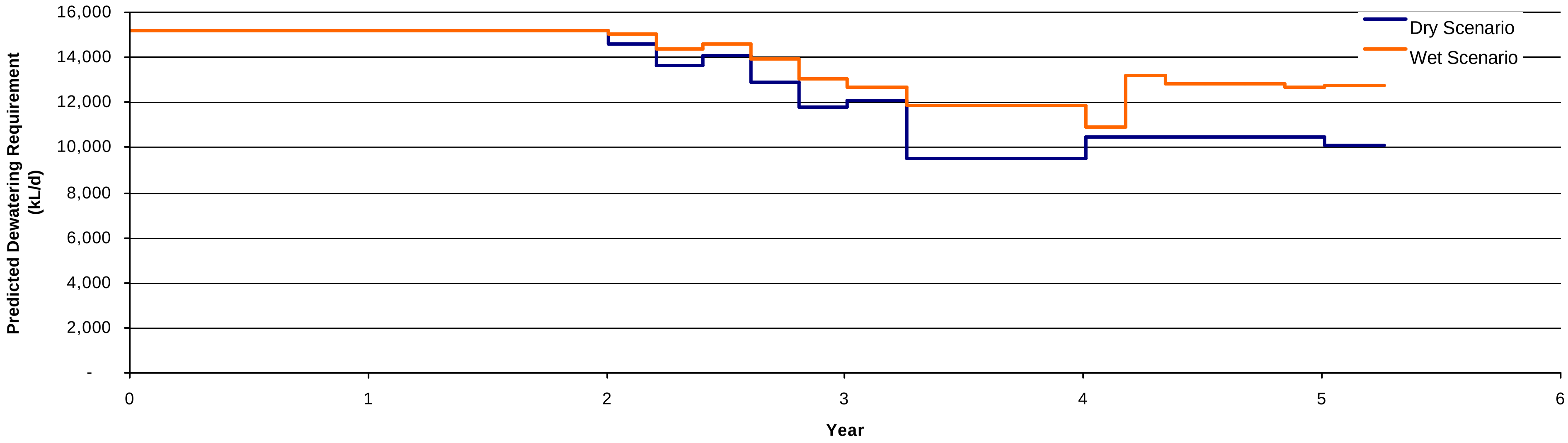
The predicted drawdowns associated the wet climatic conditions (also see Figure 15) are significantly less than those for the dry conditions. Drawdowns greater than 10 m only extend approximately 2.5 km upstream of OB25 (Pit 3) and 1 km downstream of OB23 for the wet case as opposed to the 4.5 km noted for the dry case.

Figure 16 presents predicted drawdown contours at various stages after dewatering for Scenario A. Simulated drawdown contours for the alternative water supply scenarios (ie Scenarios B and C), operational between Years 5 and 24, are presented in Figure 17. Water levels in the immediate vicinity of dewatered pits are predicted to recover once dewatering is complete and after the cessation of water supply pumping. Predicted groundwater levels have fully recovered to within 2 metres of pre-mining levels by Year 35 (ie 9 years after the cessation of water supply pumping and approximately 30 years after the cessation of dewatering). Small localised water level increases, or “drawup” contours predicted in Year 35 are related to seasonal variation in water level rather than long term impacts of the mine void and water supply pumping.

OB 23



OB25



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Predicted Dewatering Requirements- OB23 and OB25

Figure 12

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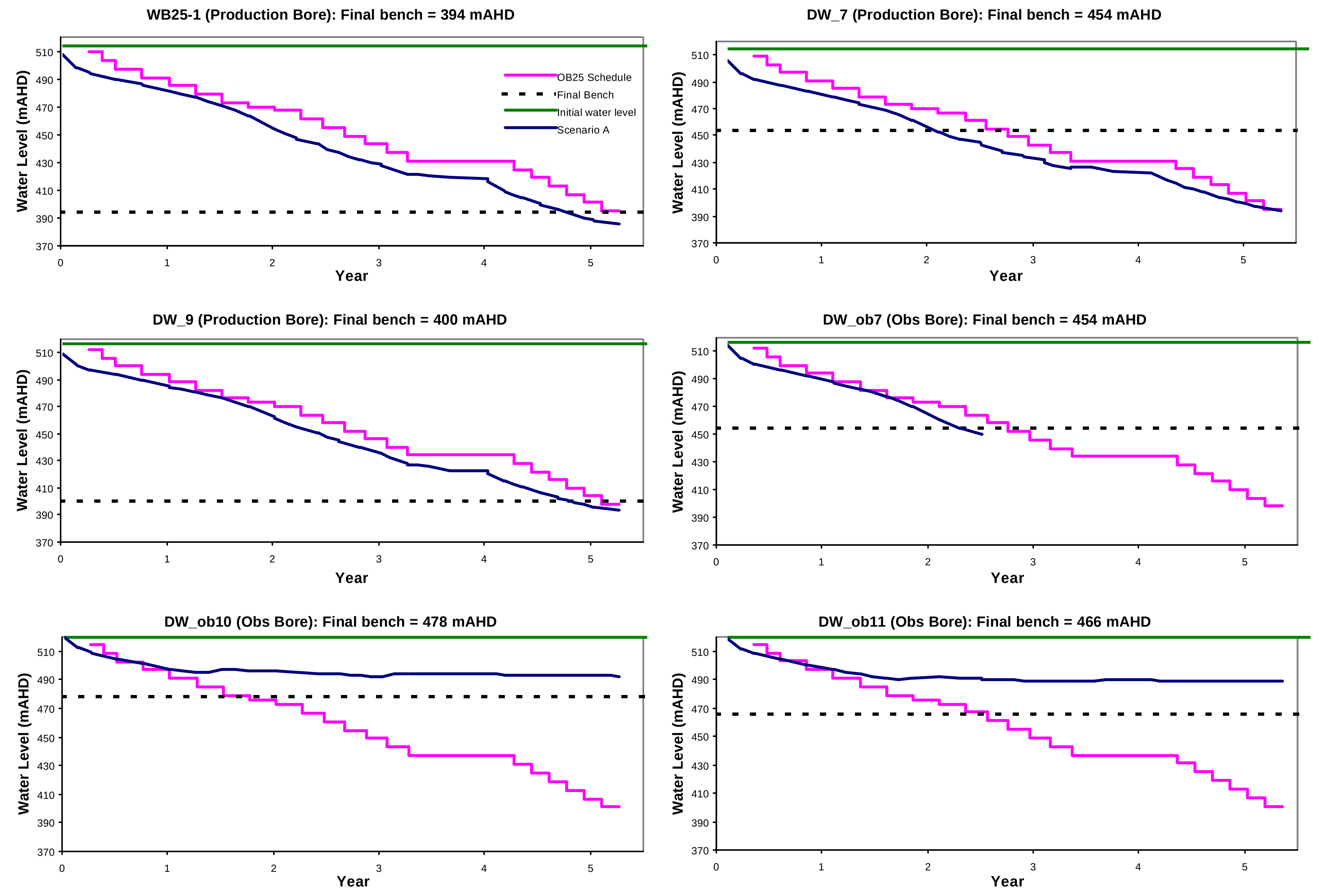

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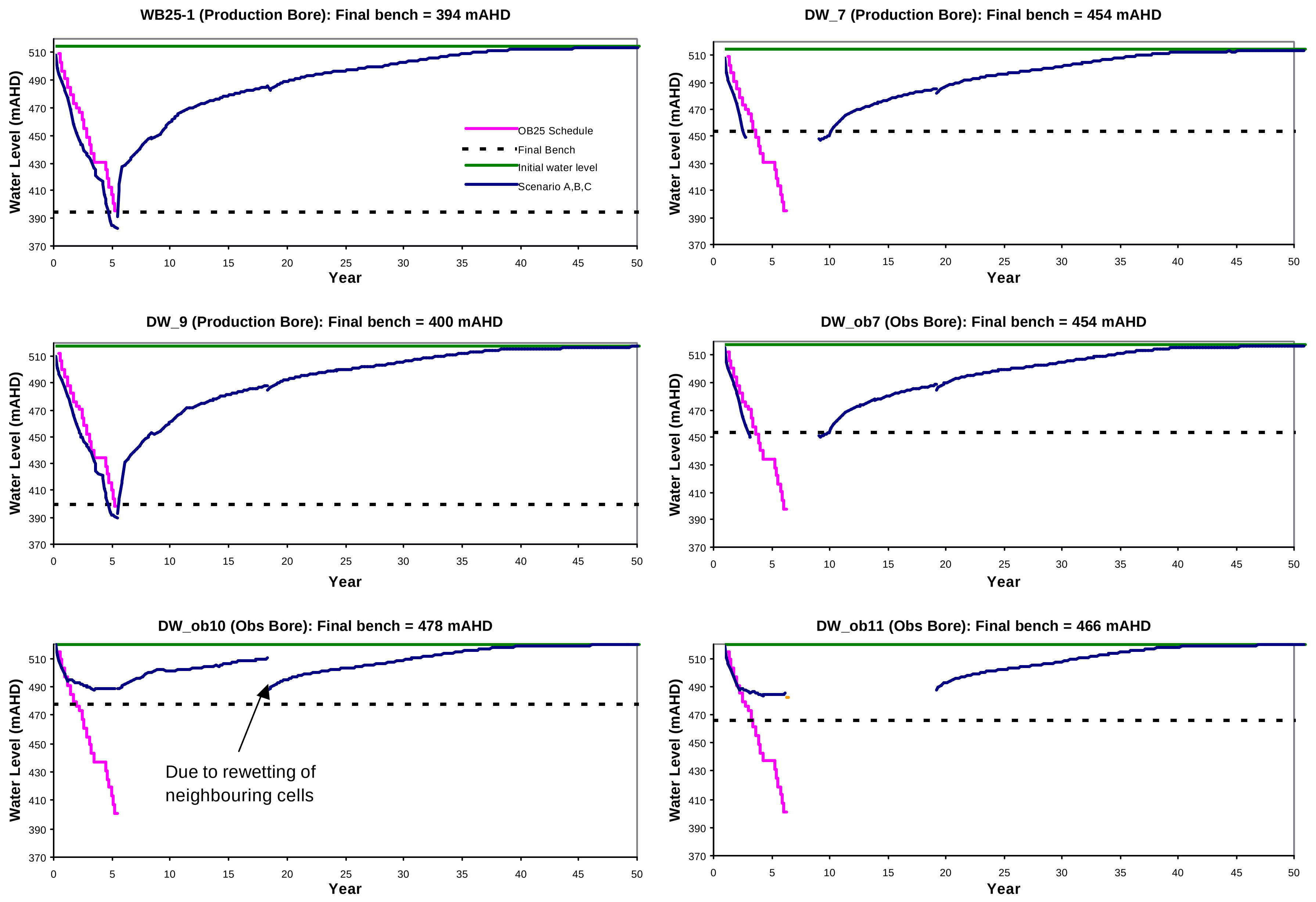
OB25 In-Pit Hydrographs during Dewatering Period

Figure 13

F:\jobs\320\OB23_25\Task E\E5\Report\[4056_figs_13&14.xls]Fig 13



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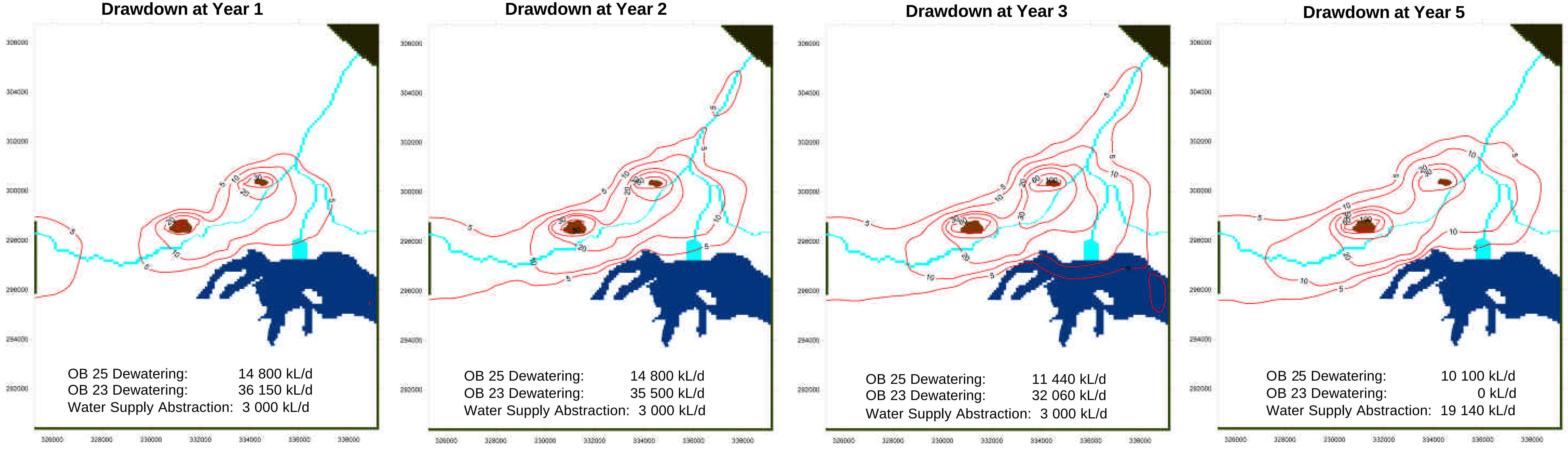
F:\jobs\320\OB23_25\Task E\E5\Report\[4056_figs_13&14.xls]Fig 14

OB25 In-Pit Hydrographs Long Term

Figure 14

MINE DEWATERING- DRY CLIMATE



Drawdown at Year 1

OB 25 Dewatering: 14 800 kL/d
OB 23 Dewatering: 36 150 kL/d
Water Supply Abstraction: 3 000 kL/d

Drawdown at Year 2

OB 25 Dewatering: 14 800 kL/d
OB 23 Dewatering: 35 500 kL/d
Water Supply Abstraction: 3 000 kL/d

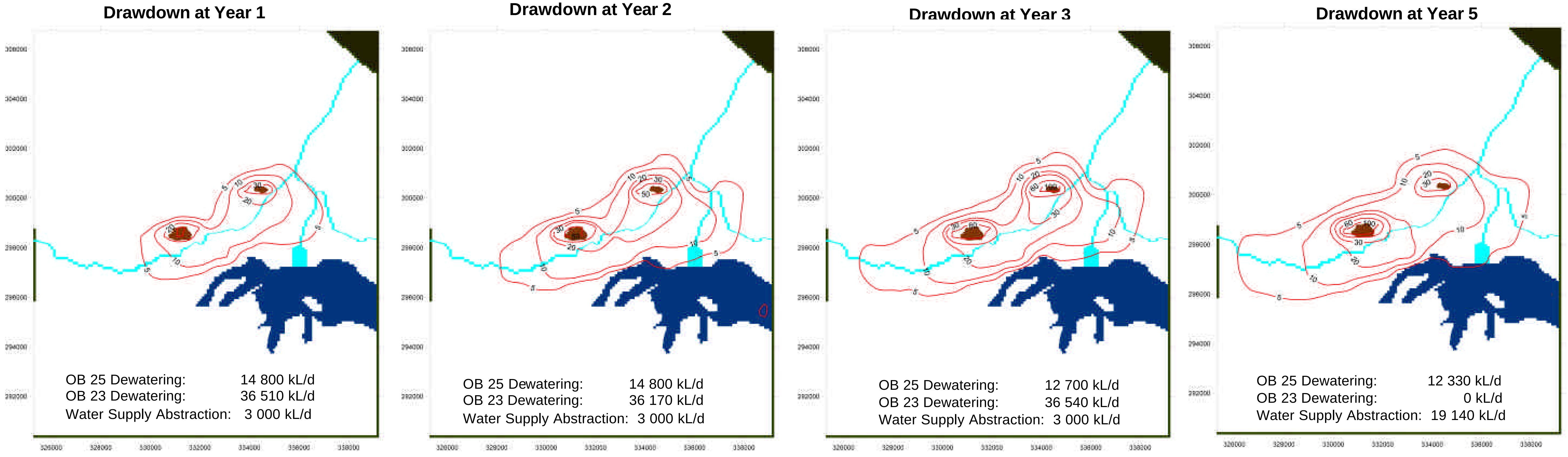
Drawdown at Year 3

OB 25 Dewatering: 11 440 kL/d
OB 23 Dewatering: 32 060 kL/d
Water Supply Abstraction: 3 000 kL/d

Drawdown at Year 5

OB 25 Dewatering: 10 100 kL/d
OB 23 Dewatering: 0 kL/d
Water Supply Abstraction: 19 140 kL/d

MINE DEWATERING- WET CLIMATE



Drawdown at Year 1

OB 25 Dewatering: 14 800 kL/d
OB 23 Dewatering: 36 510 kL/d
Water Supply Abstraction: 3 000 kL/d

Drawdown at Year 2

OB 25 Dewatering: 14 800 kL/d
OB 23 Dewatering: 36 170 kL/d
Water Supply Abstraction: 3 000 kL/d

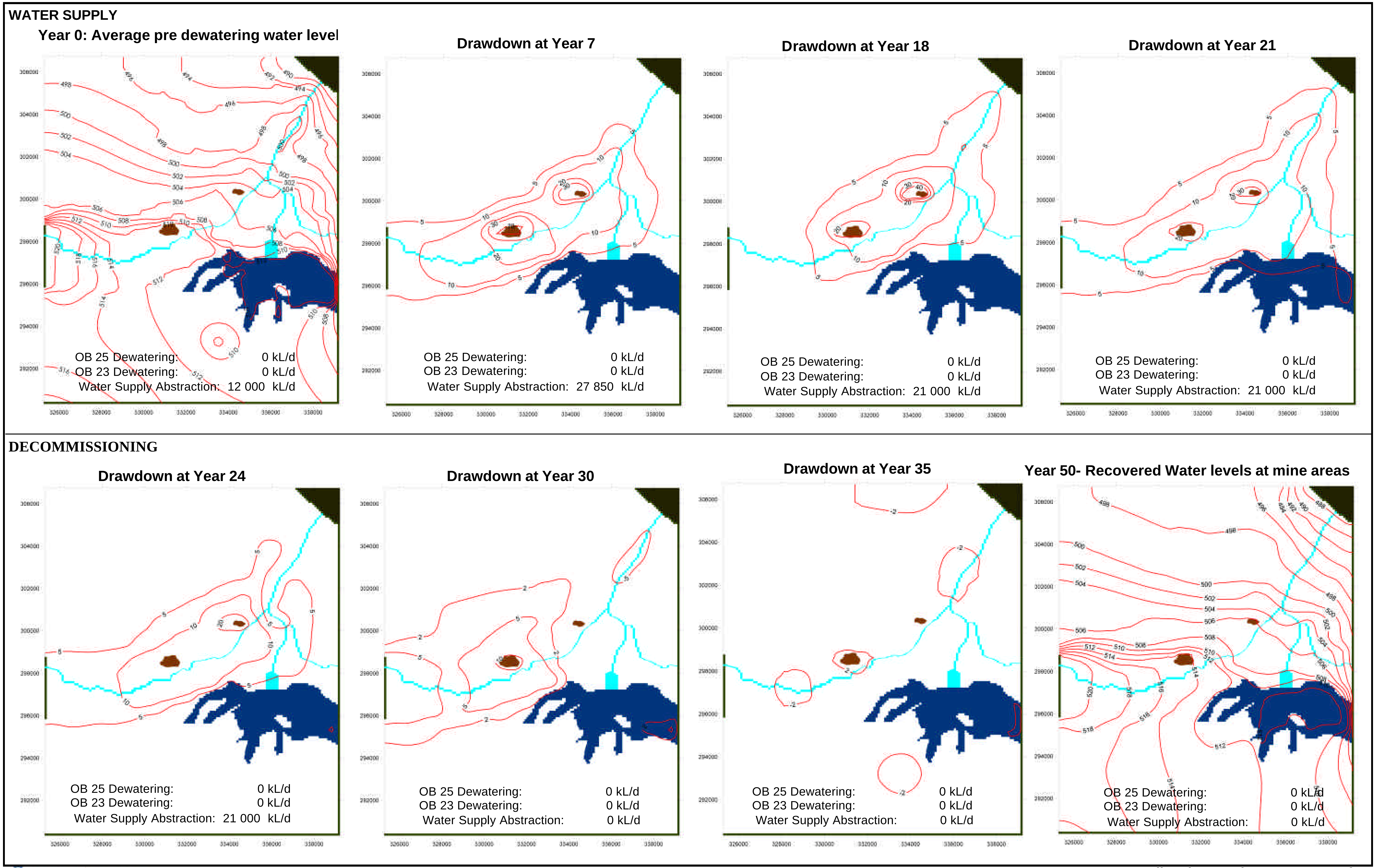
Drawdown at Year 3

OB 25 Dewatering: 12 700 kL/d
OB 23 Dewatering: 36 540 kL/d
Water Supply Abstraction: 3 000 kL/d

Drawdown at Year 5

OB 25 Dewatering: 12 330 kL/d
OB 23 Dewatering: 0 kL/d
Water Supply Abstraction: 19 140 kL/d

Predicted Groundwater Draw down
During Dewatering for Scenario A
Figure 15



WATER SUPPLY

Year 0: Average pre dewatering water level

OB 25 Dewatering: 0 kL/d
OB 23 Dewatering: 0 kL/d
Water Supply Abstraction: 12 000 kL/d

Drawdown at Year 7

OB 25 Dewatering: 0 kL/d
OB 23 Dewatering: 0 kL/d
Water Supply Abstraction: 27 850 kL/d

Drawdown at Year 18

OB 25 Dewatering: 0 kL/d
OB 23 Dewatering: 0 kL/d
Water Supply Abstraction: 21 000 kL/d

Drawdown at Year 21

OB 25 Dewatering: 0 kL/d
OB 23 Dewatering: 0 kL/d
Water Supply Abstraction: 21 000 kL/d

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Drawdown at Year 24

OB 25 Dewatering: 0 kL/d
OB 23 Dewatering: 0 kL/d
Water Supply Abstraction: 21 000 kL/d

Drawdown at Year 30

OB 25 Dewatering: 0 kL/d
OB 23 Dewatering: 0 kL/d
Water Supply Abstraction: 0 kL/d

Drawdown at Year 35

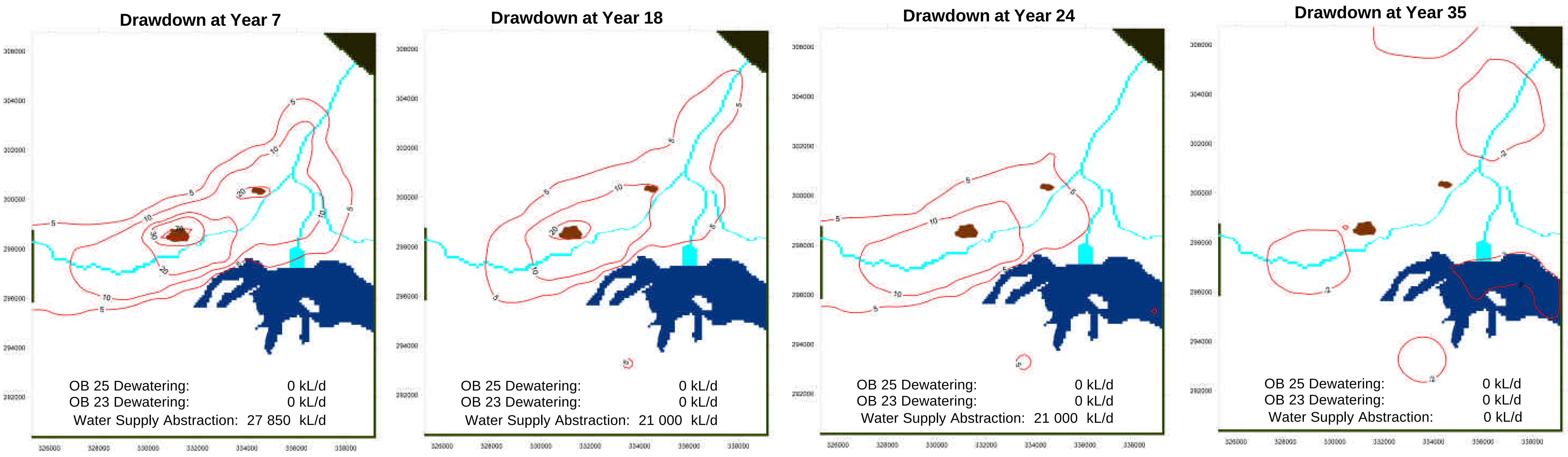
OB 25 Dewatering: 0 kL/d
OB 23 Dewatering: 0 kL/d
Water Supply Abstraction: 0 kL/d

Year 50- Recovered Water levels at mine areas

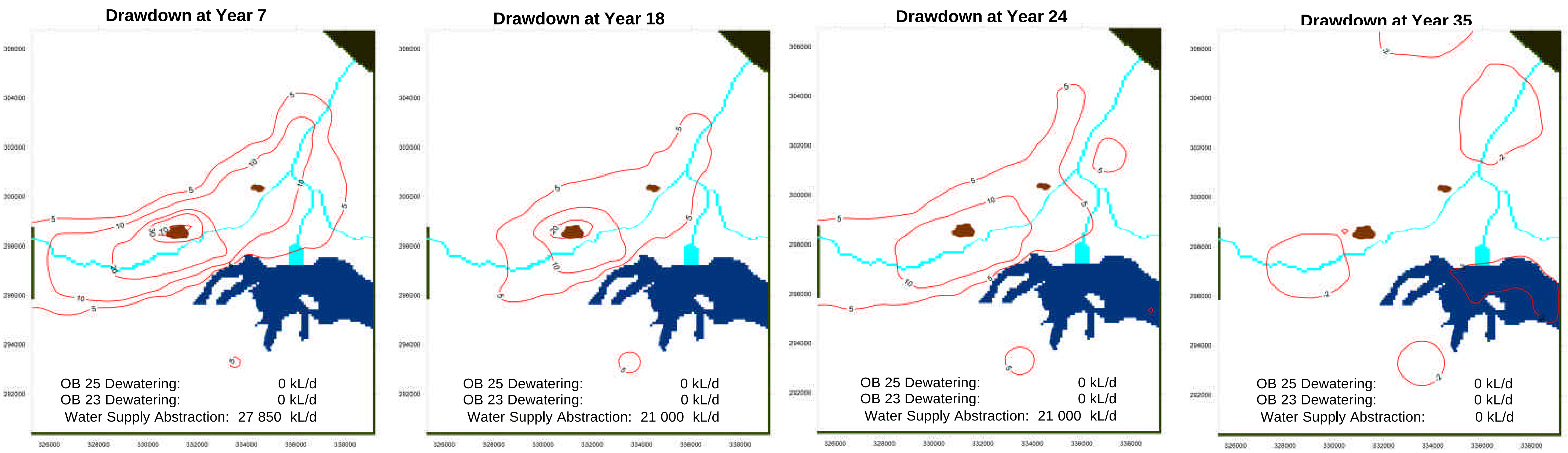
OB 25 Dewatering: 0 kL/d
OB 23 Dewatering: 0 kL/d
Water Supply Abstraction: 0 kL/d

Predicted Groundwater Contours for Water Supply Scenario A- Pit Closure
Figure 16

POST DEWATERING- SCENARIO B



POST DEWATERING- SCENARIO C



Predicted Groundwater Draw down for
Water Supply Scenario B & C- Pit Closure
Figure 17

The model predictions for Scenario E suggest that the OB23 pit lake level requires time to recover sufficiently before water supply abstraction can occur from the OB23 pit. There is therefore a period of between 8 months (wet scenario) and 12 months (dry scenario) at the end of mining OB23 (YEJ10), when the water demand can not be satisfied by the OB23 pit lake and the OB25 dewatering. During this period the Ophthalmia bores will need to be utilised for water supply purposes. However, after this period (ie once water levels have recovered sufficiently to form a pit lake), the predictions indicate that the entire water demand can be sourced from the OB23 and OB25 pit lakes without the additional use of Ophthalmia bores.

It should be noted, however, that the modelling is based on annual average water demands, not peak demands (up to 28,000 kL/d for Newman Hub). Taking this into account, the Ophthalmia bores may have to utilised for short periods during periods of peak demand.

The predicted dewatering and water supply abstraction rates are presented in Appendix E together with predicted discharge rates for excess dewatering yields.

Predicted drawdown contours during the mining of OB23 and OB25 (Pit 3) are presented in Figure 18 for both Scenarios E and F. Despite the additional two years of dewatering / mining at OB25 (Pit 3), the drawdown results during dewatering for Scenarios E and F (Figure 18) are the same as those for Scenario A. The predicted drawdowns for the dry scenario (ie worst case) extend regionally to the model boundaries, with drawdown focused along the alluvial aquifer system. Predicted drawdowns in excess of 10 m extend a maximum of approximately 4.5 km upstream and downstream of OB25 (Pit3) and OB23 respectively. The predicted drawdown at Ophthalmia Dam reaches a maximum of approximately 5 m. The predicted drawdowns associated the wet climatic conditions are significantly less than those for the dry conditions. Drawdowns greater than 10 m only extend approximately 2.5 km upstream of OB25 (Pit 3) and 1 km downstream of OB23 for the wet case as opposed to the 4.5 km noted for the dry case.

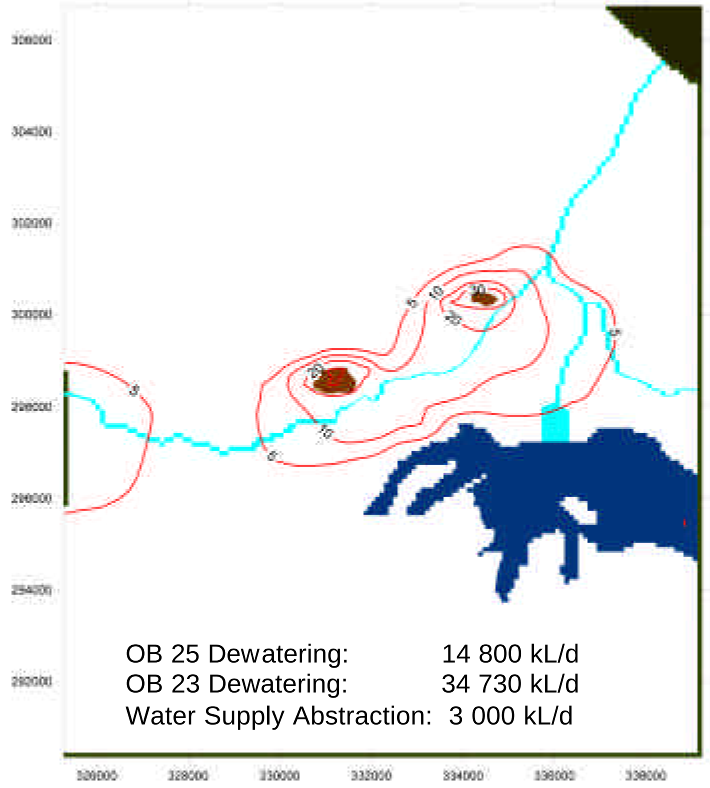
The predicted drawdown contours over the entire 50 year modelling period are presented for the dry conditions of both Scenarios E and F in Figures 19 and 20 respectively. Water levels in the immediate vicinity of dewatered pits are predicted to recover once dewatering is complete and after the cessation of water supply pumping. For Scenario F (in which OB25 Pit 3 has been in-filled), the predicted groundwater levels have fully recovered to within 2 metres of pre-mining levels by Year 35 (ie 9 years after the cessation of water supply pumping and approximately 28 years after the cessation of dewatering). Again, the small localised water level increases, or “drawup” contours predicted in Year 35 are related to seasonal variation in water level rather than long term impacts of the mine void and water supply pumping. The model results for Scenario E (open pit lakes) suggest the water table recovery is slightly slower due to the effects of evaporation on the pit lake surface. By Year 35 there is still a 10 m drawdown in the OB25 area, with full recovery by Year 40.

3.5.3 Predicted Changes to the Water Balance

The impact of pit dewatering at OB25 (Pit 3) and OB23 on the overall model water balance, is summarised in Table 3.7 as a comparison of water balance components (expressed as kL/d average over the period) during dewatering for Scenario A (dewatering) and Scenario D (no dewatering). The main difference

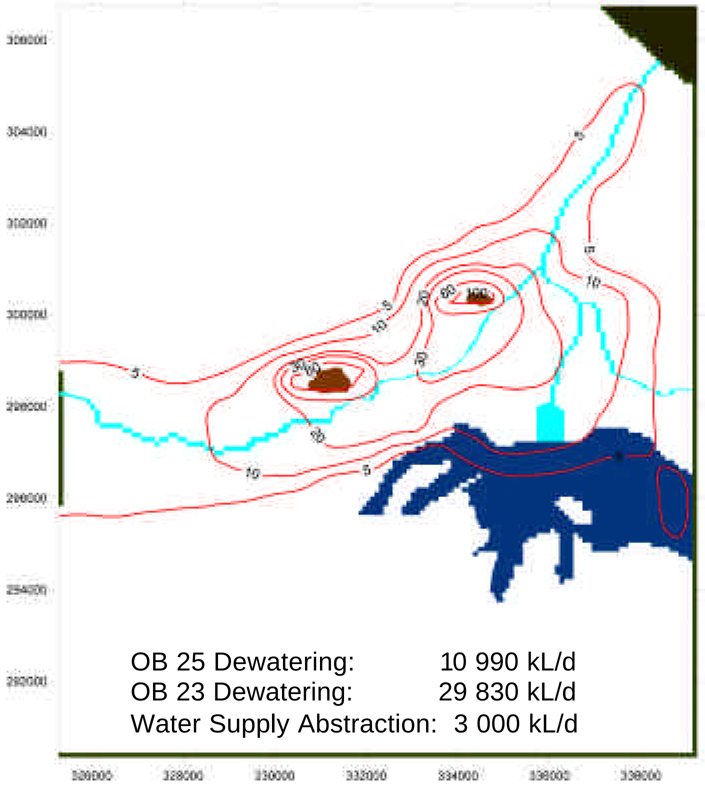
MINE DEWATERING- DRY CLIMATE

Drawdown at Year 1



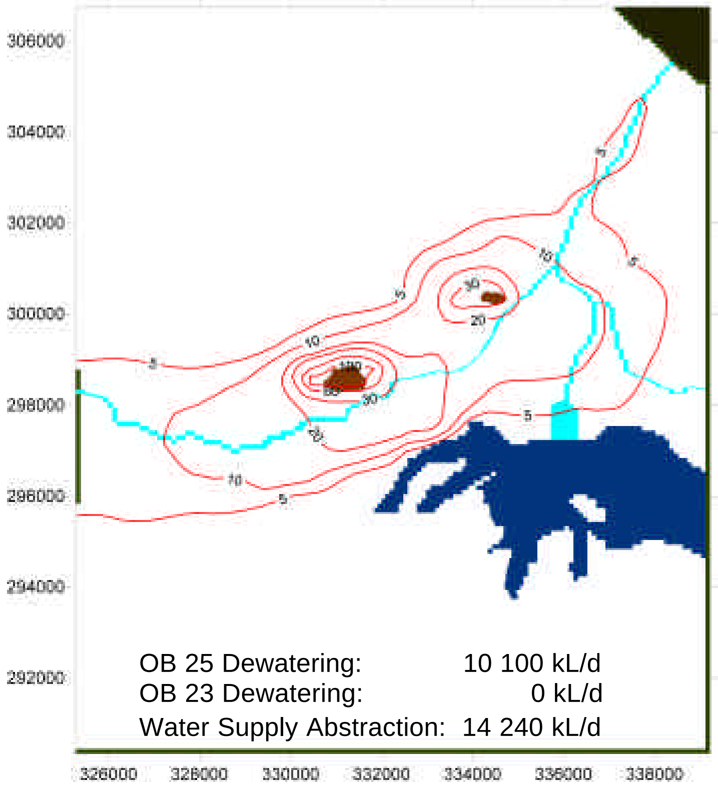
OB 25 Dewatering: 14 800 kL/d
OB 23 Dewatering: 34 730 kL/d
Water Supply Abstraction: 3 000 kL/d

Drawdown at Year 3



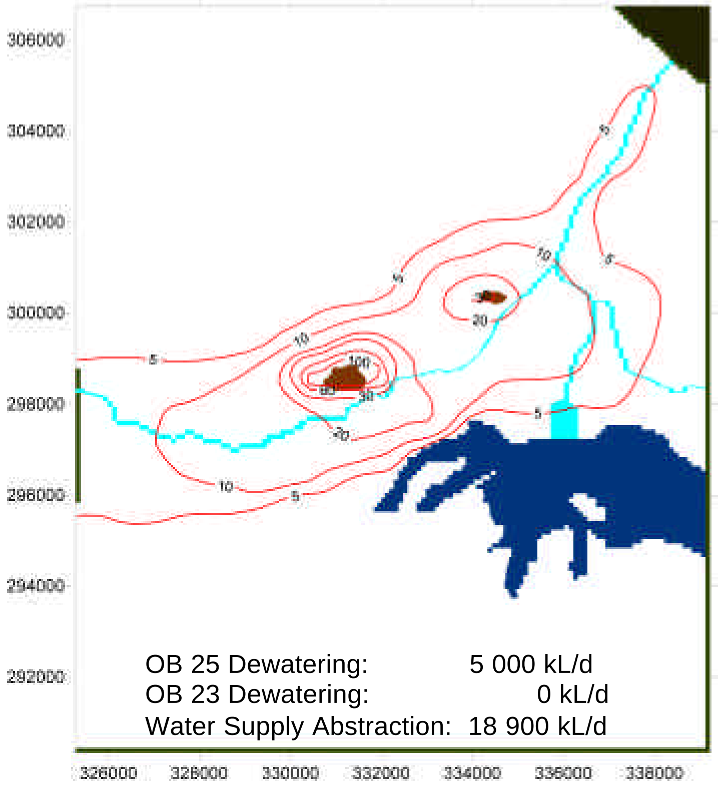
OB 25 Dewatering: 10 990 kL/d
OB 23 Dewatering: 29 830 kL/d
Water Supply Abstraction: 3 000 kL/d

Drawdown at Year 5



OB 25 Dewatering: 10 100 kL/d
OB 23 Dewatering: 0 kL/d
Water Supply Abstraction: 14 240 kL/d

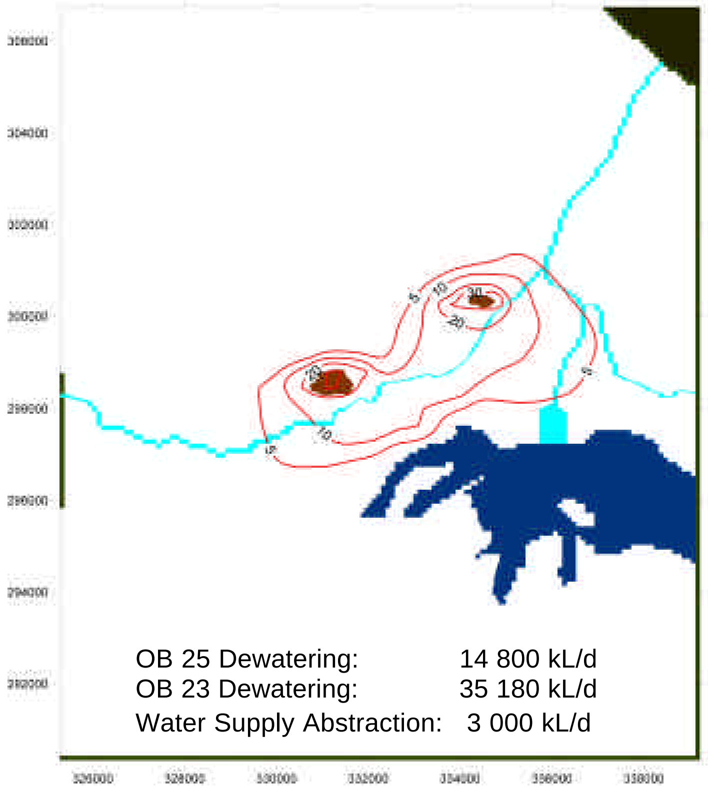
Drawdown at Year 7



OB 25 Dewatering: 5 000 kL/d
OB 23 Dewatering: 0 kL/d
Water Supply Abstraction: 18 900 kL/d

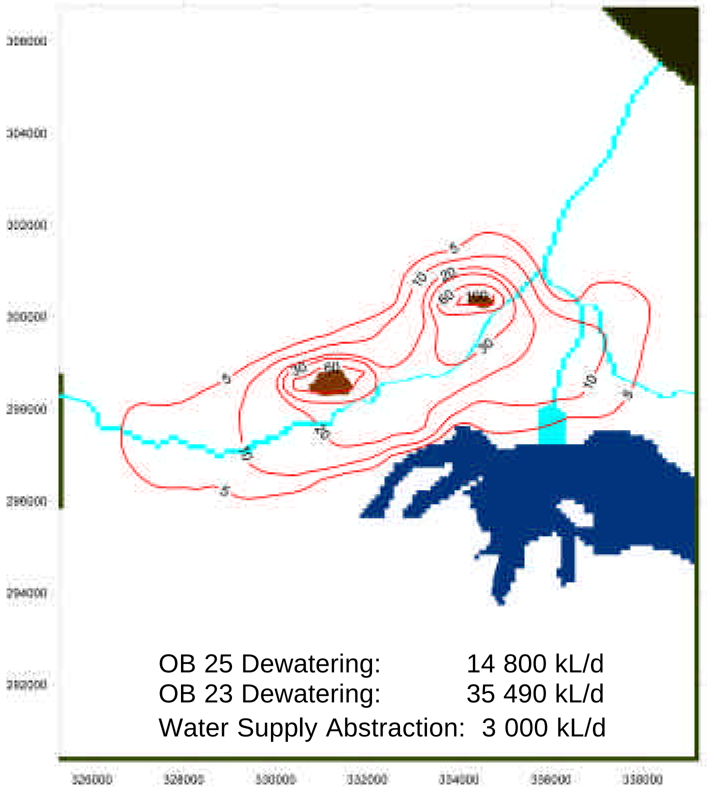
MINE DEWATERING- WET CLIMATE

Drawdown at Year 1



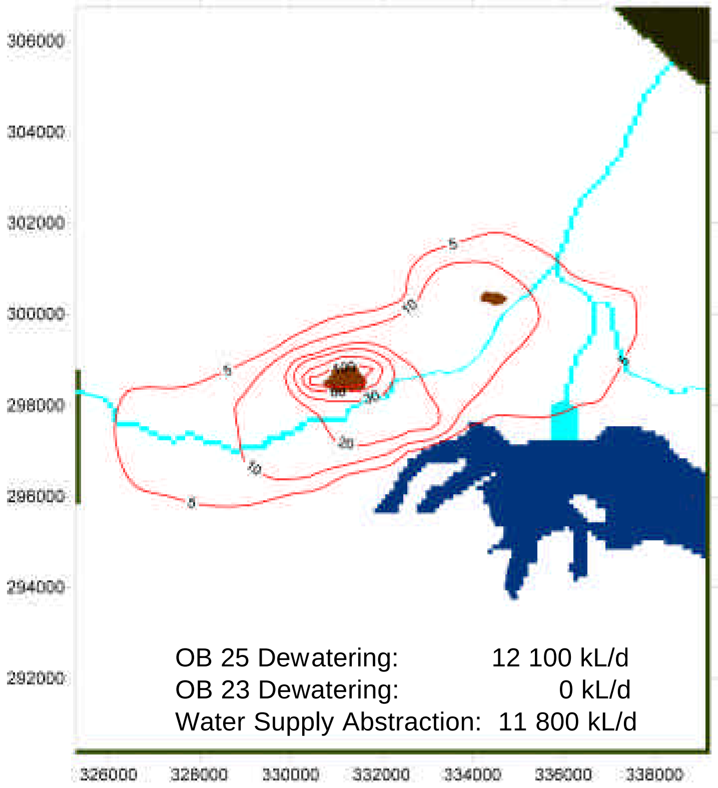
OB 25 Dewatering: 14 800 kL/d
OB 23 Dewatering: 35 180 kL/d
Water Supply Abstraction: 3 000 kL/d

Drawdown at Year 3



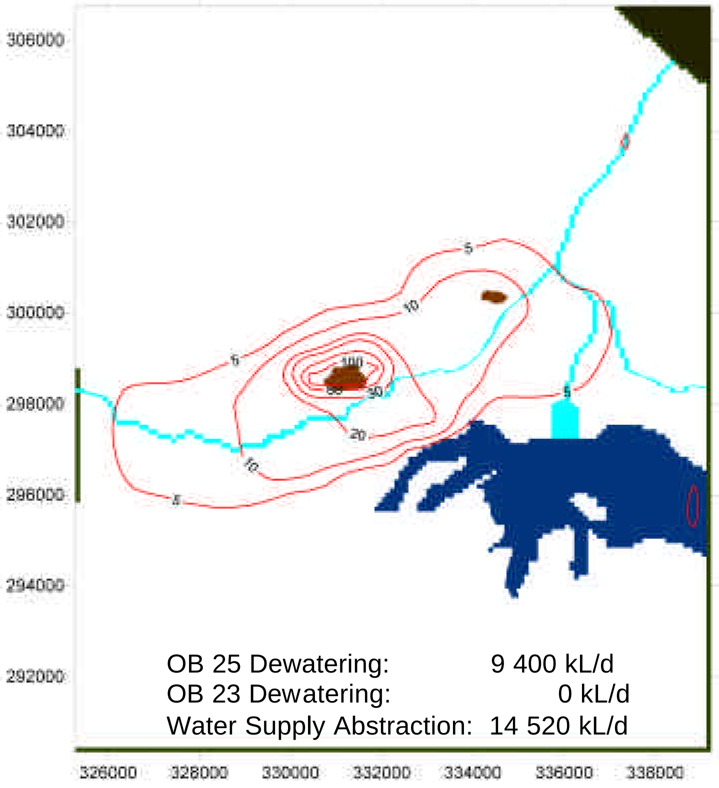
OB 25 Dewatering: 14 800 kL/d
OB 23 Dewatering: 35 490 kL/d
Water Supply Abstraction: 3 000 kL/d

Drawdown at Year 5



OB 25 Dewatering: 12 100 kL/d
OB 23 Dewatering: 0 kL/d
Water Supply Abstraction: 11 800 kL/d

Drawdown at Year 7



OB 25 Dewatering: 9 400 kL/d
OB 23 Dewatering: 0 kL/d
Water Supply Abstraction: 14 520 kL/d

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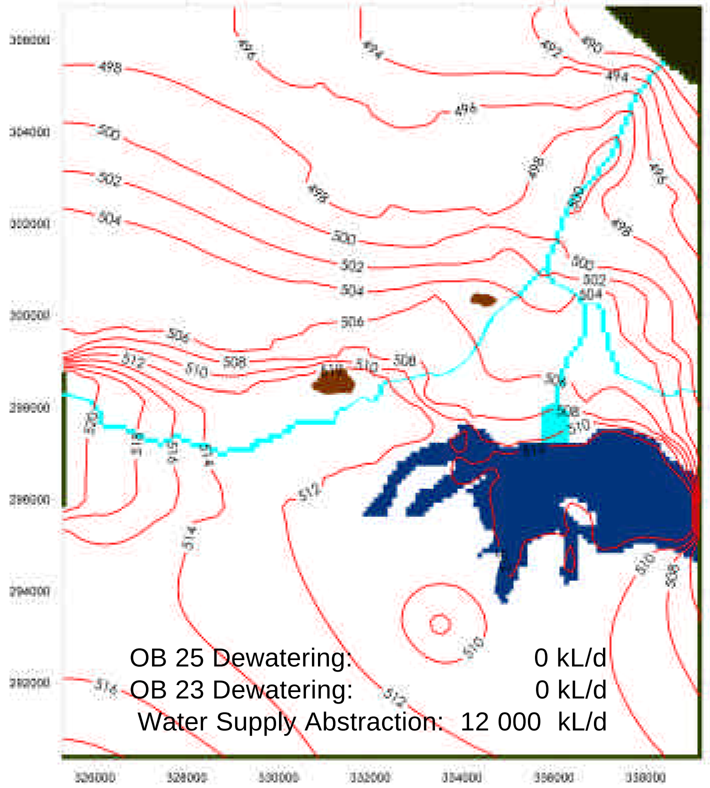
Predicted Groundwater Draw down
(Scenarios E & F) - During Dewatering
Figure 18

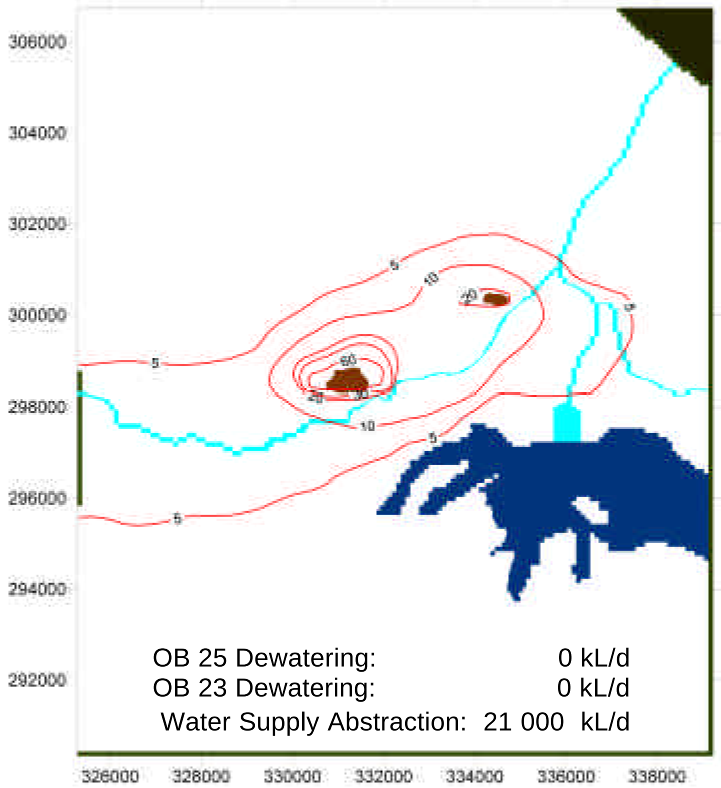
WATER SUPPLY

Year 0: Average pre dewatering water level



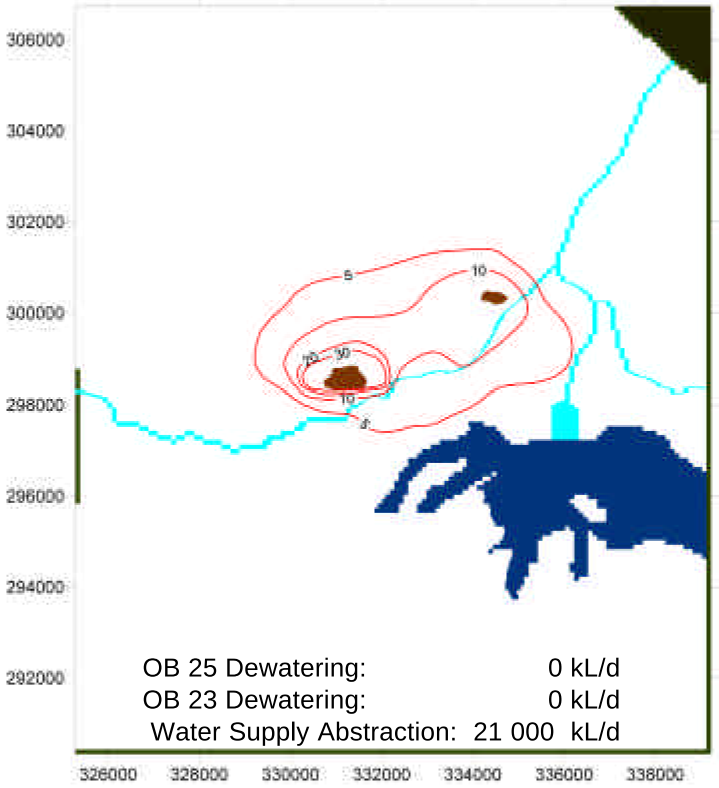
OB 25 Dewatering: 0 kL/d
OB 23 Dewatering: 0 kL/d
Water Supply Abstraction: 12 000 kL/d

Drawdown at Year 12



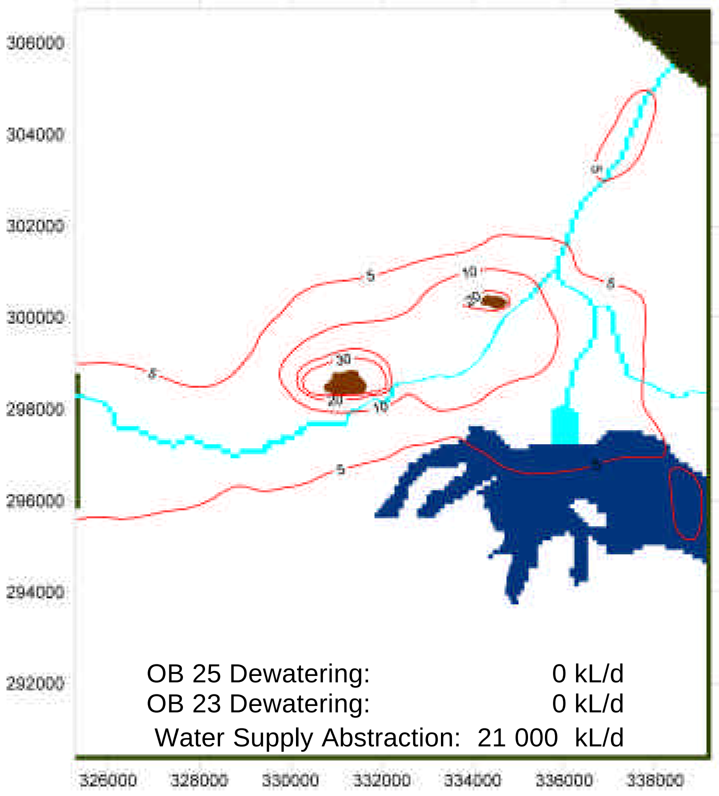
OB 25 Dewatering: 0 kL/d
OB 23 Dewatering: 0 kL/d
Water Supply Abstraction: 21 000 kL/d

Drawdown at Year 18



OB 25 Dewatering: 0 kL/d
OB 23 Dewatering: 0 kL/d
Water Supply Abstraction: 21 000 kL/d

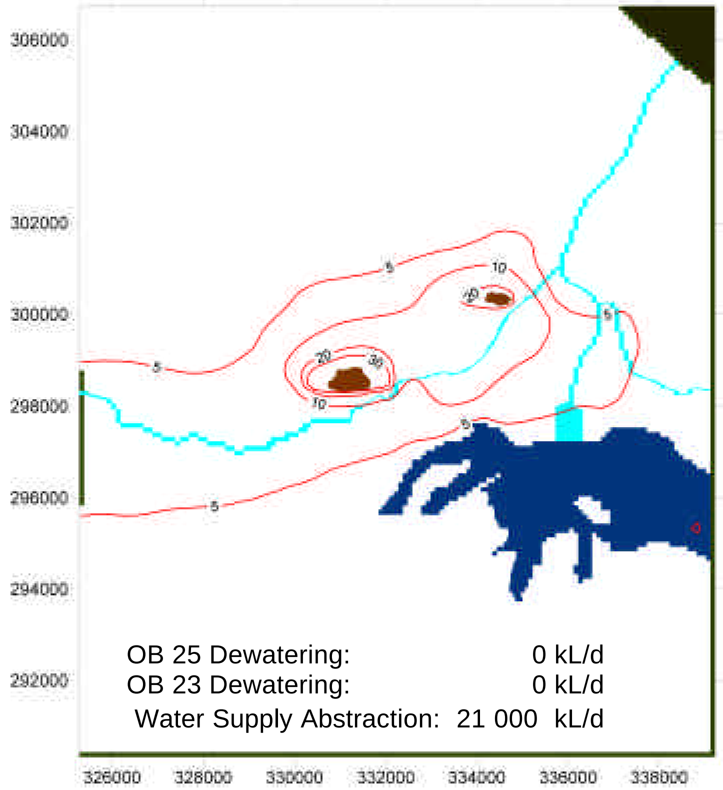
Drawdown at Year 21



OB 25 Dewatering: 0 kL/d
OB 23 Dewatering: 0 kL/d
Water Supply Abstraction: 21 000 kL/d

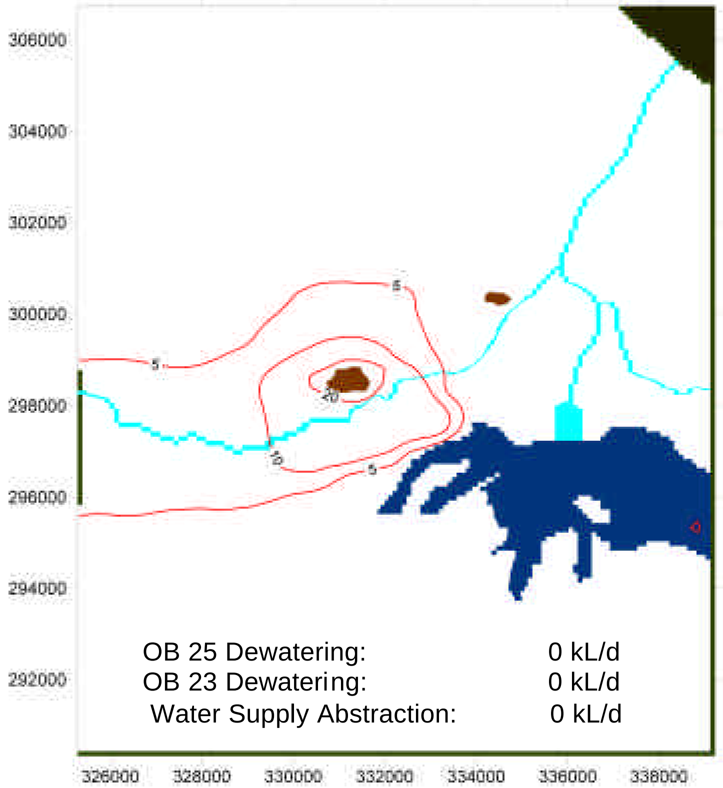
DECOMMISSIONING

Drawdown at Year 24



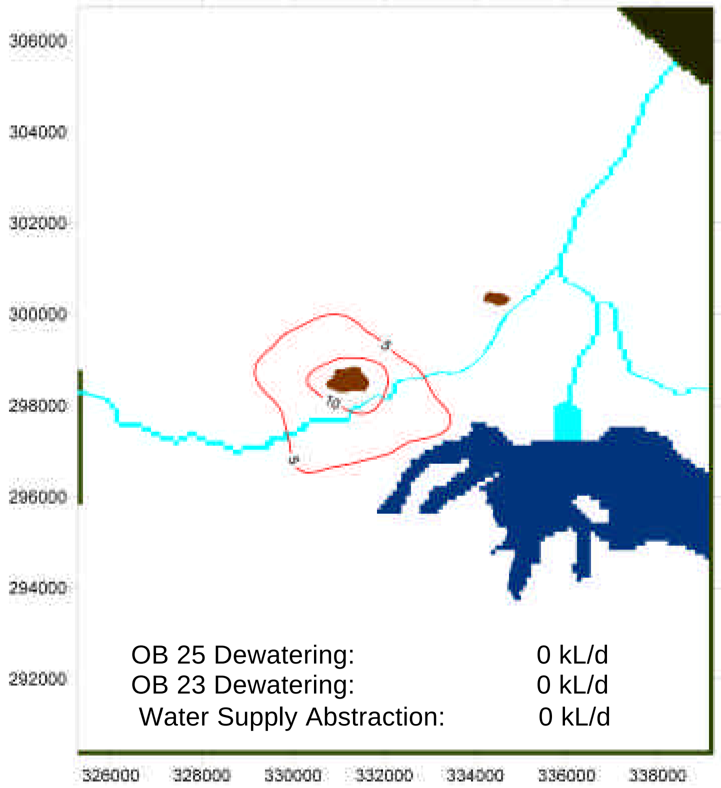
OB 25 Dewatering: 0 kL/d
OB 23 Dewatering: 0 kL/d
Water Supply Abstraction: 21 000 kL/d

Drawdown at Year 30



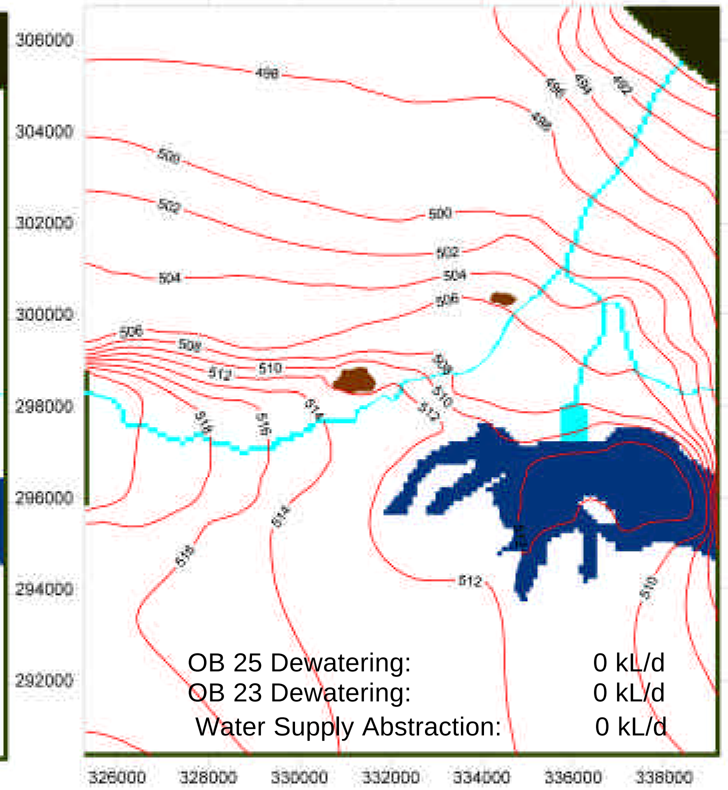
OB 25 Dewatering: 0 kL/d
OB 23 Dewatering: 0 kL/d
Water Supply Abstraction: 0 kL/d

Drawdown at Year 35



OB 25 Dewatering: 0 kL/d
OB 23 Dewatering: 0 kL/d
Water Supply Abstraction: 0 kL/d

Year 50- Recovered Water levels at mine areas



OB 25 Dewatering: 0 kL/d
OB 23 Dewatering: 0 kL/d
Water Supply Abstraction: 0 kL/d

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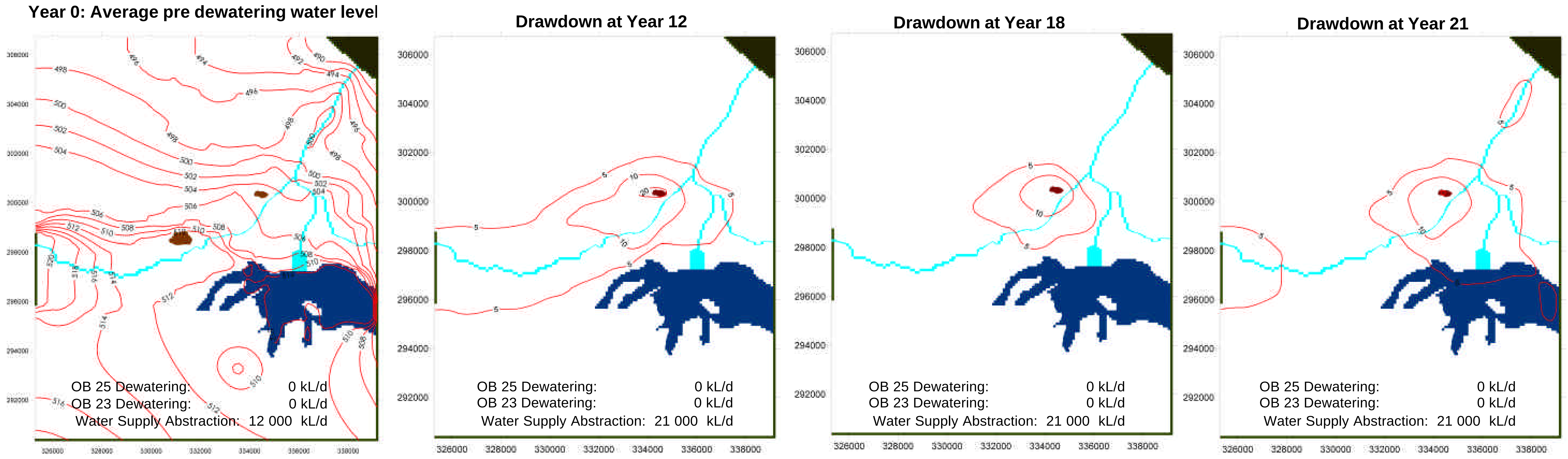
Predicted Groundwater Scenario E – After Dewatering
Figure 19

WATER SUPPLY



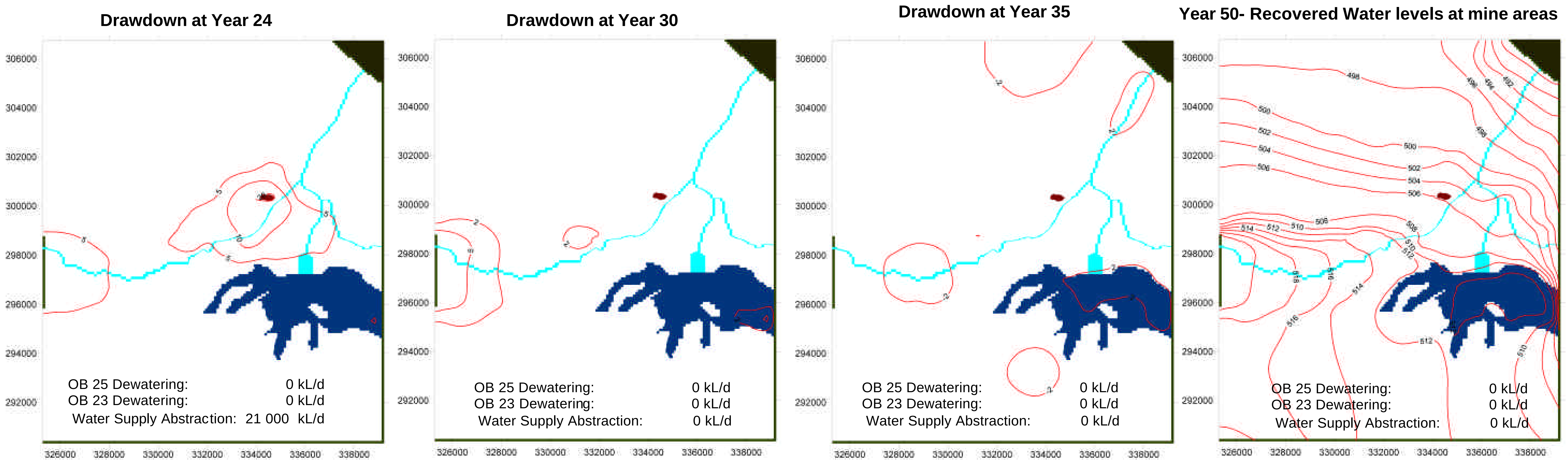
Year 0: Average pre dewatering water level

Drawdown at Year 12

Drawdown at Year 18

Drawdown at Year 21

DECOMMISSIONING



Drawdown at Year 24

Drawdown at Year 30

Drawdown at Year 35

Year 50- Recovered Water levels at mine areas

Predicted Groundwater Scenario F – After Dewatering
Figure 20

between Scenario A (presented) and more recent model runs (ie Scenarios E and F) is the time period over which dewatering at OB25 takes place, which has minimal impact on the average water balance flows listed.

Figures G1 to G6 (Appendix G) present the variations in inflows, outflows, dam seepage, river leakage and evapotranspiration over time, both for the dewatering and closure periods.

Table 3.7
Predicted Changes to Water Balance during Dewatering

Component	Dry Scenario		Wet Scenario	
	Without Dewatering (Scenario D)	With Dewatering (Scenario A)	Without Dewatering (Scenario D)	With Dewatering (Scenario A)
INFLOW (kL/d)				
Groundwater Inflow	4570	4620	5490	5350
Recharge	760	860	1420	1420
Ophthalmia Dam Seepage	15110	20330	19620	25390
Fortescue River Leakage	4170	4780	10870	13020
Homestead & Shovelanna Creek Leakage	7440	7360	8100	8230
OUTFLOW (kL/d)				
Groundwater Outflow	11770	10330	15100	13720
Evapotranspiration	2400	1000	5690	3800
Groundwater Leakage into Ophthalmia Dam	270	220	330	300
Groundwater Leakage into Fortescue River	260	30	800	350
Ophthalmia Well field	24340	4370	24340	4370
Dewatering	-	33920	-	36230

Note:
Values presented above are average rates over the period of dewatering (5.25 years)

During dewatering, the outflow from the model (ie throughflow from the modelled area to the downstream Ethel Gorge) is predicted to decrease by an average of 10 to 15% (dependent on the climatic conditions). Similarly, the water taken up by vegetation (evapotranspiration) is predicted to decrease by an average of between 50% to over 100% (depending on the climatic conditions) as water levels will drop below the root zone in some areas. Seepage from the Ophthalmia Dam is predicted to increase by an average of 30 to 35% due to the lowered water levels under the dam area.

Table 3.8 presents the predicted impact of the various water supply scenarios on the modelled water balance during the pit closure simulations for Scenarios A, B and C. The only difference between these scenarios and the more recent model runs (Scenarios E and F) is a longer dewatering period at OB25 for the later runs. This has minimal impacts on the long term water balance. The model predicts that, after 19 years of pit recovery (ie Year 24) water balance components are similar for all scenarios, with the exception of abstraction from Ophthalmia Wellfield.

By Year 50, it is predicted that the system will have recovered from the dewatering and water supply abstraction and returned to a state of equilibrium.

Table 3.8
Predicted Changes to Water Balance Post-Dewatering

Component	End of Year 24			Year 50
	Scenario A	Scenario B	Scenario C	Scenario A
INFLOW (kL/d)				
Groundwater Inflow	5930	7720	6780	2850
Recharge	5510	5510	5510	4480
Ophthalmia Dam Seepage	33010	31040	31920	20730
Fortescue River Leakage	39850	33370	37760	1810
Homestead & Shovelanna Creek Leakage	5510	7990	7990	7490
OUTFLOW (kL/d)				
Groundwater Outflow	9330	10070	9490	12960
Evapotranspiration	4430	6530	4630	14270
Groundwater Leakage into Ophthalmia Dam	0	0	0	0
Groundwater Leakage into Fortescue River	0	120	0	1600
Ophthalmia Wellfield	5000	21000	21000	0

3.6 PIT LAKE SALINITY MODELLING

3.6.1 Methodology

Mining activities at both OB23 and OB25 (Pit 3) are not expected to result in the exposure of any potentially acid-forming material. As a result, the water quality of the resulting mine pit lakes will develop as a result of evaporative concentration. A conservative one dimensional mass balance model was used to estimate the development of salinity within the mine pit lakes at both OB23 and OB25, assuming non in-filled mine voids and the following assumptions:

- Water can enter a mine void lake via groundwater inflow from the surrounding rocks, or from runoff from the pit catchment.
- Water can leave a mine void lake via evaporation or groundwater outflow.
- Full recovery of groundwater lake levels is complete with variations in the long-term lake levels in the order of 1 to 2 metres only, resulting from seasonal variation in hydrological conditions.
- Any increase in salinity during the recovery period for both mine void lakes is small compared to the predicted increased over the longer term, and is not included.
- The salinity of run-off which recharges the mine void lake is 50 mg/L.
- Ambient groundwater salinity (ie groundwater inflow) for both mine void lake is 1000 mg/L.
- Water within the mine void lake is fully mixed and any increase in salinity in the mine void lake is immediately propagated to the area of groundwater outflow. (NB. This is a conservative assumption as it is likely that the salt migration process would be significantly slower than this).

The water flux components of the mass balance model (groundwater inflow and outflow to/from the mine void lake, recharge and evaporation) were extracted from the groundwater flow model simulation results for steady state flow conditions.

For the OB25 infill case (pit infill to above pre-mining water table), there will be no daylighting of groundwater above the infill level.

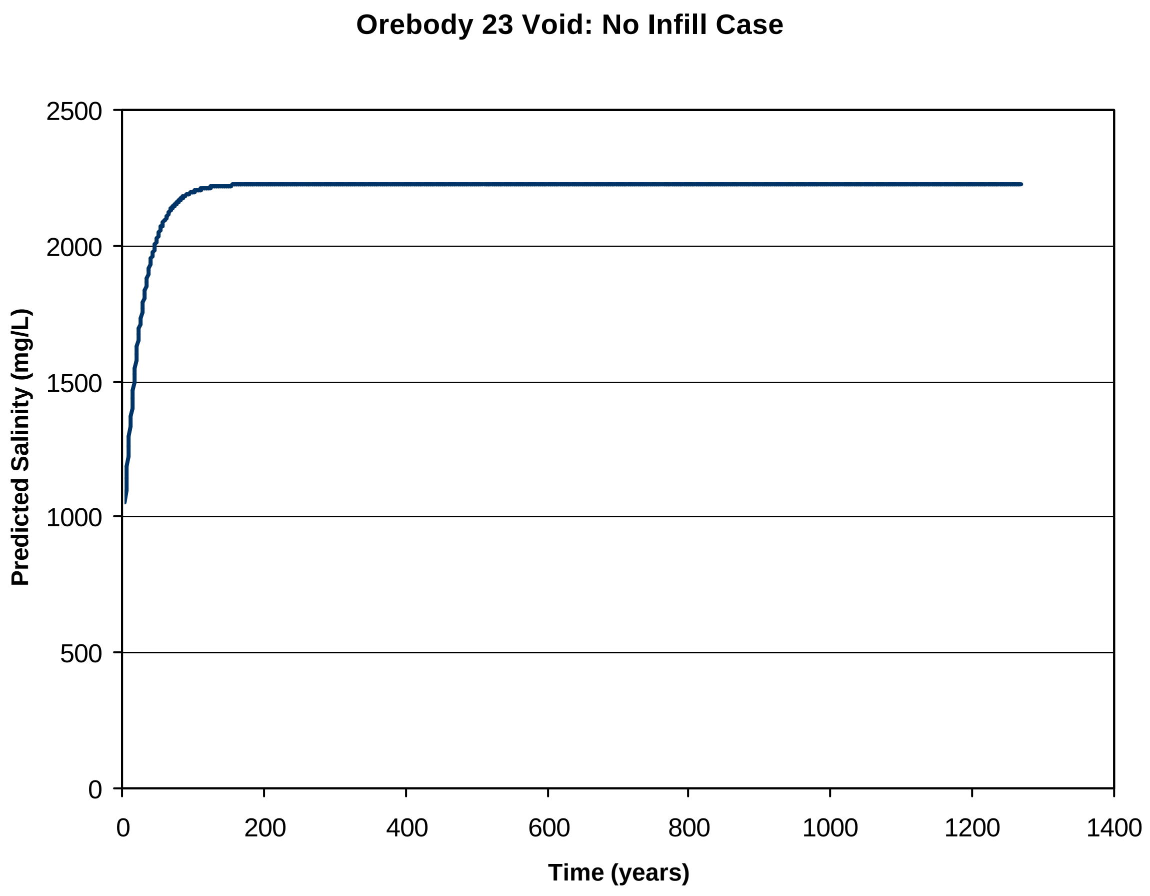
It should also be noted that the infilling of the OB25 pit void is not predicted to have any impact on the OB23 water balance.

3.6.2 Results

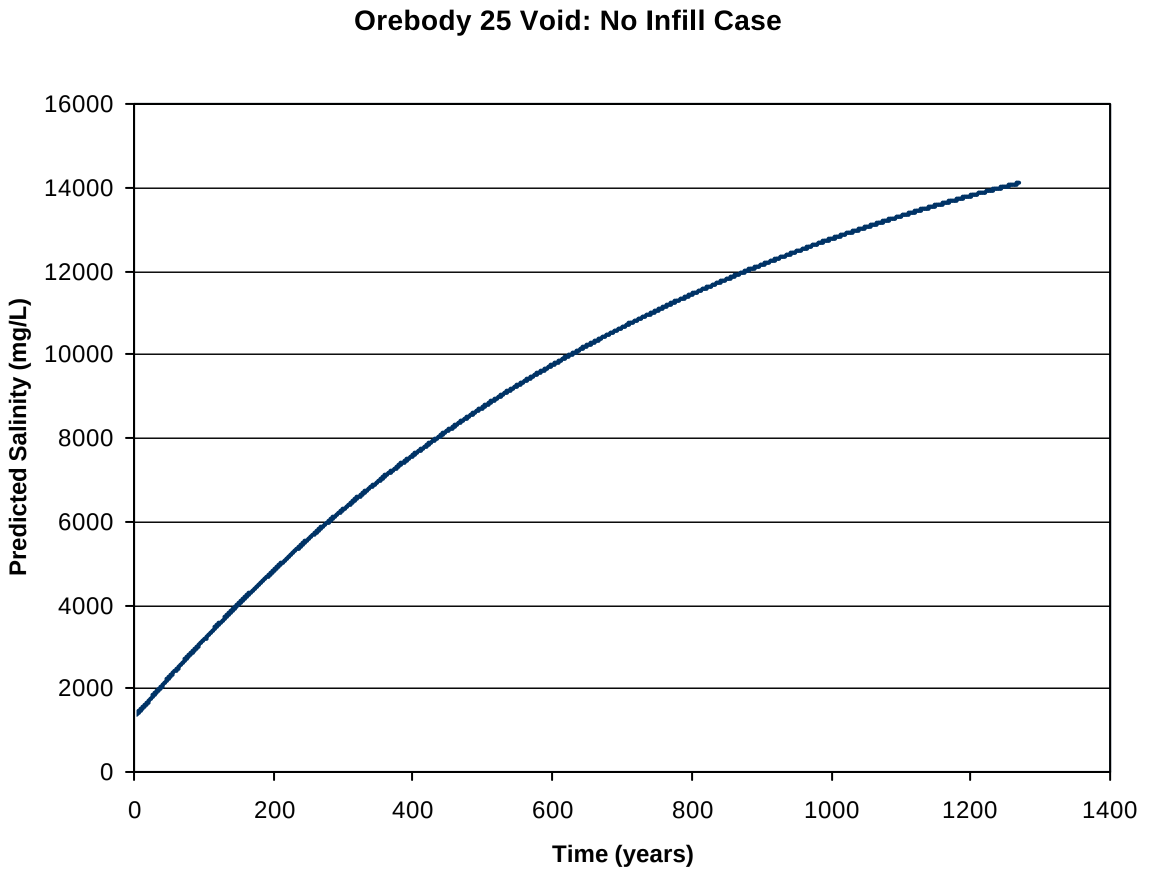
The predicted maximum long-term increase in salinity for the OB23 and OB25 (Pit 3) pit void lakes is shown in Figure 21.

The modelling results indicate that, once full recovery of water levels is complete, there will be some groundwater outflow from both OB23 and OB25. This groundwater outflow from both mine void lakes will limit the long-term development of salinity within the void lakes (as outflow results in a net export of salt) and equilibrium salinity levels will eventually be reached.

At OB23, the maximum predicted salinity is lower, and reached much faster than the OB25 case. The model predicts a long-term salinity in OB23 of around 2,200mg/L TDS, with steady state conditions occurring in the first 100 years after mining. At OB25, the model predicts that the pit lake salinity will be at around 12,000 mg/L after around 1,000 years and will still be increasing (ie steady sate conditions will not be reached for at least 2,000 years). The reason for the difference lies in the much larger groundwater outflow from the OB23 void lake, as a result of the much higher permeability on the downstream side of the OB23 void lake. If the balance between groundwater outflow and evaporation from OB25 can be shifted towards higher groundwater outflows (eg by reducing evaporation from the mine void lake surface, via the selective placement of infill), the long-term salinity in the OB25 pit could be reduced.



Orebody 23 Void: No Infill Case



Orebody 25 Void: No Infill Case

F:\jobs\320\OB23_25\Task E\E5\Report\[4056 Fig 21.xls]Fig21

Note: different vertical scales

Orebody 23 and 25 Predicted Salinity Increase

Figure 21

SECTION 4 - CONCLUSIONS & RECOMMENDATIONS

4.1 DEWATERING OF OB25 (PIT 3)

It is anticipated that three in-pit dewatering bores and up to four ex-pit, shallow dewatering bores will be required to achieve water levels below the base of mining at OB25 (Pit 3). The in-pit bores are anticipated to be high yielding, with a maximum yield of 4,000 kL/d. As the ore is dewatered, the reduced thickness of saturated aquifer and the associated reduced transmissivity will result in bore yields declining. Thus, as the pit approaches its maximum depth, the effectiveness of the in-pit bores will decline and it is anticipated that they will be replaced with in-pit sumps.

As described in Section 1, the alluvial sequence to the south of OB25 (Pit 3) is substantially thinner and less permeable than that to the south of OB23. As a result, throughflow of groundwater from the alluvial aquifers to the orebody are somewhat constrained and the predicted dewatering requirements and sustainable bore yields are substantially less than at OB23. However, the low permeability of the shale to the south of the pit also means that ex-pit bores in this area will be shallow (only installed through the overlying Tertiary sediments), and low-yielding, with predicted discharge rates in the order of 600 kL/d. As the ex-pit bores will be shallow, their effectiveness may be short-lived. Should these bores be decommissioned as water levels decline, it is anticipated that they may be recommissioned in the wet seasons when recharge from the Homestead Creek will increase water levels in this area.

Total predicted dewatering requirements for OB25 (Pit 3) range from 14,800 kL/d in the early years to approximately 10,000 kL/d at the end of mining. Total dewatering requirements for both OB25 (Pit 3) and OB23 range from 38,900 kL/d at the start to approximately 35,000 kL/d when mining at OB23 is complete.

It is proposed that a reticulation system will be installed such that the dewatering discharge can be used for process water at OB25 or fed into the Ophthalmia E Line for either use at Mt Whaleback (Newman Hub) or discharge to Ophthalmia Dam (ie if production is in excess of water supply requirements). Water balance calculations for the dam suggest that excess water from OB23 and OB25 will not result in overflow from the dam.

4.2 HYDROGEOLOGICAL IMPACTS AND IMPACT MANAGEMENT STRATEGIES

4.2.1 During Active Dewatering

Water Levels

The impacts of the dewatering at OB25 (Pit 3), in combination with dewatering at OB23 and on-going water supply abstraction, are detailed in Section 3. Although the predicted drawdown contours are centred on the dewatered deposits, the hydraulic connection of the orebodies with the alluvial aquifer results in drawdowns extending along the main creek lines. As shown in the predicted drawdown contours for the dry and wet climatic conditions (Figures 15 and 16), the precise impact will be dependent on the climatic conditions at the time of dewatering. The dry conditions, however, should give the worst-case scenario, with substantial drawdown (ie greater than 10 m) extending approximately 4.5 km upstream and downstream of OB25 (Pit3) and OB23 respectively and maximum predicted drawdowns at Ophthalmia Dam of approximately 5 m.

It should be noted, that the drawdown impacts resulting from dewatering at OB23 extend over the OB25 (Pit 3) area. As a result, the dewatering requirements at OB25 (Pit 3) are slightly less than if the two deposits were mined independently.

The results of the dewatering and associated drawdowns are predicted to have an impact on the modelled water balance. The outflow from the model (ie throughflow from the modelled area to the downstream Ethel Gorge) is predicted to decrease during dewatering by an average of 30 to 40% (dependent on the climatic conditions). Similarly, the water taken up by vegetation (evapotranspiration) is predicted to decrease during dewatering as water levels will drop below the root zone in some areas. The rate of evapotranspiration is predicted to decrease by an average of 35 to 60%, dependent on the climatic conditions. Seepage from the Ophthalmia Dam is predicted to increase by an average of 30 to 35% due to the lowered water levels under the dam area.

Water Quality

Active dewatering is not expected to have any impact on groundwater quality. From other investigations and long term monitoring in the region, groundwater within the main regional aquifers systems are fresh and, with the exception of some parameters, largely potable. Active groundwater recharge processes will replenish depleted groundwater storage and, if anything, groundwater quality might improve. That is, older groundwater will be abstracted and replaced by recharge that might have otherwise run off.

We also understand that mineral exploration to date has not encountered pyritic shales at OB25 (Pit 3). This being the case, it is not anticipated that acid rock drainage (ARD) as a result of runoff over pit walls or drainage through lower pit walls will be a problem.

Flora and Fauna

Drawdowns in response to dewatering and water supply pumping may have some localised impact on phreatophytic vegetation and stygofauna species that are known to inhabit the area. The magnitudes of predicted drawdowns in key area are summarised below, while the potential impacts have been specifically addressed in parallel investigations.

Phreatic vegetation is largely concentrated within the main drainage courses of the Fortescue River, Homestead Creek and Shovellana Creek. Predicted worst case drawdowns (ie Scenario A, Dry Climate case) are plotted on Figure 15. This shows predicted drawdowns of 5m at the end of dewatering (ie Year 5) extending:

- West beneath Whaleback Creek to the model boundary (ie some 3km to the west of OB25).
- East beneath Shovelanna Creek to some 1.5km east of OB23.
- North beneath the Fortescue River to some 1km north of OB23.

To the south the drawdowns are restricted by the presence of Ophthalmia Dam. Drawdowns in excess of 20m are restricted to a narrow zone beneath Whaleback Creek only and extending no more than 500m upstream of OB25 or downstream of OB23.

The main potential stygofauna habitats are the calcrete and gravel horizons in the valley fill sediments, which extend across most of the width of the main drainages and are distributed vertically throughout the valley fill sequence. Shallow calcrete can extend to over 20m below water table whilst deeper calcrete and the gravel horizons can extend to over 40m below water table. As outlined above, predicted drawdowns in excess of 20m (for the worst case scenario) are restricted to a narrow zone beneath Whaleback Creek and extend no more than 500m upstream of OB25 or downstream of OB23. Predicted drawdowns in excess of 40m are restricted to the immediate vicinity of each pit.

4.2.2 Post Dewatering

Water Levels

Following dewatering, the water levels at OB25 (Pit 3) are predicted to recover irrespective of the water supply scenario for Newman and the Satellite Orebodies. Assuming that the pit is left open, the model simulations suggest that water levels in the vicinity of the pit will have recovered to within 20 m of the pre-mining levels (ie 85% recovery) 19 years after the cessation of dewatering with aquifer drawdowns in excess of 10m being restricted to an area within 2km of OB25 (and negligible drawdown around OB23).

Assuming that OB25 is infilled to above the pre-miming water table (ie Scenario F) groundwater levels are predicted to have recovered to within 2 metres of pre-mining levels by Year 35 (ie 9 years after the cessation of water supply pumping and approximately 28 years after the cessation of dewatering).

Water Quality

Given the absence of pyritic shale, the only potential impacts of mine closure on groundwater quality are related to the potential salinity increases in the pit lake due to evaporative concentration of salts if the pits are left as is.

Groundwater modelling results indicate that, once full recovery of water levels is complete, there will be some groundwater outflow from OB25 (Pit 3). This groundwater outflow will limit the long-term development of salinity within the pit lake (as it results in a net export of salt). The mass balance model predicts that the pit lake salinity will be at around 12,000 mg/L after around 1,000 years and will still be increasing (ie steady sate conditions will not be reached for at least 2,000 years). However, the impacts of such outflows (low flow rates at elevated salinity) would likely have negligible impact on down-gradient groundwater quality due to blending and dilution with the much higher rates of fresh throughflow in the paleovalley aquifer. Measurable impacts would be expected to be limited to the immediate vicinity of the pit, where groundwater outflows remained within the Brockman Iron Formation.

Notwithstanding the above, BHPBIO have committed to backfilling OB25 (Pit 3) to just above the pre-mining water table. As a result, there will be no daylighting of groundwater and there will be no increased salinity due to the evaporative concentration of salts in a pit lake. As such, there should be no long-term impact on groundwater quality within or outside the pit area.

Flora and Fauna

In relation to phreatophytic vegetation and stygofauna habitats, the predicted long term drawdowns around each pit are minimal (refer Figure 16), and are expected to have no impacts.

SECTION 5 - REFERENCES

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HGM, 1999. Orebody 23 Flood Study, unpublished report prepared by Halpern Glick Maunsell for BHP Iron Ore Pty ltd (Report No. TH995350).

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Tahal Consulting Engineers, 1981. Newman Water Resource Development Project: Stage 2 Final Report, unpublished report prepared for Mt Newman Mining Co. Pty Limited.

Woodward-Clyde, 1997. Orebody 23 Dewatering Investigation, unpublished report prepared for BHP Iron Ore (Report No. R074-b).

APPENDIX A

COMPOSITE BORELOGS

125 Melville Parade
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COMPOSITE WELL LOG

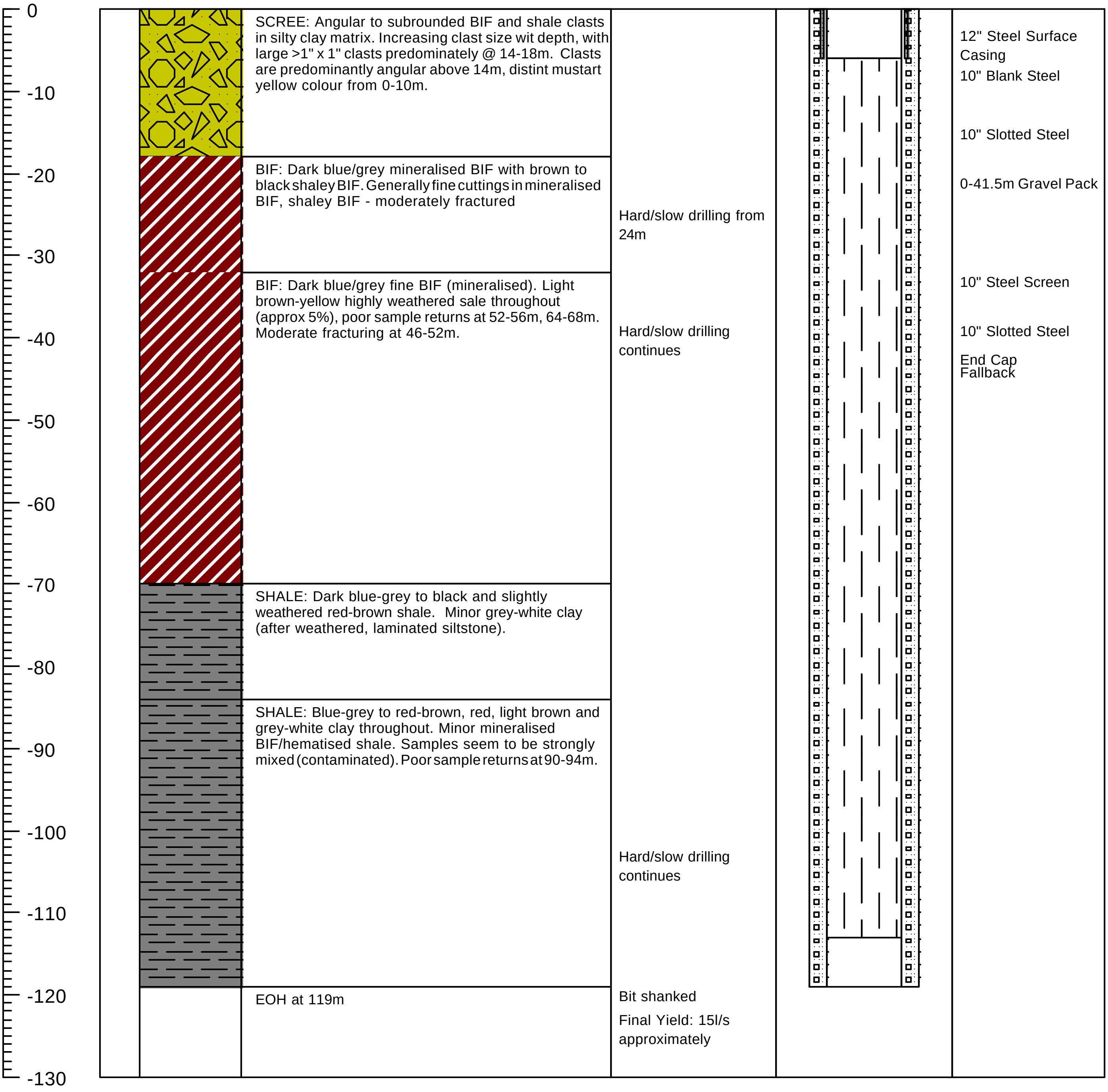
Well No: WB25-1

Client: BHPBIO
Project: OB25 Mining Below Water Table

Commenced: 1/04/04	**Method:** DTH - Roller Bit	**Area:** Pit 3 West
Completed: 7/04/04	**Fluid:** Mud	**East:** 298267.4
Drilled: Nudrill	**Bit Record:** 0-6 m: 17.5", 6-46 m: 14.75"	**North:** 331052.9
Logged By: SJW		**Elevation:** 523.777

Static Water Level: tba
Date: tba

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes



Lithological Description

SCREE: Angular to subrounded BIF and shale clasts in silty clay matrix. Increasing clast size wit depth, with large >1" x 1" clasts predominately @ 14-18m. Clasts are predominantly angular above 14m, distint mustart yellow colour from 0-10m.

BIF: Dark blue/grey mineralised BIF with brown to black shaley BIF. Generally fine cuttings in mineralised BIF, shaley BIF - moderately fractured

BIF: Dark blue/grey fine BIF (mineralised). Light brown-yellow highly weathered sale throughout (approx 5%), poor sample returns at 52-56m, 64-68m. Moderate fracturing at 46-52m.

SHALE: Dark blue-grey to black and slightly weathered red-brown shale. Minor grey-white clay (after weathered, laminated siltstone).

SHALE: Blue-grey to red-brown, red, light brown and grey-white clay throughout. Minor mineralised BIF/hematised shale. Samples seem to be strongly mixed (contaminated). Poor sample returns at 90-94m.

EOH at 119m

Field Notes

Hard/slow drilling from 24m

Hard/slow drilling continues

Hard/slow drilling continues

Bit shanked

Final Yield: 15l/s approximately

Well Completion Notes

12" Steel Surface Casing

10" Blank Steel

10" Slotted Steel

0-41.5m Gravel Pack

10" Steel Screen

10" Slotted Steel

End Cap

Fallback

File Ref: F:\jobs\320\OB23_25\Task E\Fieldwork\WB25-1 Well No: WB25-1 Sheet 1 of 1

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COMPOSITE WELL LOG

Well No: WB25-2

Client: BHPBIO
Project: OB25 Mining Below Water Table

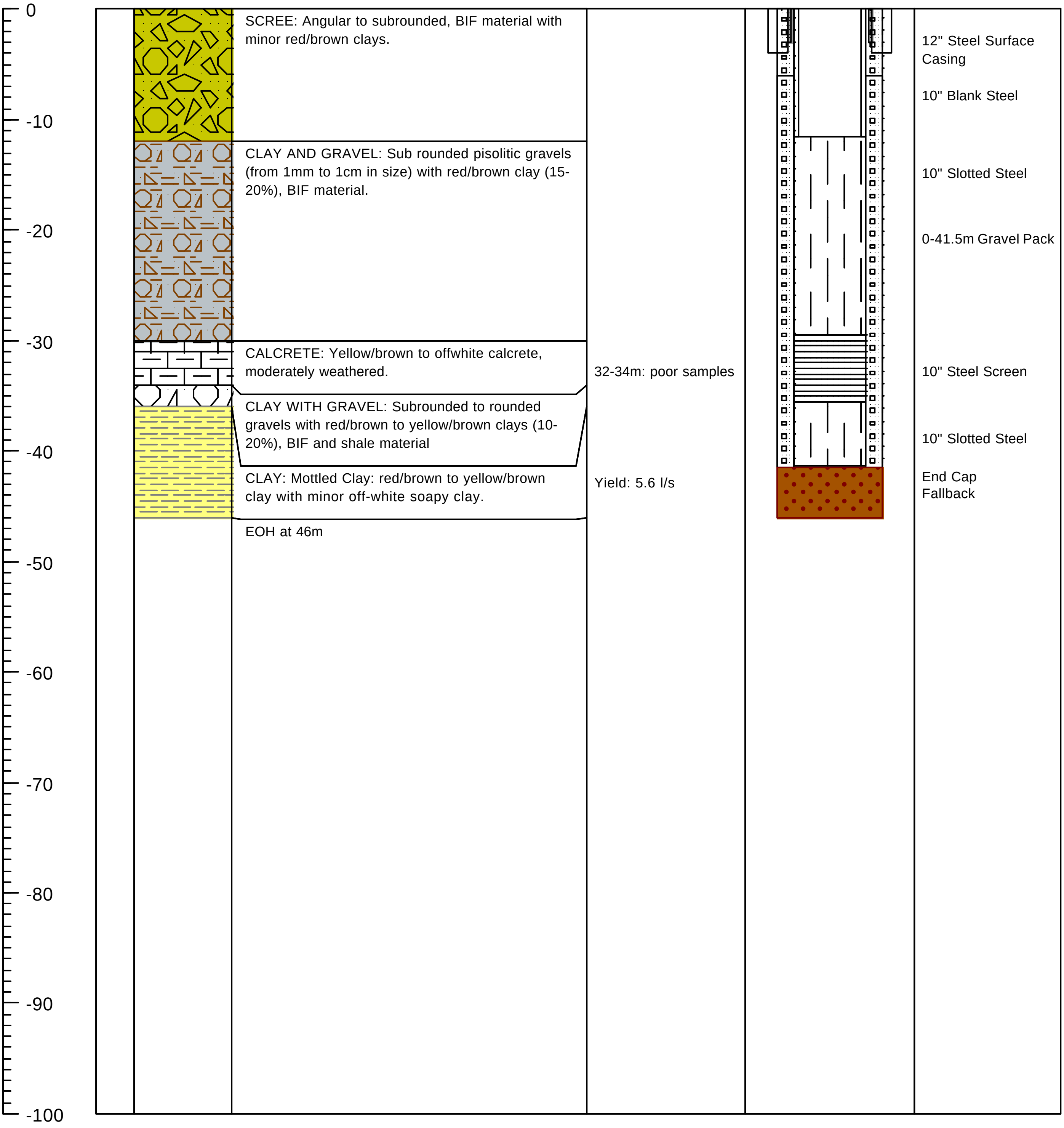
Commenced: 12/04/04
Completed: 16/04/04
Drilled: Nudrill
Logged By: JRG

Method: DTH
Fluid: Mud
Bit Record: 0-6 m: 17.5", 6-46 m: 14.75"

Area: Pit 3 West
East: 298267.4
North: 331052.9
Elevation: 523.777

Static Water Level: tba
Date: tba

Depth (mbgl) | **Geology** | **Graphic Log** | **Lithological Description** | **Field Notes** | **Well Completion** — **Diagram** | **Notes**



SCREE: Angular to subrounded, BIF material with minor red/brown clays.

CLAY AND GRAVEL: Sub rounded pisolitic gravels (from 1mm to 1cm in size) with red/brown clay (15-20%), BIF material.

CALCRETE: Yellow/brown to offwhite calcrete, moderately weathered.

CLAY WITH GRAVEL: Subrounded to rounded gravels with red/brown to yellow/brown clays (10-20%), BIF and shale material

CLAY: Mottled Clay: red/brown to yellow/brown clay with minor off-white soapy clay.

EOH at 46m

32-34m: poor samples

Yield: 5.6 l/s

12" Steel Surface Casing

10" Blank Steel

10" Slotted Steel

0-41.5m Gravel Pack

10" Steel Screen

10" Slotted Steel

End Cap

Fallback

File Ref: F:\jobs\320\OB23_25\Task E\Fieldwork\WP25-2 Well No: WB25-2 Sheet 1 of 1

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COMPOSITE WELL LOG

Well No: WP25-1

Client: BHPBIO
Project: OB25 Pit 3 Dewatering Investigations

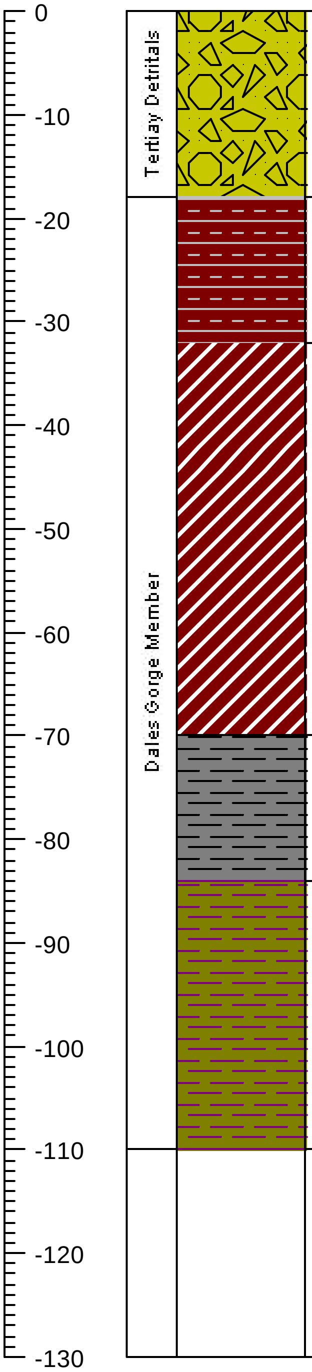
Commenced: 5/3/04
Completed: 6/3/04
Drilled: Nudrill
Logged By: SJW

Method: DTH
Fluid: Air / Foam
Bit Record: 0-6: 12.5"; 6-110: 6";

Area: Pit 3
East: 298481.5
North: 331142.6
Elevation: 514.715

Static Water Level: 5.46
Date: 6/03/04

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion: Diagram	Well Completion: Notes



SCREE: mustard-yellow (limonitic) to red-brown clayey, unconsolidated, angular to subrounded, poorly sorted BIF and shale gravel.

BIF AND SHALE: dark blue-grey, sandy mineralised BIF with brown to black shaley, moderately fractured BIF.

BIF: Dark blue-grey, sandy mineralised BIF with ubiquitous yellow-brown well weathered shale (5%).

SHALE: blue-grey to black and red-brown shale with grey-white and light brown clay.

SHALE AND IRON FORMATION: blue-grey to red-brown, red and light brown shale with grey-white clay throughout and minor BIF/hematised shale.

EOH at 110 m.

46-52 m: moderate fracturing.

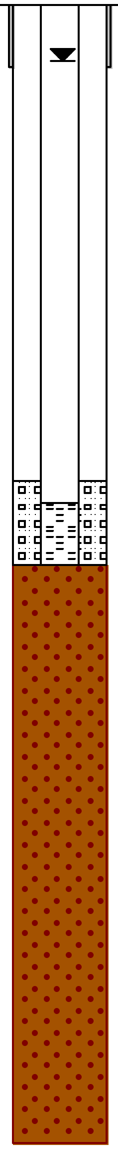
55 m: airlift yield = 10 L/sec.

52-56 m: poor sample recovery - lost circulation.

64-68 m: poor sample recovery - lost circulation.

83-110 m: poor definition/contamination in drill cutting samples due to hole wash-out.

Final airlift yield = 15-20 L/sec.



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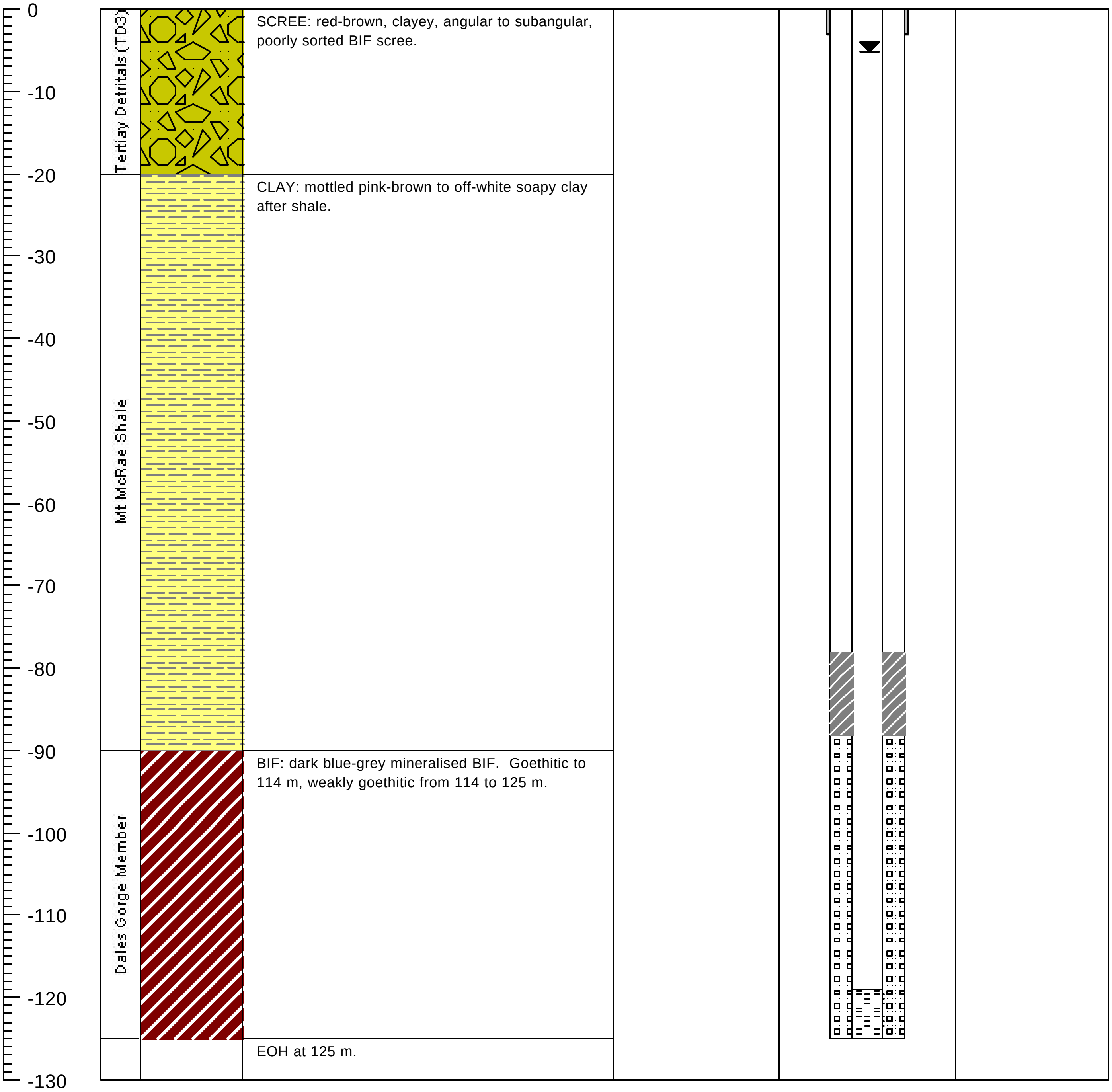
COMPOSITE WELL LOG

Well No: WP25-2d

Client: BHPBIO **Project:** OB25 Pit 3 Dewatering Investigations

Commenced: 9/3/04	**Method:** DTH	**Area:** Pit 3
Completed: 10/3/04	**Fluid:** Mud Rotary	**East:** 298432.3
Drilled: Nudrill	**Bit Record:** 0-3: 8"; 6-110: 6";	**North:** 331145.9
Logged By: SJW		**Elevation:** 514.667

Static Water Level: 5.27 mbtoc **Date:** 15/03/04



Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes
0 to -20	Tertiay Detritals (TD3)		SCREE: red-brown, clayey, angular to subangular, poorly sorted BIF scree.			
-20 to -90	Mt McRae Shale		CLAY: mottled pink-brown to off-white soapy clay after shale.			
-90 to -125	Dales Gorge Member		BIF: dark blue-grey mineralised BIF. Goethitic to 114 m, weakly goethitic from 114 to 125 m.			
-125			EOH at 125 m.			

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COMPOSITE WELL LOG

Well No: WP25-2d

Client: BHPBIO

Project: OB25 Pit 3 Dewatering Investigations

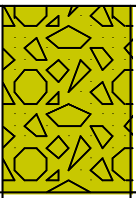
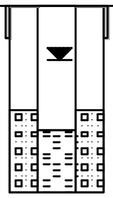
Commenced: 9/3/04
Completed: 10/3/04
Drilled: Nudrill
Logged By: SJW

Method: DTH
Fluid: Mud Rotary
Bit Record: 0-3: 8"; 6-110: 6";

Area: Pit 3
East: 298434.9
North: 331146
Elevation: 514.736

Static Water Level: 5.13 mbtoc

Date: 15/03/04

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes
0 -10	ertiay Detritals (TD3		SCREE: red-brown, clayey, angular to subangular, poorly sorted BIF scree.			
-20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130			EOH at 18 m.			

File Ref: F:\jobs\320\OB23_25\Task E\Fieldwork\WP25-2s

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COMPOSITE WELL LOG

Well No: WP25-3d

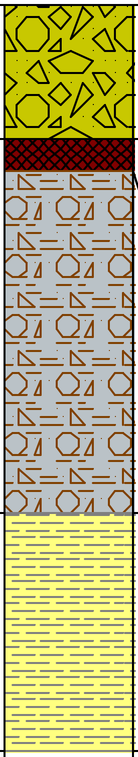
Client: BHPBIO
Project: OB25 Pit 3 Dewatering Investigations

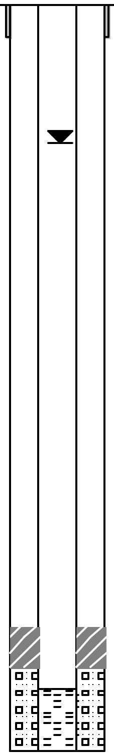
Commenced:	12/3/04	**Method:**	DTH	**Area:**	Pit 3
Completed:	13/3/04	**Fluid:**	Mud Rotary	**East:**	298271.4
Drilled:	Nudrill	**Bit Record:**	0-3: 8"; 6-72: 6";	**North:**	331144.5
Logged By:	SJW			**Elevation:**	523.065

Static Water Level: 13.32 mbtoc
Date: 15/03/04

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes
	TD3		SCREE: red-brown, clayey (10%), angular to subangular, poorly sorted BIF scree.			
			FERRICRETE: pale red-brown ferricrete with minor rounded gravel.			
	TD2		CLAY AND GRAVEL: clayey (>50%) rounded to subangular, poorly sorted gravel; 16-34 m: red-brown; 34-46 m: pale brown to yellow brown; 46-49 m: mauve. Minor weathered calcrete at 38-40 m.			
	Mt McRae Shale		CLAY: pale yellow-brown to off-white soapy clay with highly weathered shale.			
			EOH at 72 m.			

Depth (mbgl): 0, -10, -20, -30, -40, -50, -60, -70, -80, -90, -100, -110, -120, -130





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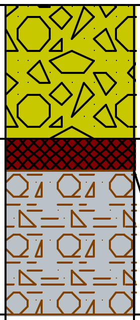
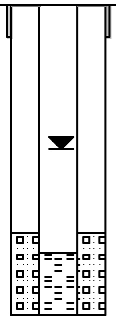
COMPOSITE WELL LOG

Well No: WP25-3s

Client: BHPBIO
Project: OB25 Pit 3 Dewatering Investigations

Commenced:	14/3/04	**Method:**	DTH	**Area:**	Pit 3
Completed:	14/3/04	**Fluid:**	Mud Rotary	**East:**	298272
Drilled:	Nudrill	**Bit Record:**	0-3: 8"; 6-30: 6";	**North:**	331143.1
Logged By:	SJW			**Elevation:**	523.156

Static Water Level: 13.90 mbtoc
Date: 15/03/04

Depth (mbgl)	**Geology**	**Graphic Log**	**Lithological Description**	**Field Notes**	**Well Completion** Diagram	**Well Completion** Notes
0	TD3		SCREE: red-brown, clayey (10%), angular to subangular, poorly sorted BIF scree.			
-10	TD2		FERRICRETE: pale red-brown ferricrete with minor rounded gravel.			
-20			CLAY AND GRAVEL: red-brown to yellow brown, clayey (>50%) rounded to subangular, poorly sorted gravel.			
-30			EOH at 30 m.			
-40						
-50						
-60						
-70						
-80						
-90						
-100						
-110						
-120						
-130						

aquaterra

125 Melville Parade
Como
WA 6152
Australia
Tel: (+61) (08) 9368 4044
Fax: (+61) (08) 9368 4055

COMPOSITE WELL LOG

Well No: WP25-4d

Client: BHPBIO
Project: OB25 Pit 3 Dewatering Investigations

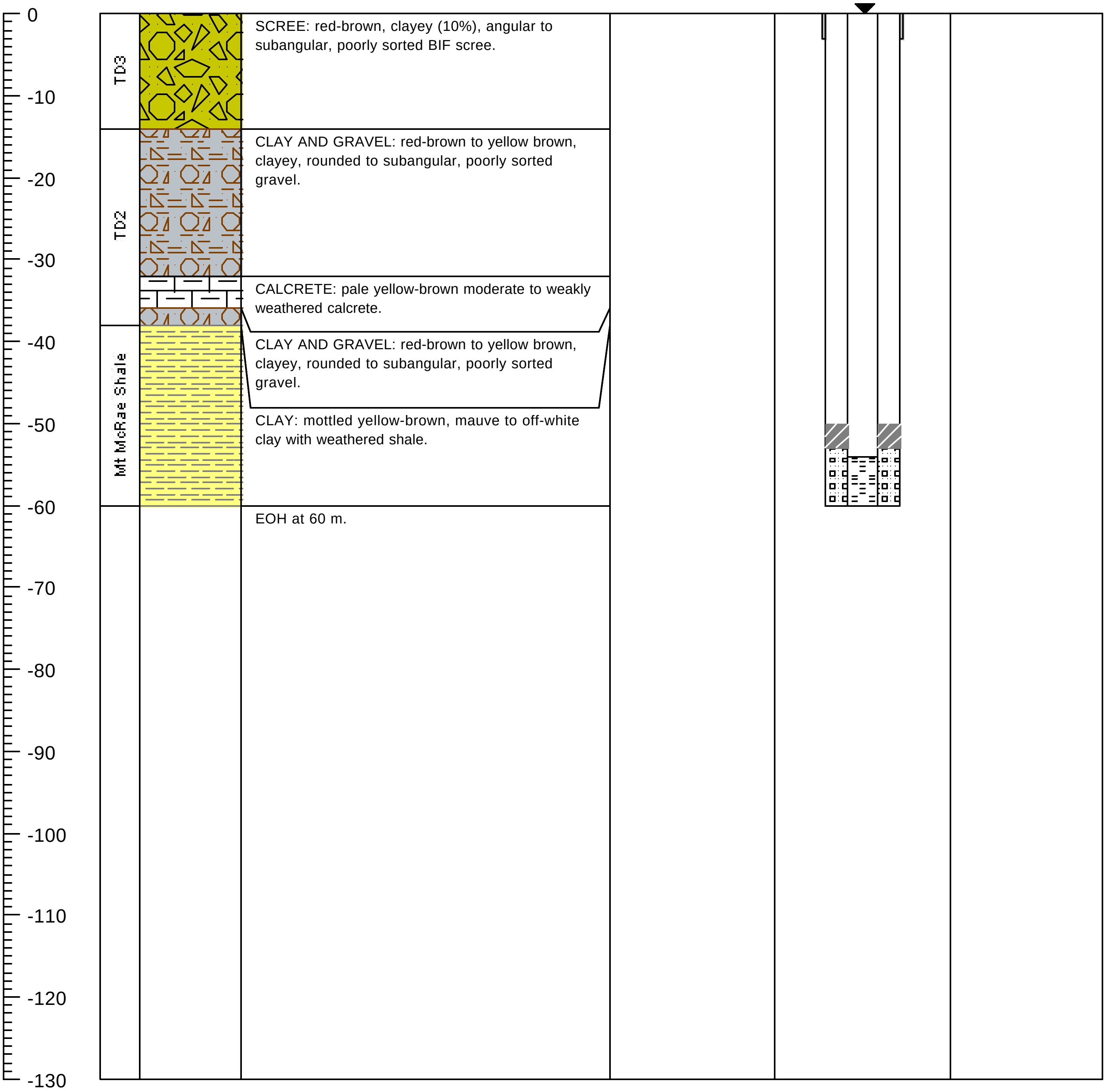
Commenced: 15/3/04
Completed: 16/3/04
Drilled: Nudrill
Logged By: SJW

Method: DTH
Fluid: Mud Rotary
Bit Record: 0-3: 8"; 3-60: 6";

Area: Pit 3
East: 298.276.3
North: 331038.5
Elevation: 524.348

Static Water Level: tba
Date: tba

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes



SCREE: red-brown, clayey (10%), angular to subangular, poorly sorted BIF scree.

CLAY AND GRAVEL: red-brown to yellow brown, clayey, rounded to subangular, poorly sorted gravel.

CALCRETE: pale yellow-brown moderate to weakly weathered calcrete.

CLAY AND GRAVEL: red-brown to yellow brown, clayey, rounded to subangular, poorly sorted gravel.

CLAY: mottled yellow-brown, mauve to off-white clay with weathered shale.

EOH at 60 m.

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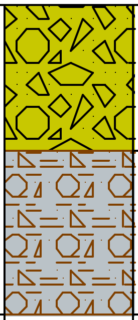
COMPOSITE WELL LOG

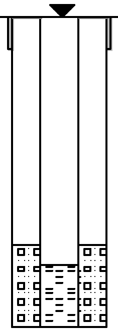
Well No: WP25-4s

Client: BHPBIO **Project:** OB25 Pit 3 Dewatering Investigations

Commenced: 30/3/04	**Method:** DTH	**Area:** Pit 3
Completed: 30/3/04	**Fluid:** Mud Rotary	**East:** 298279.1
Drilled: Nudrill	**Bit Record:** 0-3: 8"; 3-30: 6";	**North:** 331039.2
Logged By: SJW		**Elevation:** 524.164

Static Water Level: tba **Date:** tba

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes
0	Tertiay Detritals (TD3)		SCREE: red-brown, clayey (10%), angular to subangular, poorly sorted BIF scree.			
			CLAY AND GRAVEL: red-brown to yellow brown, clayey, rounded to subangular, poorly sorted gravel.			
-30			EOH at 30 m.			



0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130

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125 Melville Parade
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WA   6152
Australia
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Fax: (+61) (08) 9368 4055

COMPOSITE WELL LOG

Well No: WP25-5

Client: BHPBIO
Project: OB25 Pit 3 Dewatering Investigations

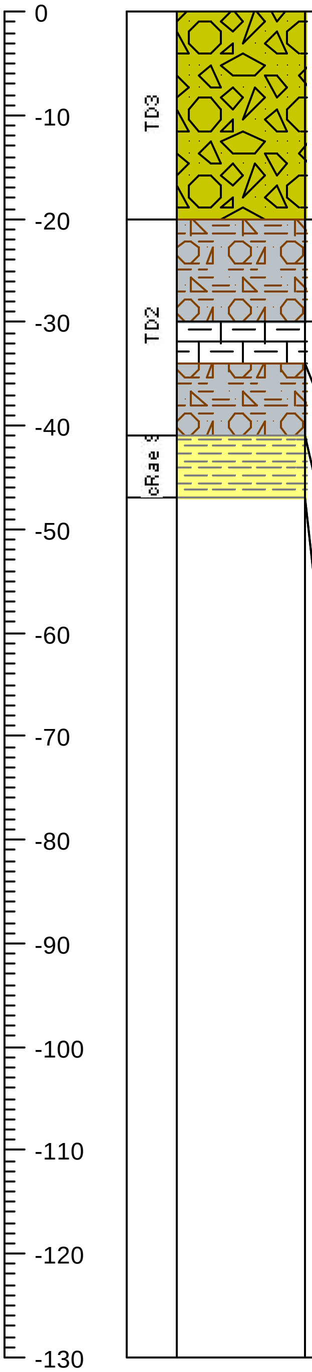
Commenced: 31/03/04
Completed: 31/03/04
Drilled: Nudrill
Logged By: SJW

Method: Mud Rotary
Fluid: Mud
Bit Record: 0-47: 6";

Area: Pit 3
East: 298279.5
North: 331294.2
Elevation: 519.628

Static Water Level: tba
Date: tba

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes



SCREE: red-brown, silty, angular to subangular, poorly sorted BIF and shale scree.

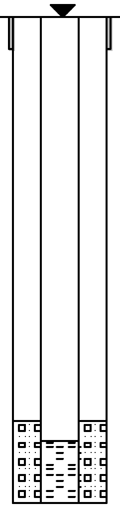
CLAY AND GRAVEL: red-brown, clayey (10-20%), subrounded to rounded pisolitic gravel (1mm to 10mm diam) and minor subangular BIF gravel.

CALCRETE: yellow-brown to off-white, moderately weathered calcrete.

CLAY AND GRAVEL: yellow-brown to red-brown, clayey (10-20%), subrounded to rounded BIF, shale and pisolitic gravel (1mm to 10mm diam).

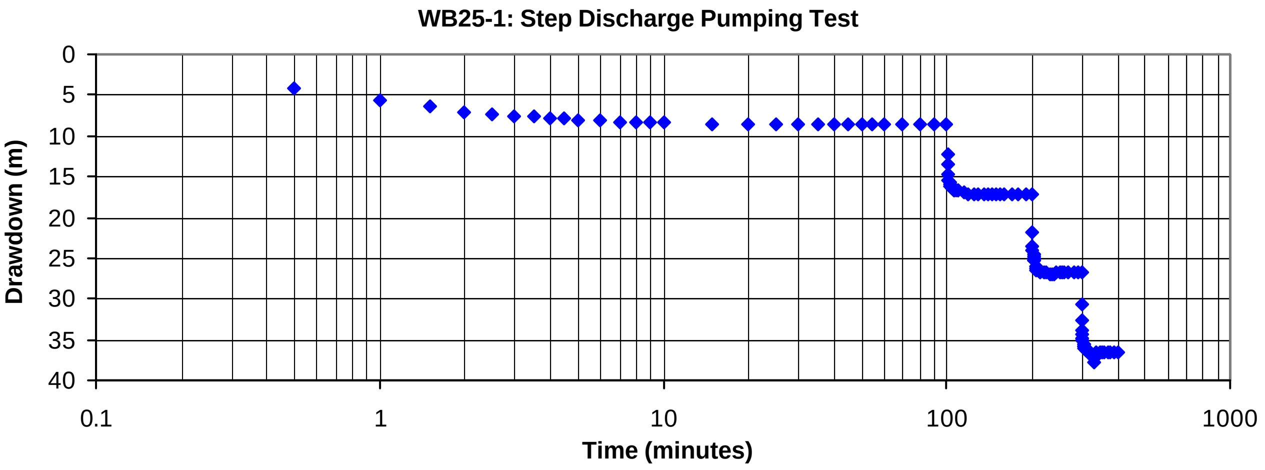
CLAY: mottled red-brown to yellow-brown and off-white soapy clay after shale. Note: 46-47 m - clay with mauve to grey-black moderately weathered shale fragments.

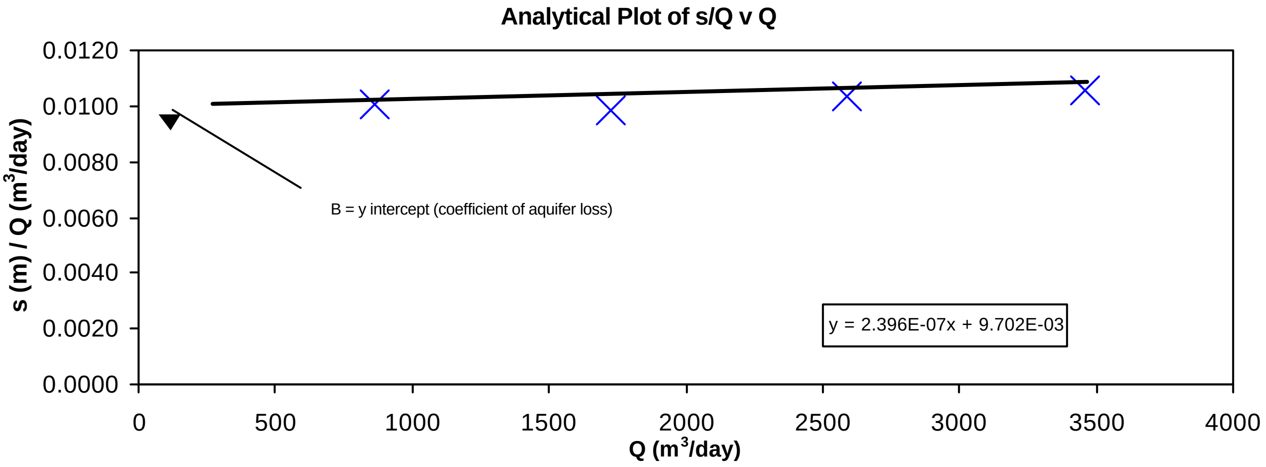
EOH at 47 m.



APPENDIX B

TEST PUMPING PLOTS





$s_{w(n)} = BQ_n + CQ_n^P$ (Rorabaugh's equation)

Where:
B = Intercept with y axis (coefficient of aquifer loss or laminar flow)
C = Gradient (coefficient of turbulent flow loss or apparent well loss)
s = Drawdown in the borehole
P = Value determined using Rorabaugh's method of superposition

Components of Jacob's (1947) equation BQ and CQ^2 are termed the aquifer loss and apparent well loss respectively. They give an indication of the proportion of total drawdown caused by laminar and turbulent flow.

Please note: 1. In thin or fissured aquifers large components of well loss are due to high flow velocities in the aquifer rather than inefficient bore design. Therefore, the term "apparent well loss" is better than well loss.
2. In aquifers where the flow horizons are vertically anisotropic, changes in bore performance often relate to changes in the rest water level with respect to the primary aquifer horizons.

$Ew = (BQ/(BQ + CQ^P) \times 100$

Ew or Well Efficiency represents the proportion of drawdown caused by laminar flow

From plot of s/Q v Q (trend line equation): **Intercept (B)** 9.702E-03
Gradient (C) 2.396E-07

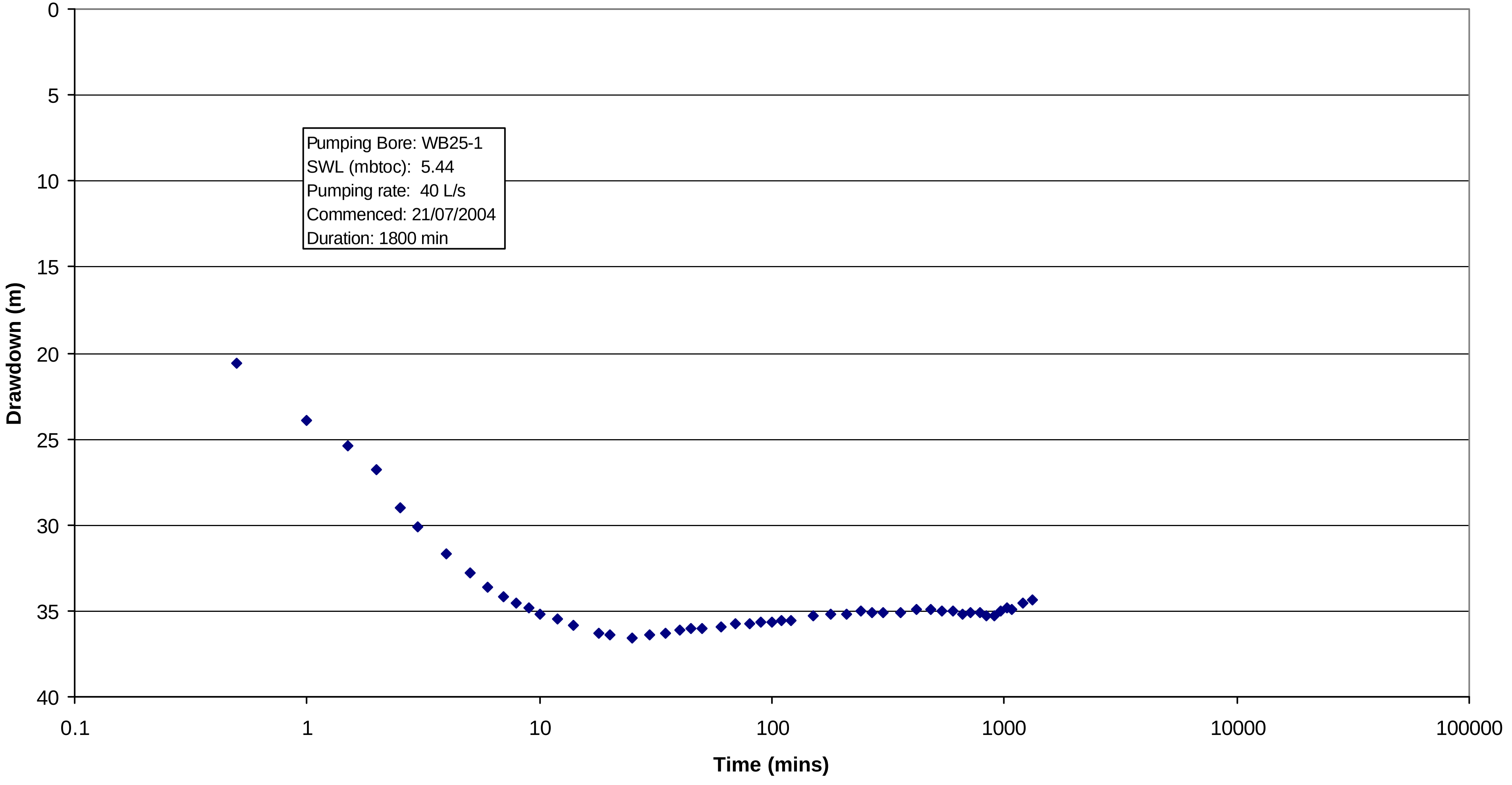
ANALYSIS TABLE

Calculation of well efficiency and comparison of observed and predicted drawdowns

Step (100 minute duration)	Discharge (l/s)	Discharge (Q) (m^3/d)	Measured Incremental Drawdown (metres)	Corrected Drawdown (metres)	Predicted Drawdown (metres)	s/Q	Apparent Efficiency (Ew) %
1	10.0	864	8.69	8.69	8.56	0.0101	97.9
2	20.0	1728	8.36	17.05	17.48	0.0099	95.9
3	30.0	2592	9.84	26.89	26.76	0.0104	94.0
4	40.0	3456	9.67	36.56	36.39	0.0106	92.1

Step Discharge Test - WB25-1
Figure B1

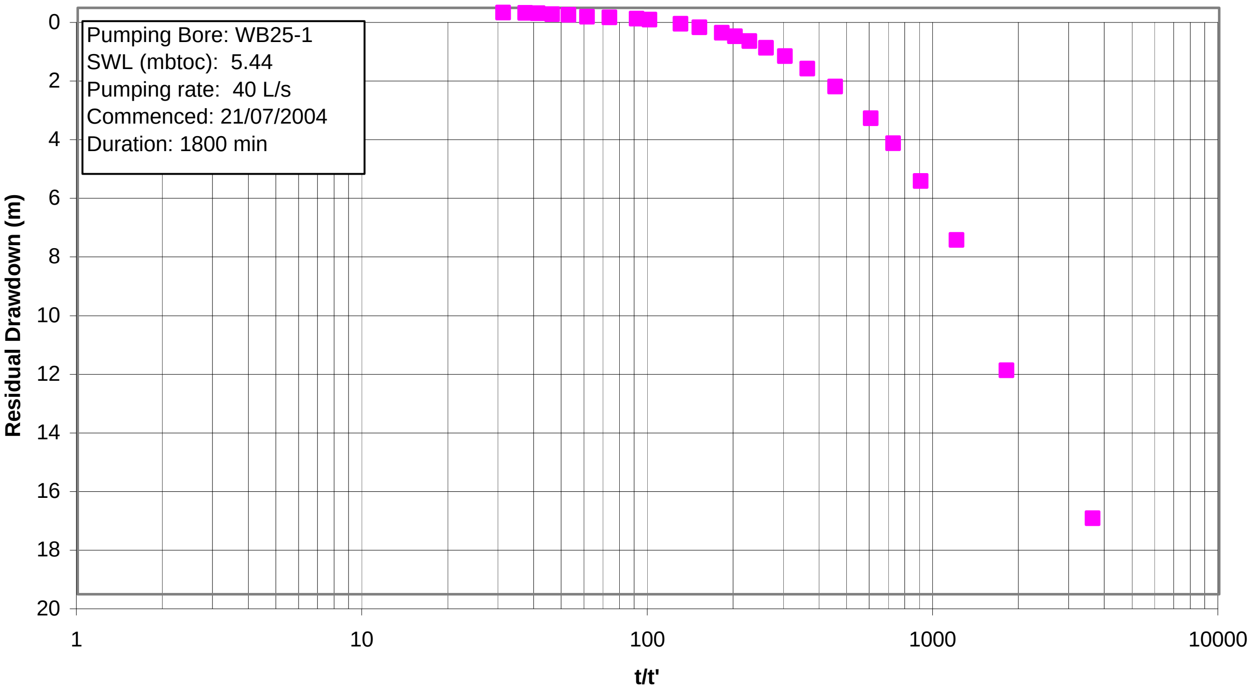
WB25-1 Constant Rate Test



Constant Rate Test - WB25-1
Figure B2

No Step Recovery Test Available for WB25-1

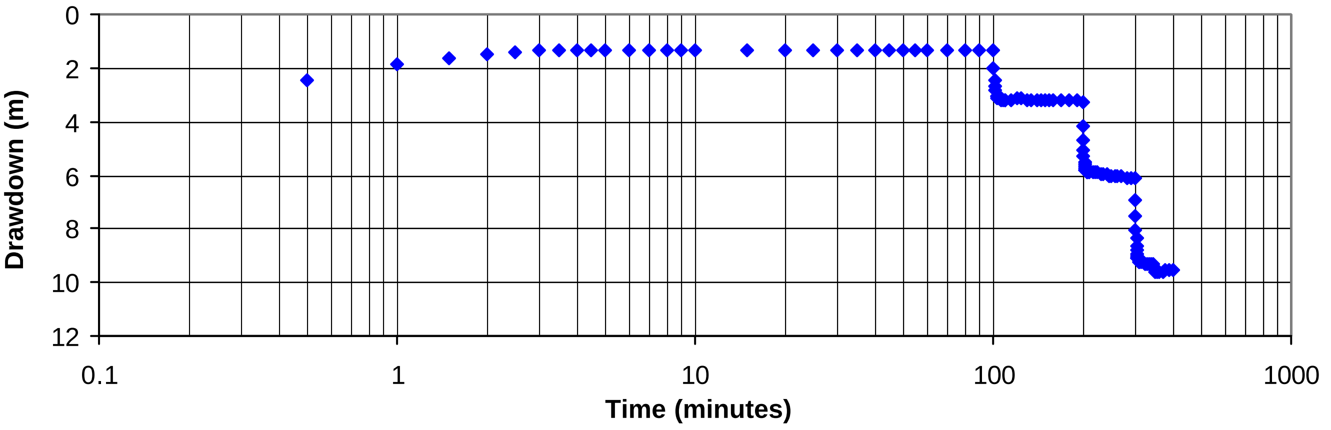
WB25-1 Constant Rate Recovery Test



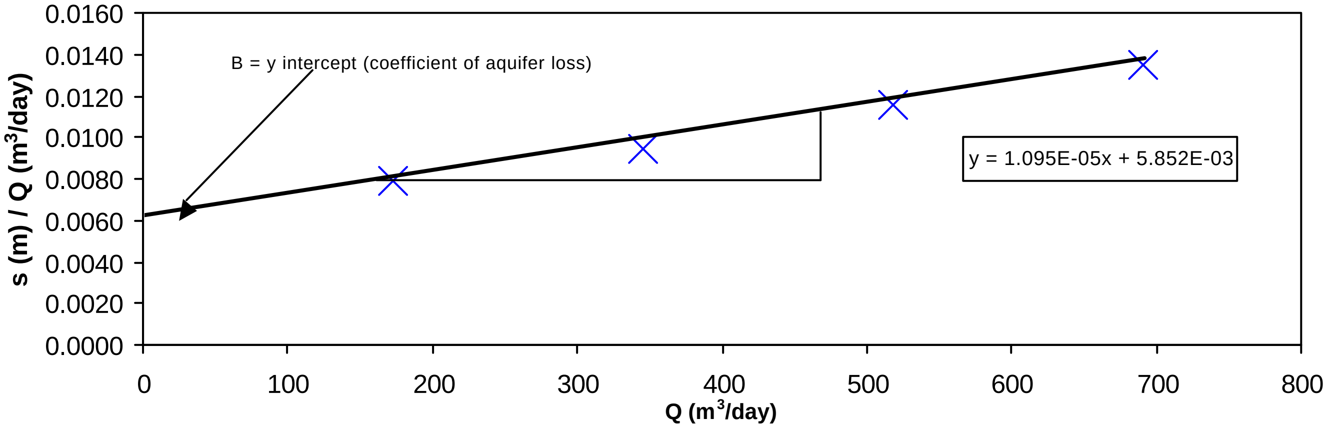
Constant Rate Recovery Test - WB25-2
Figure B3

F:\jobs\320\OB23_25\Task E\E5\final report\AppB\[4056 App B.xls]WB25-1 Recoveries

WB25-2: Step Discharge Pumping Test



Analytical Plot of s/Q v Q



$s_{w(m)} = BQ_n + CQ_n^P$ (Rorabaugh's equation)

Where:
B = Intercept with y axis (coefficient of aquifer loss or laminar flow)
C = Gradient (coefficient of turbulent flow loss or apparent well loss)
s = Drawdown in the borehole
P = Value determined using Rorabaugh's method of superposition

Components of Jacob's (1947) equation BQ and CQ^2 are termed the aquifer loss and apparent well loss respectively. They give an indication of the proportion of total drawdown caused by laminar and turbulent flow.

Please note:
1. In thin or fissured aquifers large components of well loss are due to high flow velocities in the aquifer rather than inefficient bore design. Therefore, the term "apparent well loss" is better than well loss.
2. In aquifers where the flow horizons are vertically anisotropic, changes in bore performance often relate to changes in the rest water level with respect to the primary aquifer horizons.

$Ew = (BQ/(BQ + CQ^P)) \times 100$

Ew or Well Efficiency represents the proportion of drawdown caused by laminar flow

From plot of s/Q v Q (trend line equation): **Intercept (B)** 5.852E-03

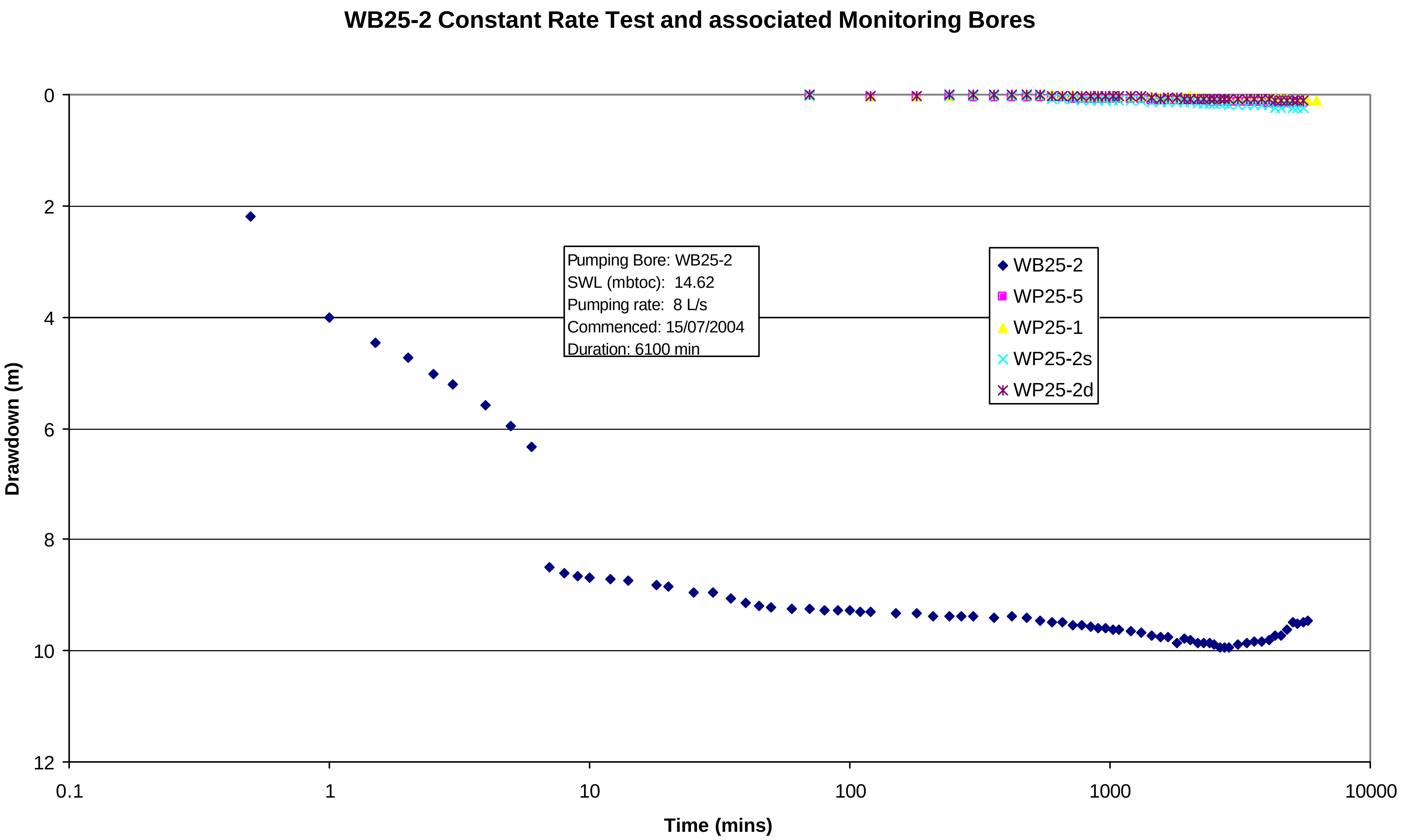
Gradient (C) 1.095E-05

ANALYSIS TABLE

Calculation of well efficiency and comparison of observed and predicted drawdowns

Step (100 minute duration)	Discharge (l/s)	Discharge (Q) (m^3/d)	Measured Incremental Drawdown (metres)	Corrected Drawdown (metres)	Predicted Drawdown (metres)	s/Q	Apparent Efficiency (Ew) %
1	2.0	173	1.36	1.36	1.34	0.0079	75.6
2	4.0	346	1.90	3.26	3.33	0.0094	60.7
3	6.0	518	2.73	5.99	5.98	0.0116	50.8
4	8.0	691	3.32	9.31	9.28	0.0135	43.6

Step Discharge Test - WB25-2
Figure B4



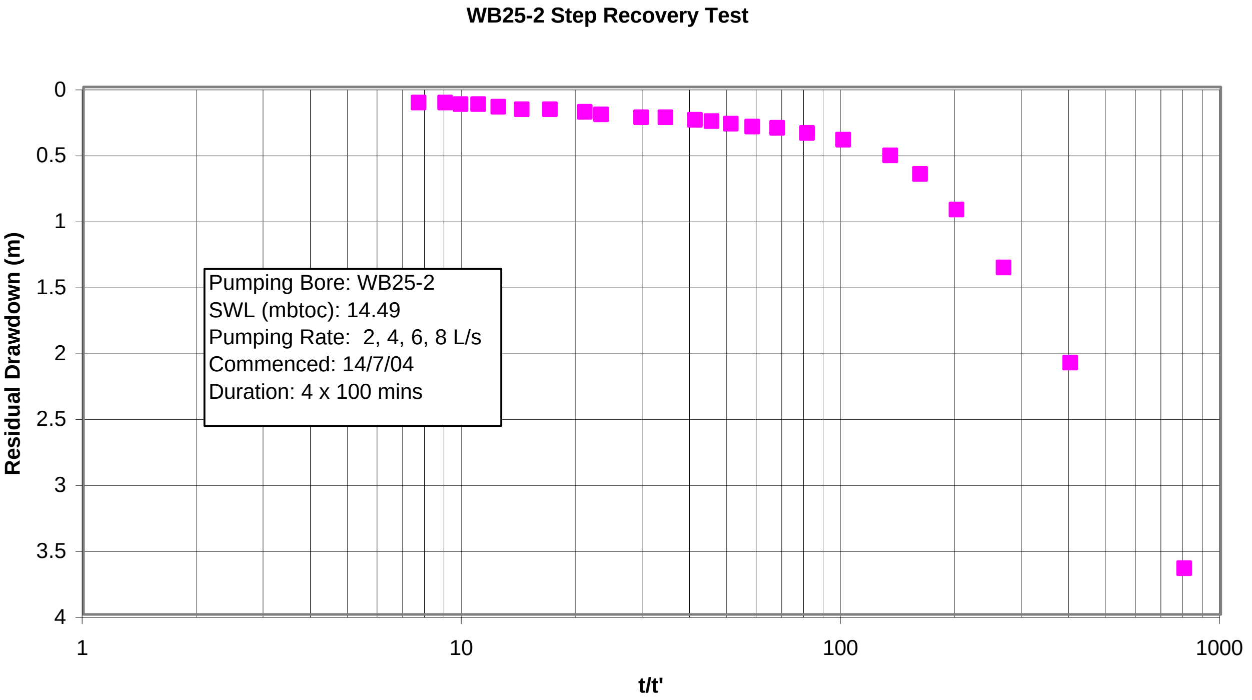
WB25-2 Constant Rate Test and associated Monitoring Bores

Pumping Bore: WB25-2
SWL (mbtoc): 14.62
Pumping rate: 8 L/s
Commenced: 15/07/2004
Duration: 6100 min

Constant Rate Test - WB25-2
Figure B5

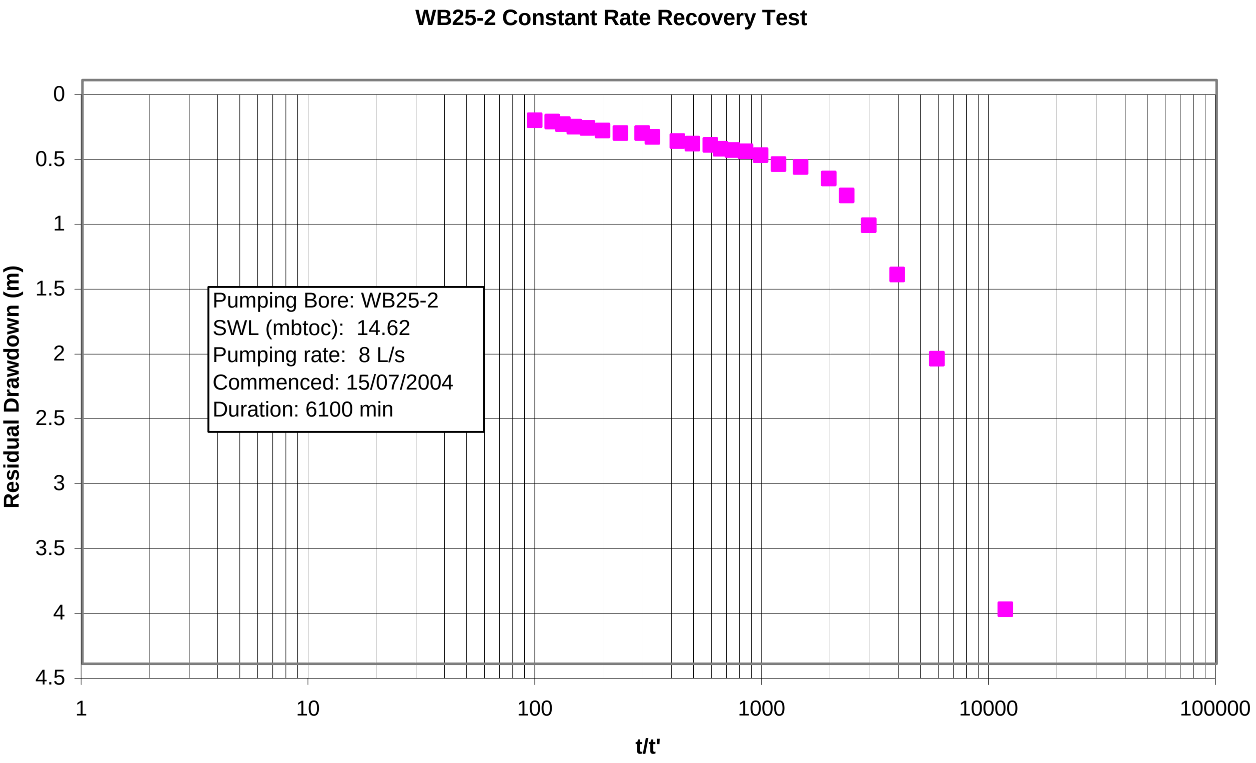
F:\jobs\320\OB23_25\Task E\E5\final report\AppB\[4056 App B.xls]WB25-2 CRT

aquaterra



Pumping Bore: WB25-2
SWL (mbtoc): 14.49
Pumping Rate: 2, 4, 6, 8 L/s
Commenced: 14/7/04
Duration: 4 x 100 mins

Step Recovery Test - WB25-2
Figure B6



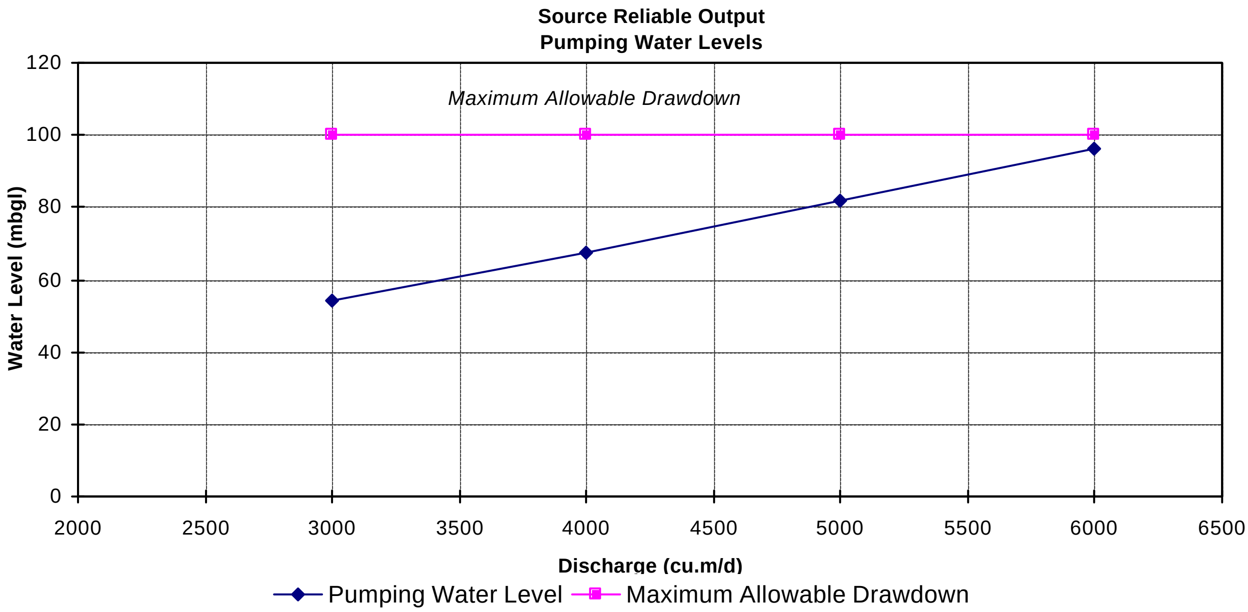
Pumping Bore: WB25-2
SWL (mbtoc): 14.62
Pumping rate: 8 L/s
Commenced: 15/07/2004
Duration: 6100 min

Constant Rate Recovery Test - WB25-2
Figure B7

APPENDIX C

SOURCE RELIABLE OUTPUTS

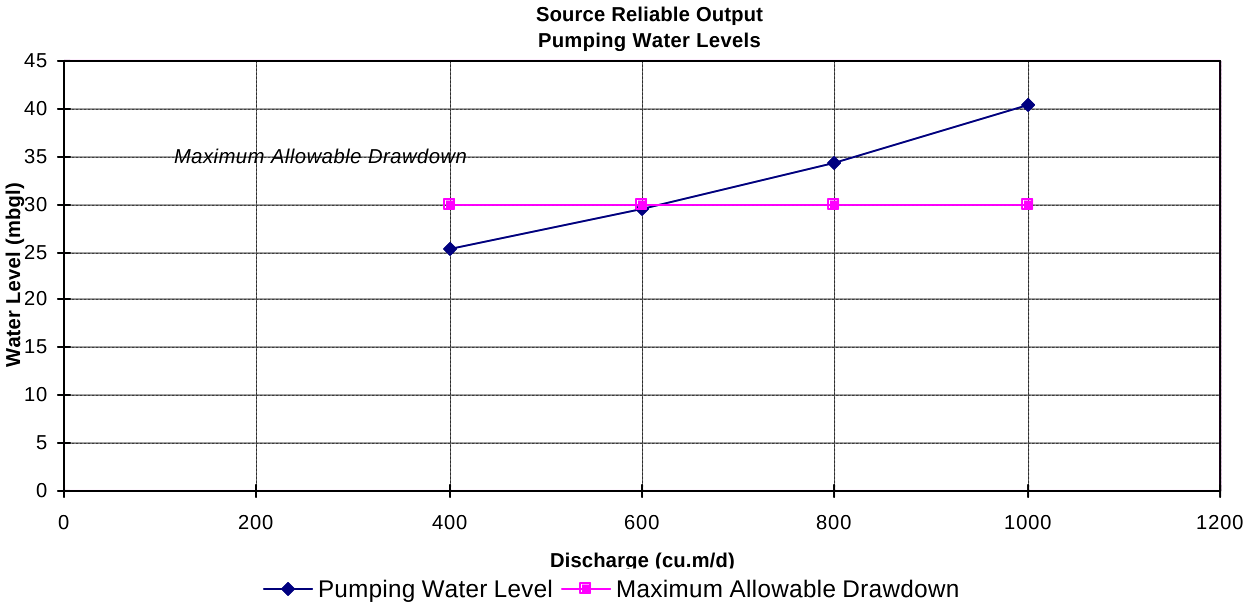
Discharge	Short Term Drawdown	Long Term Drawdown	Interference Effects	Total Drawdown	Pumping Water Level
3000	31.26	6.81	10.95	49.03	54.03
4000	42.64	9.08	10.95	62.68	67.68
5000	54.50	11.35	10.95	76.80	81.80
6000	66.84	13.62	10.95	91.41	96.41



Source Reliable Output - WB25-1

Figure C1

Discharge	Short Term Drawdown	Long Term Drawdown	Interference Effects	Total Drawdown	Pumping Water Level
400	4.09	1.51	5.21	10.81	25.31
600	7.45	2.27	5.21	14.93	29.43
800	11.69	3.03	5.21	19.92	34.42
1000	16.80	3.78	5.21	25.79	40.29



Source Reliable Output - WB25-2

Figure C2

APPENDIX D

WATER QUALITY DATA

SGS

LABORATORY REPORT COVERSHEET

18/8/04

DATE:	13 August 2004
TO:	Ecowise Data Services Pty Ltd PO Box 312 NEWMAN WA 6753
ATTENTION:	Mr Steve Orr
YOUR REFERENCE:	Newman Run 24 Aquaterra Drilling
OUR REFERENCE:	82855
SAMPLES RECEIVED:	4/08/2004
SAMPLES/QUANTITY:	2 Waters

The above samples were received intact and analysed according to your written instructions. Unless otherwise stated, solid samples are reported on a dry weight basis and liquid samples as received.
ANZECC and NHMRC guidelines are attached. Analytical data exceeding these guidelines are highlighted.

JANICE VENNING
Manager, Perth

LIEN TANG
Manager Reporting Systems

This report supersedes preliminary results that were reported by E-Mail.
This report must not be reproduced except in full.

CLIENT: Ecowise Data Services Pty Ltd
PROJECT: Newman Run 24 Aquaterra Drilling

OUR REFERENCE: 82855

LABORATORY REPORT

Your Reference Our Reference Date Sampled Type of Sample	Units	Packsaddle Bore 1 82855-1 27/07/2004 Water	WBP 3-1 (WB25-1) 82855-2 22/07/2004 Water
pH	pH Units	7.5	7.3
Electrical Conductivity @ 25 oC	µS/cm	840	1,400
Total Dissolved Solids (calc as NaCl)	mg/L	540	880
Total Suspended Solids @ 103°C	mg/L	<5	<5
Total Alkalinity as $CaCO_3$	mg/L	270	370
Hardness (equivalent $CaCO_3$)	mg/L	340	560
Bicarbonate, HCO_3	mg/L	330	460
Nitrate, NO_3	mg/L	20	5.8
Carbonate, CO_3	mg/L	<1	<1
Chloride, Cl	mg/L	82	180
Sulphate, SO_4	mg/L	77	100
Sodium, Na	mg/L	52	95
Potassium, K	mg/L	8.3	7.6
Calcium, Ca	mg/L	60	83
Magnesium, Mg	mg/L	46	86
Aluminium, Al	mg/L	<0.1	<0.1
Iron, Fe (soluble)	mg/L	<0.1	<0.1
Manganese, Mn	mg/L	<0.01	0.01
Zinc, Zn	mg/L	0.05	0.08
Copper, Cu	mg/L	0.01	<0.01
Cadmium, Cd	mg/L	<0.001	<0.001
Lead, Pb	mg/L	<0.005	<0.005
Arsenic, As	mg/L	<0.001	<0.001
Mercury, Hg	mg/L	<0.0005	<0.0005
Chromium, Cr	mg/L	<0.01	<0.01
Nickel, Ni	mg/L	<0.01	<0.01

SGS

CLIENT: Ecowise Data Services Pty Ltd **OUR REFERENCE:** 82855
PROJECT: Newman Run 24 Aquaterra Drilling

LABORATORY REPORT

TEST PARAMETERS	UNITS	LOR	METHOD
Standard			
pH	pH Units	0.1	PEI-001
Electrical Conductivity @ 25°C	µS/cm	1	PEI-032
Total Dissolved Solids (calc as NaCl)	mg/L	5	PEI-032
Total Suspended Solids @ 103°C	mg/L	5	PEI-003
Total Alkalinity as $CaCO_3$	mg/L	5	PEI-006
Hardness (equivalent $CaCO_3$)	mg/L	5	PEI-043
Bicarbonate, HCO_3	mg/L	5	PEI-006
Nitrate, NO_3	mg/L	0.2	PEI-020
Carbonate, CO_3	mg/L	1	PEI-006
Chloride, Cl	mg/L	1	PEI-020
Sulphate, SO_4	mg/L	1	PEI-020
Sodium, Na	mg/L	0.5	PEM-001
Potassium, K	mg/L	0.5	PEM-001
Calcium, Ca	mg/L	0.5	PEM-002
Magnesium, Mg	mg/L	0.5	PEM-002
Aluminium, Al	mg/L	0.1	PEM-002
Iron, Fe (soluble)	mg/L	0.1	PEM-001
Manganese, Mn	mg/L	0.01	PEM-001
Zinc, Zn	mg/L	0.01	PEM-001
Copper, Cu	mg/L	0.01	PEM-001
Cadmium, Cd	mg/L	0.001	PEM-003
Lead, Pb	mg/L	0.005	PEM-003
Arsenic, As	mg/L	0.001	PEM-004
Mercury, Hg	mg/L	0.0005	PEM-005
Chromium, Cr	mg/L	0.01	PEM-003
Nickel, Ni	mg/L	0.01	PEM-002

SGS

CLIENT: Ecowise Data Services Pty Ltd **OUR REFERENCE:** 82855
PROJECT: Newman Run 24 Aquaterra Drilling

LABORATORY REPORT

NOTES:
LOR - Limit of Reporting.
For soluble metals analysis, samples received as raw water (not acidified) are filtered to pass a 0.45æm membrane filter and acidified with nitric acid prior to analysis unless otherwise specified. Samples received in acidified containers, are filtered only prior to analysis.

LABORATORY REPORT COVERSHEET

DATE: 3 August 2004

TO: Ecowise Data Services Pty Ltd
PO Box 312
NEWMAN WA 6753

ATTENTION: Mr Steve Orr

YOUR REFERENCE: Newman Run 24 Aquaterra Drilling

OUR REFERENCE: 82528

SAMPLES RECEIVED: 21/07/2004

SAMPLES/QUANTITY: 1 Water

The above samples were received intact and analysed according to your written instructions. Unless otherwise stated, solid samples are reported on a dry weight basis and liquid samples as received.

JANICE VENNING
Manager, Perth

LIEN TANG
Manager Reporting Systems

This report supersedes our preliminary results that were reported by facsimile.
This report must not be reproduced except in full.

CLIENT: Ecowise Data Services Pty Ltd

PROJECT: Newman Run 24 Aquaterra Drilling

OUR REFERENCE: 82528

LABORATORY REPORT

(WB25-2)

Your Reference Our Reference Date Sampled Type of Sample	Units	WBP3-2 82528-1 19/07/2004 Water
pH	pH Units	7.6
Electrical Conductivity @ 25 oC	µS/cm	1,700
Total Dissolved Solids (calc as NaCl)	mg/L	1,100
Total Suspended Solids @ 103°C	mg/L	<5
Total Alkalinity as $CaCO_3$	mg/L	330
Hardness (equivalent $CaCO_3$)	mg/L	700
Bicarbonate, HCO_3	mg/L	400
Nitrate, NO_3	mg/L	96
Carbonate, CO_3	mg/L	<1
Chloride, Cl	mg/L	300
Sulphate, SO_4	mg/L	160
Sodium, Na	mg/L	110
Potassium, K	mg/L	7.5
Calcium, Ca	mg/L	100
Magnesium, Mg	mg/L	110
Aluminium, Al	mg/L	<0.1
Iron, Fe (soluble)	mg/L	<0.1
Manganese, Mn	mg/L	<0.01
Zinc, Zn	mg/L	0.16
Copper, Cu	mg/L	<0.01
Cadmium, Cd	mg/L	<0.001
Lead, Pb	mg/L	<0.005
Arsenic, As	mg/L	0.001
Mercury, Hg	mg/L	<0.0005
Chromium, Cr	mg/L	<0.01
Nickel, Ni	mg/L	<0.01

SGS

CLIENT: Ecowise Data Services Pty Ltd **OUR REFERENCE:** 82528
PROJECT: Newman Run 24 Aquaterra Drilling

LABORATORY REPORT

TEST PARAMETERS	UNITS	LOR	METHOD
Standard			
pH	pH Units	0.1	PEI-001
Electrical Conductivity @ 25°C	µS/cm	1	PEI-032
Total Dissolved Solids (calc as NaCl)	mg/L	5	PEI-032
Total Suspended Solids @ 103°C	mg/L	5	PEI-003
Total Alkalinity as $CaCO_3$	mg/L	5	PEI-006
Hardness (equivalent $CaCO_3$)	mg/L	5	PEI-043
Bicarbonate, HCO_3	mg/L	5	PEI-006
Nitrate, NO_3	mg/L	0.2	PEI-061
Carbonate, CO_3	mg/L	1	PEI-006
Chloride, Cl	mg/L	5	PEI-008
Sulphate, SO_4	mg/L	10	PEI-034
Sodium, Na	mg/L	0.5	PEM-001
Potassium, K	mg/L	0.5	PEM-001
Calcium, Ca	mg/L	0.5	PEM-002
Magnesium, Mg	mg/L	0.5	PEM-002
Aluminium, Al	mg/L	0.1	PEM-002
Iron, Fe (soluble)	mg/L	0.1	PEM-001
Manganese, Mn	mg/L	0.01	PEM-001
Zinc, Zn	mg/L	0.01	PEM-001
Copper, Cu	mg/L	0.01	PEM-001
Cadmium, Cd	mg/L	0.001	PEM-003
Lead, Pb	mg/L	0.005	PEM-003
Arsenic, As	mg/L	0.001	PEM-004
Mercury, Hg	mg/L	0.0005	PEM-005
Chromium, Cr	mg/L	0.01	PEM-003
Nickel, Ni	mg/L	0.01	PEM-002

CLIENT: Ecowise Data Services Pty Ltd
PROJECT: Newman Run 24 Aquaterra Drilling

OUR REFERENCE: 82528

LABORATORY REPORT

NOTES:
LOR - Limit of Reporting.

APPENDIX E

MODEL FEATURES AND CALIBRATION PLOTS

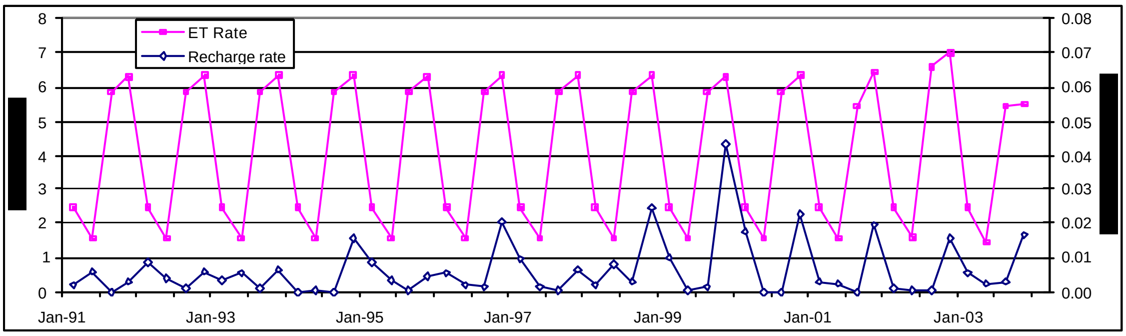
MODEL FEATURES

Evapotranspiration

Water use by phreatophytic vegetation in the creek drainage lines and to the south of Ophthalmia Dam is represented in the model using the Evapotranspiration (ET) Package. The package requires the specification of an ET surface, an extinction depth and maximum ET rate, such that if the aquifer water level rises to the ET surface, ET occurs at the maximum rate. The ET surface was set consistent with ground levels (obtained from various ground surveys conducted in the area). The extinction depth was set at a constant depth of 2m below the ET surface, such that if water levels fall below the ET surface, ET decreases linearly from the maximum ET rate to zero as the water level reaches the extinction depth. The maximum ET rate was varied quarterly and was set at 50% of pan evaporation recorded at Newman.

The simulated ET rate (mm/d) over the period of the transient calibration is presented in Figure E1 below. Measured evaporation data from the Whaleback weather station was used for May 2001 to Feb 2004. Quarterly averages were used for the remainder of the calibration period (prior to 2001).

Figure E1
Simulated Evapotranspiration and Recharge Rate



Recharge

Rainfall recharge to the alluvial aquifer was varied quarterly and specified at a rate of 0.5% of total rainfall recorded in the area. No recharge was specified in basement outcrop areas. A conceptual hydrogeological review completed in 1994 (Mackie Martin-PPK, 1994) indicated that aquifer response in the area is strongly influenced by streamflow contributions and seepage from the Ophthalmia Dam. Direct rainfall recharge to the aquifer was expected to be of smaller magnitude.

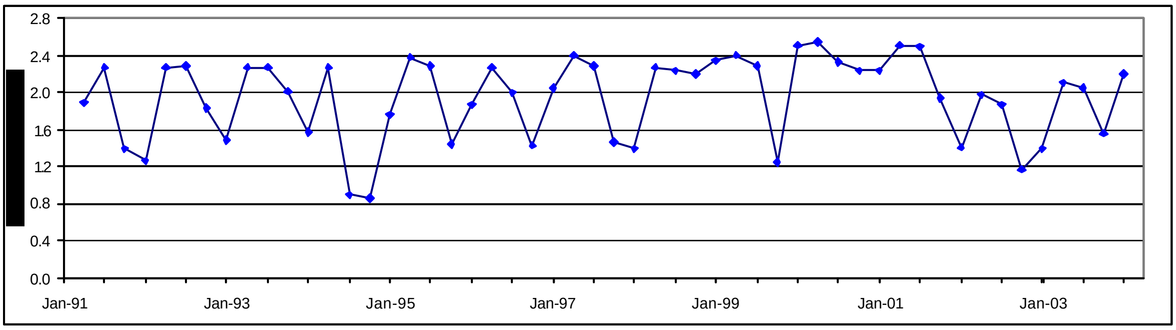
The simulated recharge rate over the period of the transient calibration is shown above. Rainfall measured from the Ophthalmia weather station was used in the model. During periods of no data from the Ophthalmia station, data from the Newman post office and airport rainfall stations were used.

Homestead and Shovelanna Creeks

The River Package was used to represent the downstream reaches of Homestead and Shovelanna Creeks which lie in the model area. The river package requires the specification of stage height along the river, the elevation of the river bed bottom, and a conductance term which governs the rate of leakage between the river and the aquifer. Stage height elevation for Homestead Creek is available from a gauging station located near the Railway Bridge. Data for the gauging station is however only available since 1999. Data for the remainder of the calibration period was extrapolated from an approximate relationship between rainfall and stage height over the period of available record. The height of flow in the creek measured at the gauging station was applied over the whole length of Homestead Creek which lies in the model area. The same height of flow was also specified for the downstream section of Shovelanna Creek feeding into the Fortescue River. In the absence of gauging station data, this was considered to be reasonable as the catchment areas for Homestead Creek (318 km^2) and Shovelanna Creek (306 km^2) are very similar, and peak flows predicted for the two creeks (HGM, 1999) are also of a similar magnitude. Simulated water levels in both creeks are presented in Figure E2.

The conductance of the creek beds was varied along the length of the creek to help simulate the observed response in monitoring bores located along the creek.

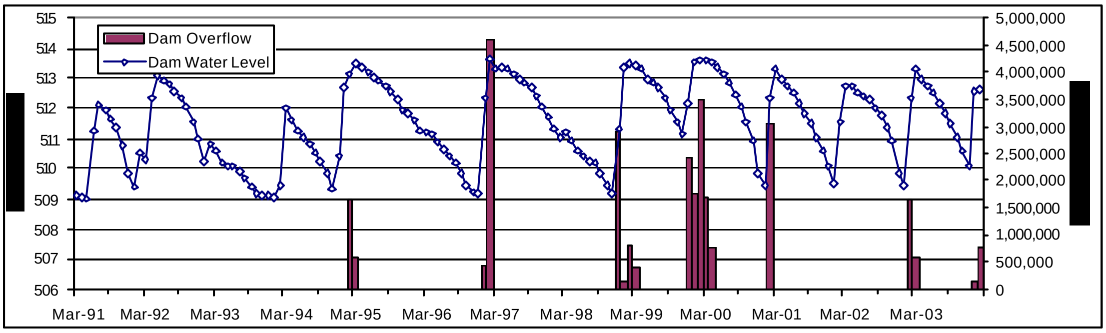
Figure E2
Simulated Homestead and Shovelanna Creek Water Level



Ophthalmia Dam Seepage

Seepage from Ophthalmia Dam is believed to be one of the most significant contributors to the water balance of the area, being a source of artificial recharge to balance abstraction from the Ophthalmia Wellfield. The Reservoir Package was used to simulate seepage from Ophthalmia Dam. The package requires the specification of a stage-time relationship for the water level in the dam, a conductance term which controls the rate of seepage, and the ground elevation. The area of seepage from the dam is applied to areas where the stage level in the dam is higher than the ground elevation. Therefore, as the water level in the dam rises, the area of seepage also increases. Records of dam water level kept by the Water and Rivers Commission were used to develop the stage-time relationship for the period of calibration. Data from the gauging station was only available up to May 2002. Data for the remainder of the calibration period was estimated from periods of similar rainfall records. These data are presented in Figure E3.

Figure E3
Opthalmia Dam Water Level and Overflow Rates



Ophthalmia Dam Overflow (Fortescue River)

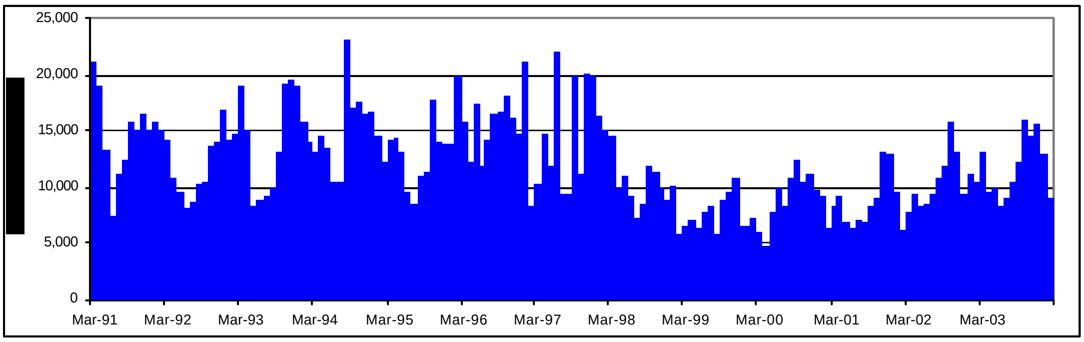
The Streamflow-Routing (STR) Package was used to simulate leakage from spills downstream of Ophthalmia Dam. Rates of spill were specified at gauged records kept by the Water and Rivers Commission. The STR package then routes this flow down the stream channel (Fortescue River) using the Mannings Equation, with a certain proportion of the flow leaking into the aquifer, and the remainder flowing downstream. A conductance term is used to specify the rate of leakage between the stream and the aquifer, similar to the River Package. Data from the gauging station was only available up to May 2002. Data for the remainder of the calibration period was estimated from periods of similar rainfall records.

An additional component of flow for the Fortescue River will be the discharge of Homestead and Shovelanna Creeks. However, there is no information on the volumes discharging from Homestead and Shovelanna Creek tributaries into the Fortescue River. The influence of this flow was indirectly accounted for by increasing the conductance of the Fortescue River further downstream of the confluence between Shovelanna and Homestead Creeks and the Fortescue River.

Ophthalmia Wellfield Abstraction

The Well Package was used to represent abstraction from the Ophthalmia Wellfield. Bores in the wellfield are located along Homestead Creek, to the south of Ophthalmia Dam, and to the north of Ophthalmia Dam along the Fortescue River. Records of abstraction from each bore were specified in the model and are presented in Figure E4.

Figure E4
Ophthalmia Wellfield Abstraction

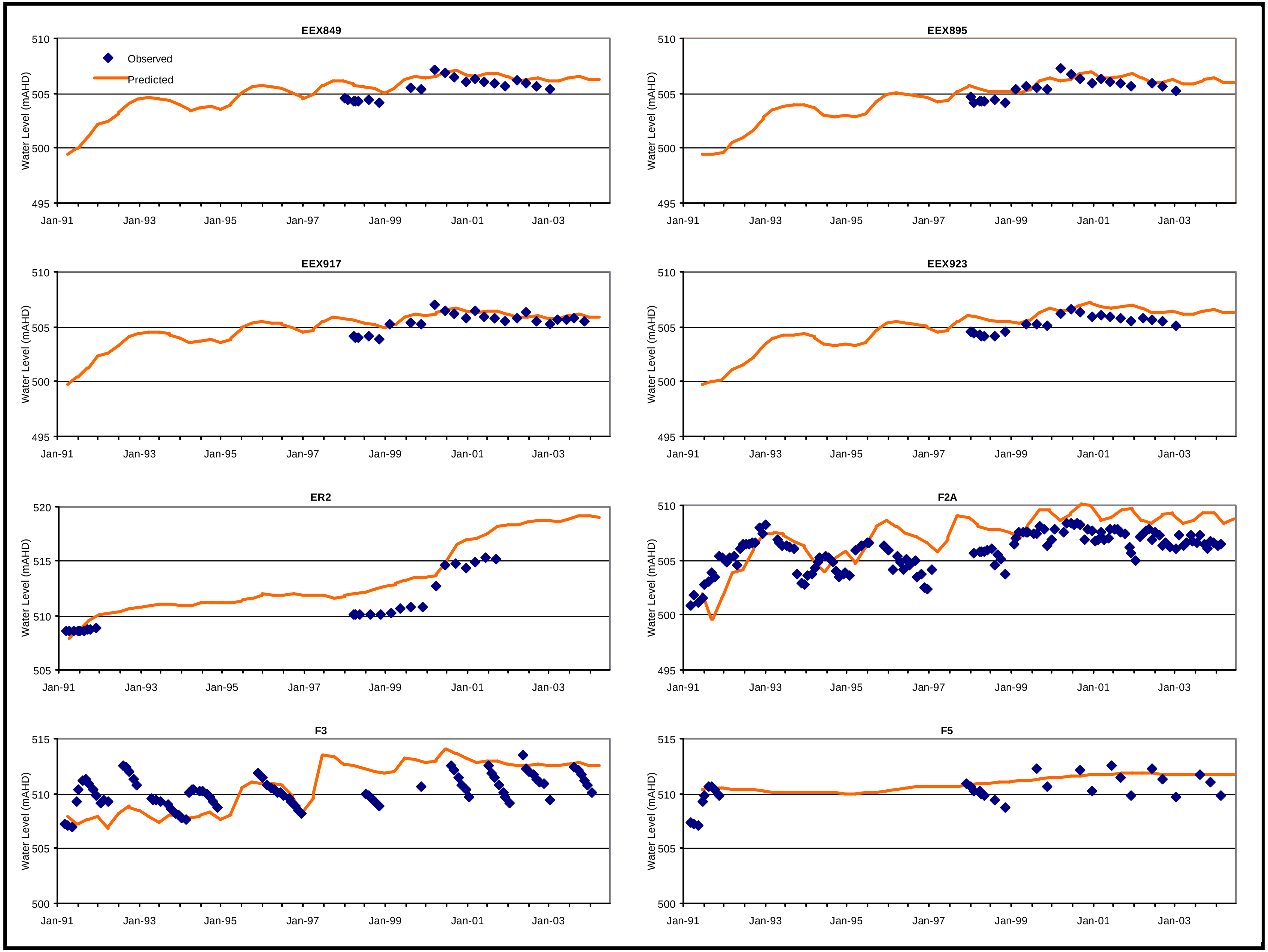


Calibration Hydrographs

A full set of calibration hydrographs for the transient regional calibration are presented in Figures E5 to E14.

Specified Pumping

The adopted pumping rates (for dewatering and water supply) for the longer-term (24 year) predictions of water level drawdowns are presented in Figures E15 and E16.



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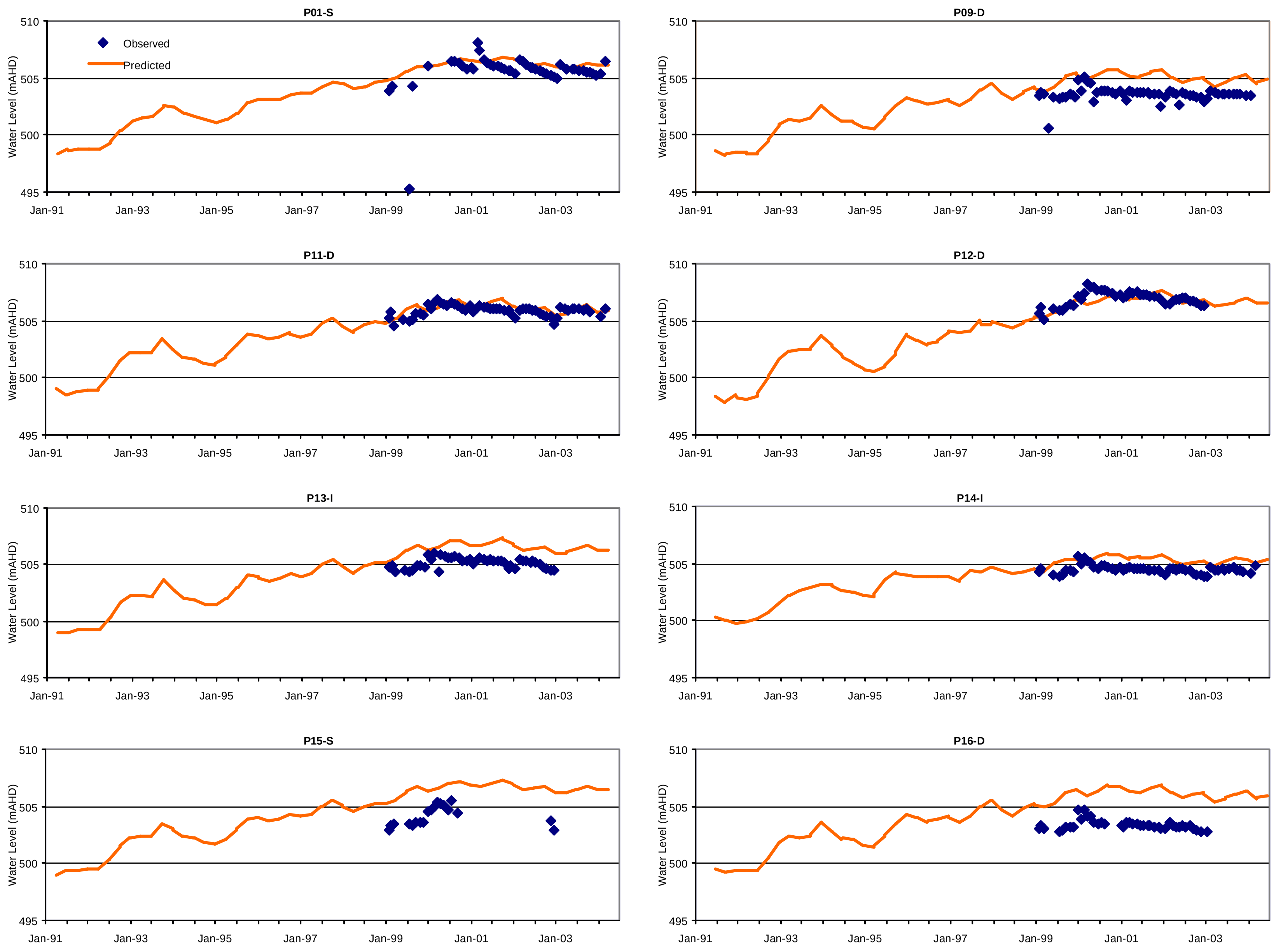
Calibration Hydrographs
Figure E5



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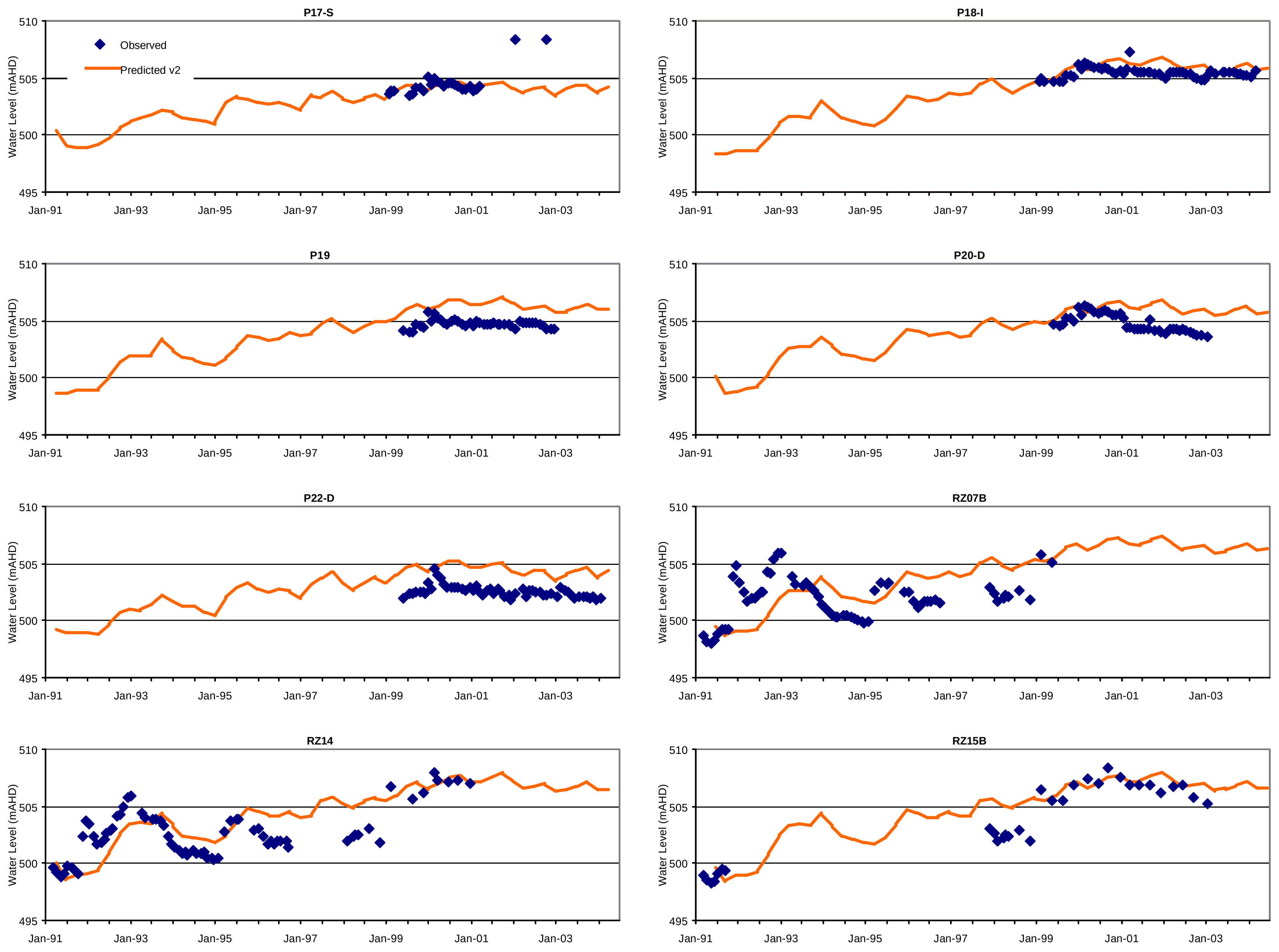
Calibration Hydrographs
Figure E6



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Calibration Hydrographs

Figure E7

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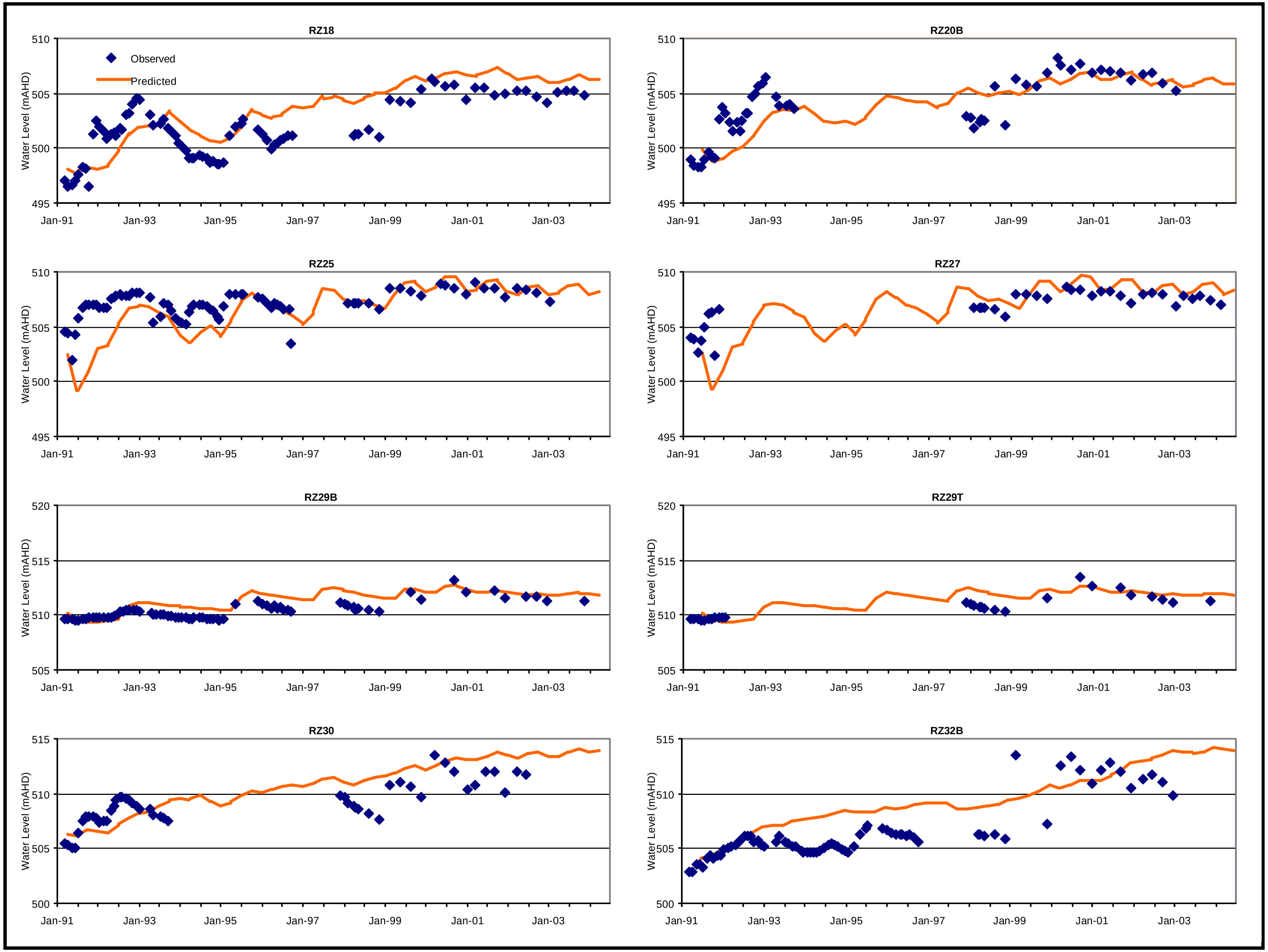

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Calibration Hydrographs

Figure E8

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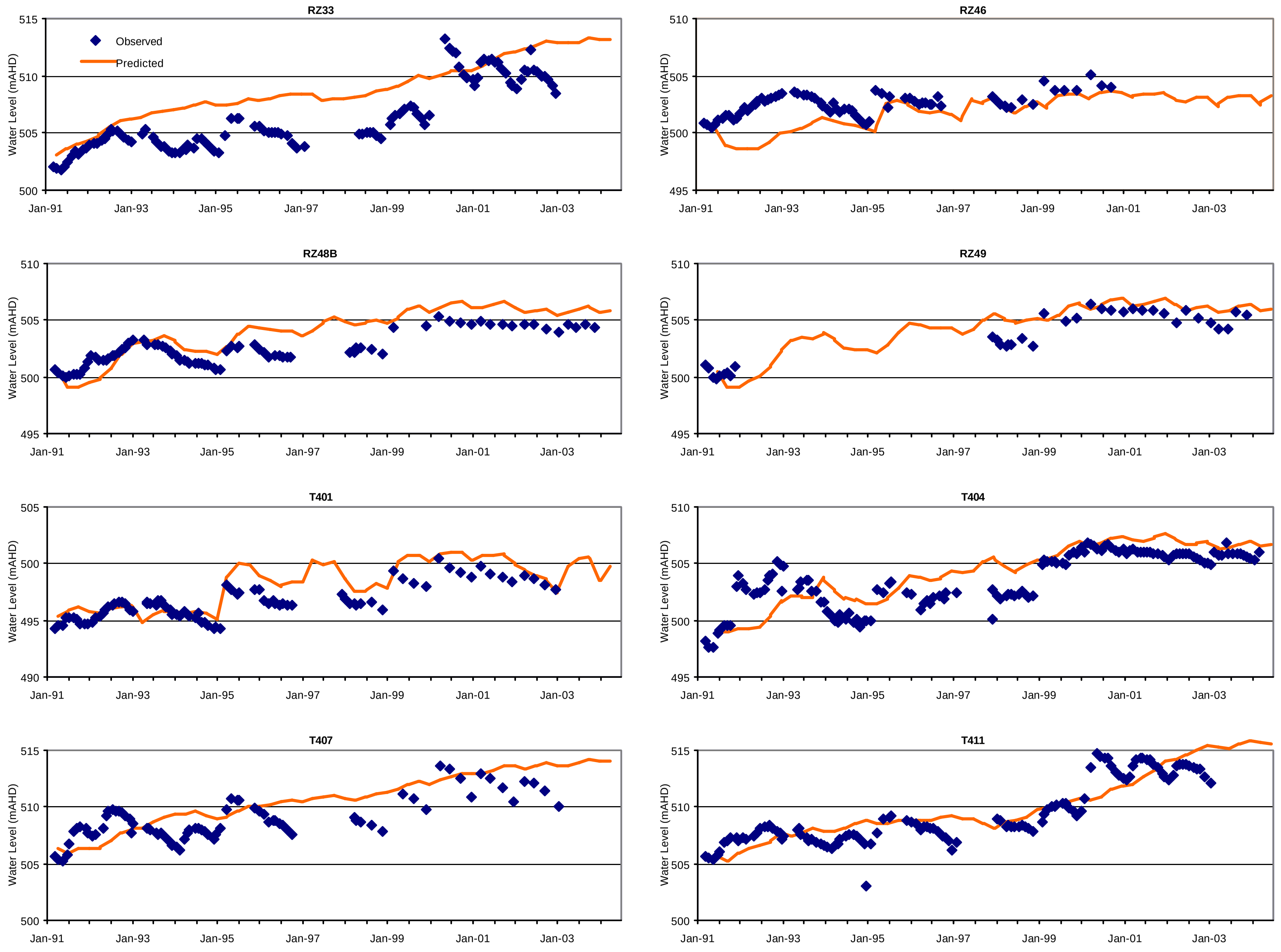

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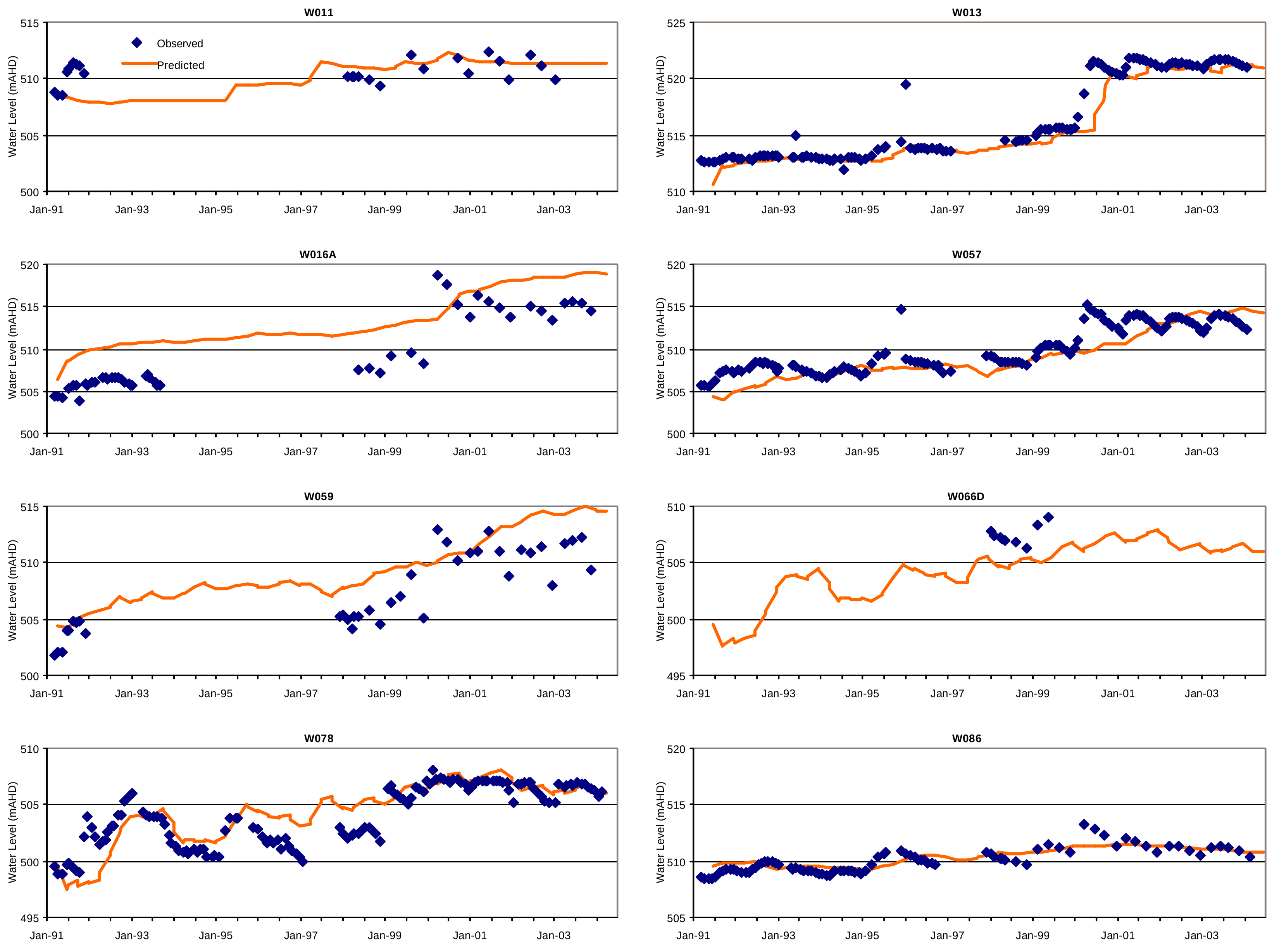
Calibration Hydrographs

Figure E9



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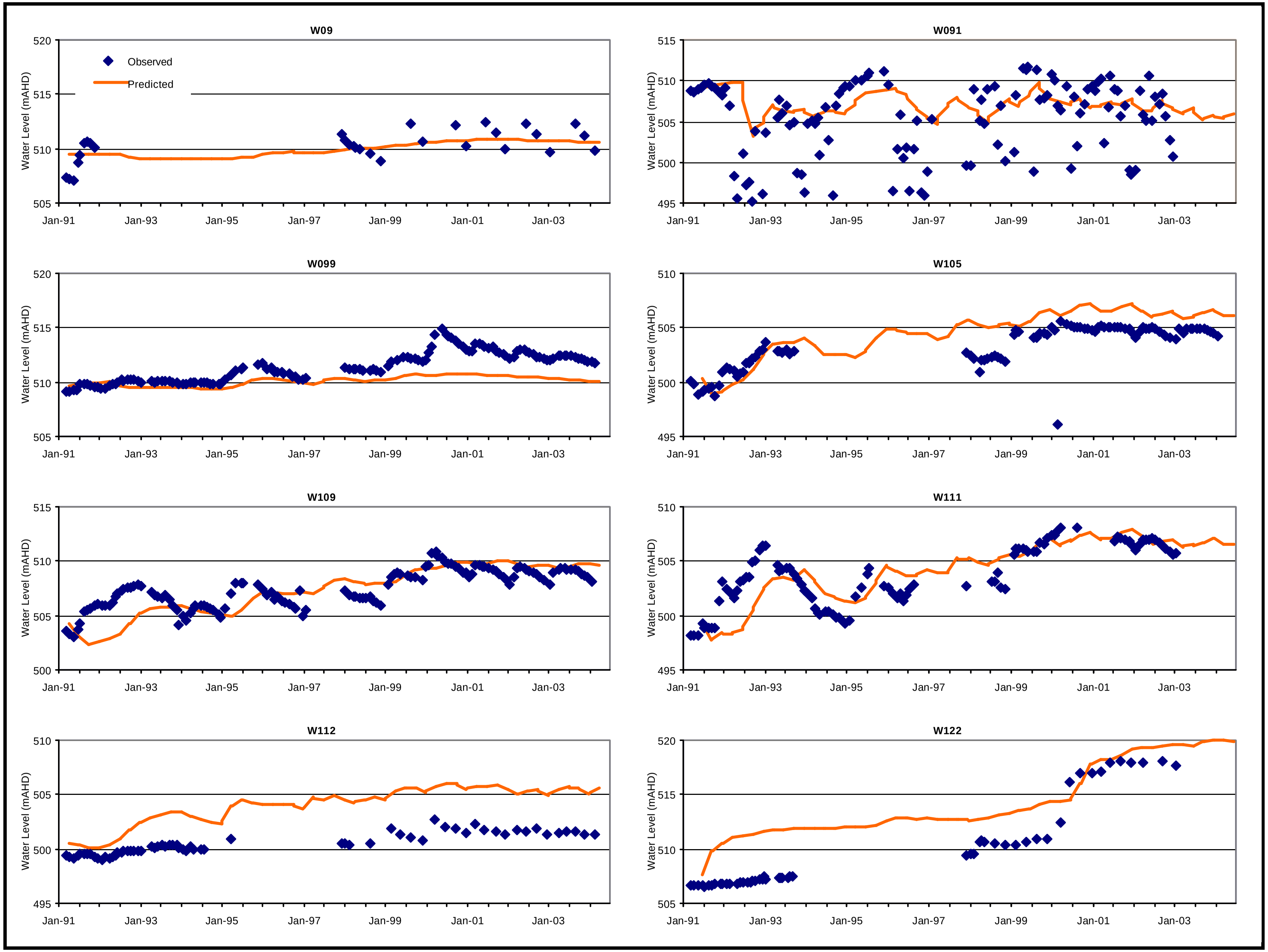
Calibration Hydrographs

Figure E10



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Calibration Hydrographs

Figure E11

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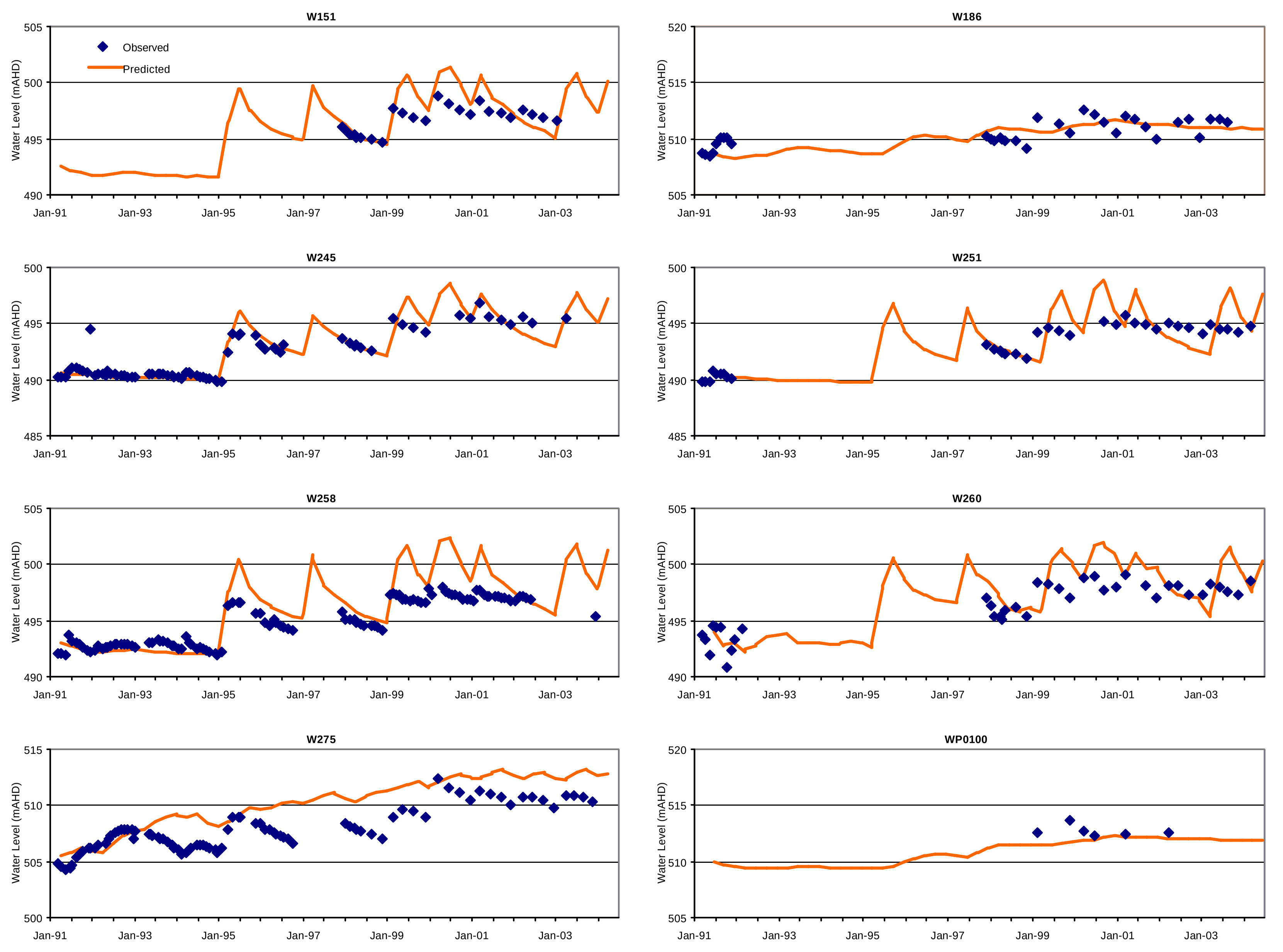

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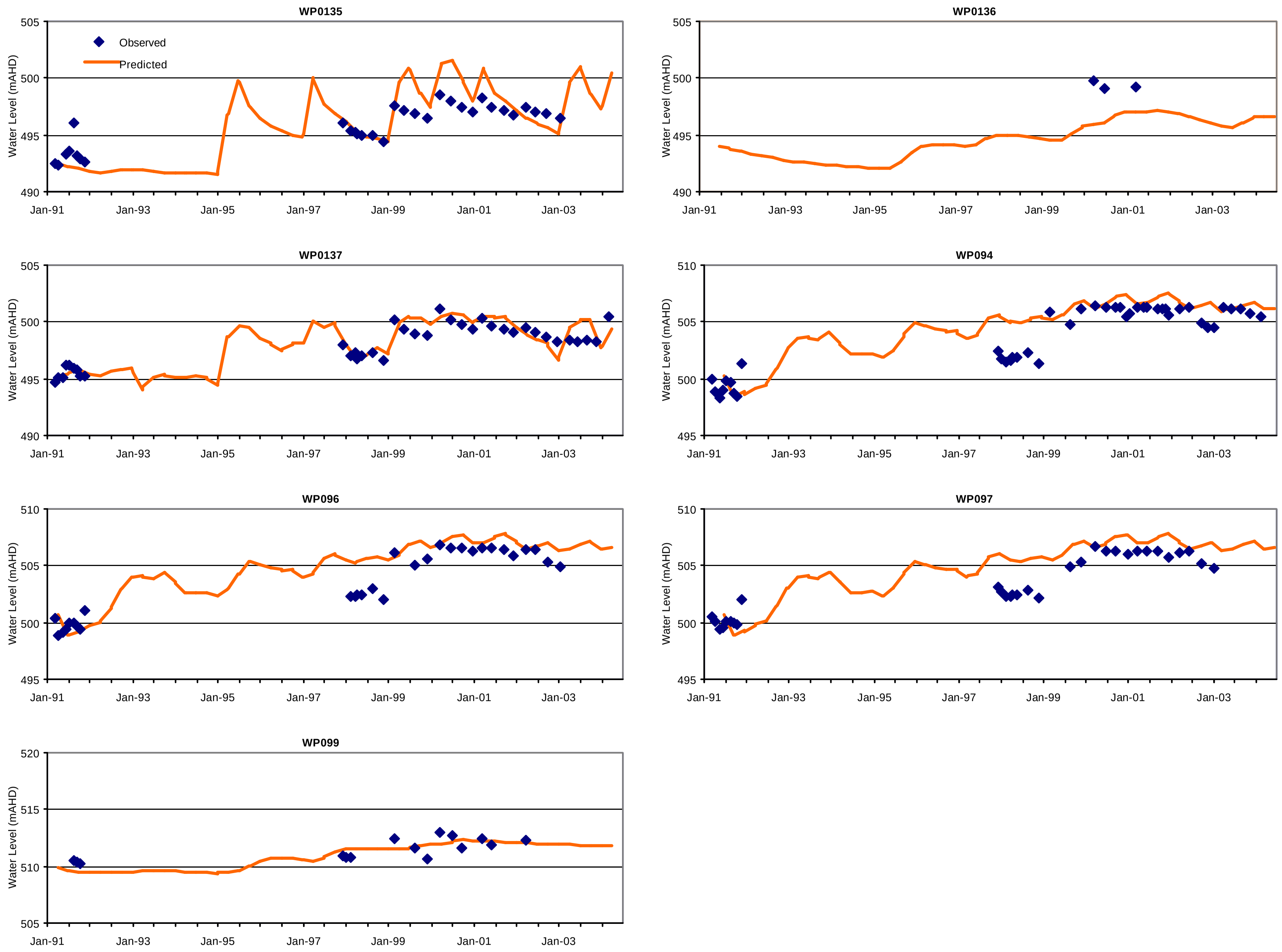
Calibration Hydrographs
Figure E12



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Calibration Hydrographs

Figure E13

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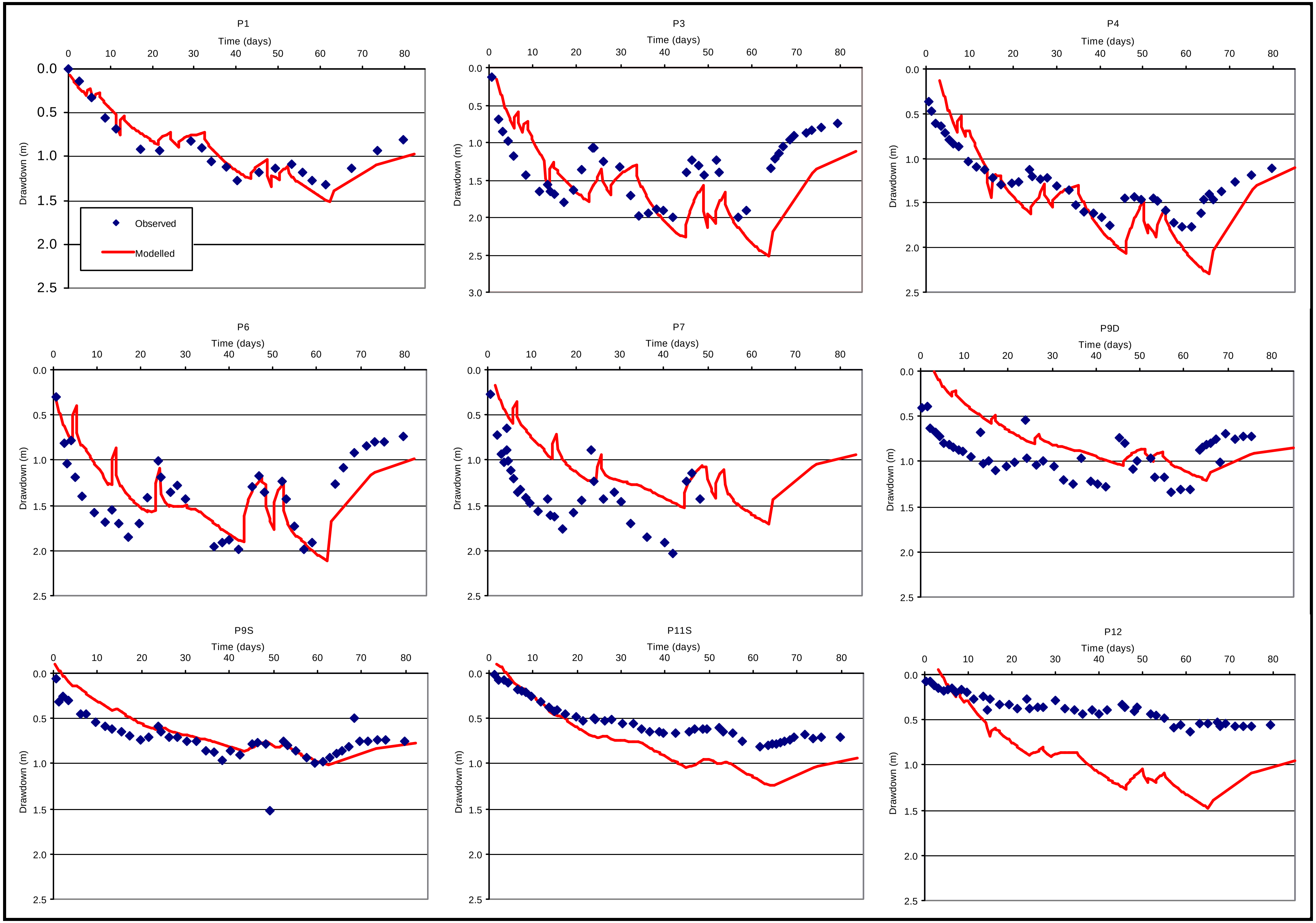

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OB23 Pumping Test Calibration

Figure E14

F:\jobs\320\OB23_25\Task E\E5\final report\[4056 Fig E14.xls]Fig E14

Scenario A - Continued abstraction from OB23 / OB25 for water supply

From	To	Dewatering Year	Years of Mining (completed)	OB23 Dewatering (kL/d)	OB25 Dewatering (kL/d)	OB25 Water Use (kL/d)	OB24 Water Use (kL/d)	Newman Hub Water Use (kL/d)	H-Line Abstraction (kL/d)	Abstraction from K Bores (kL/d)	Abstraction from E Bores (kL/d)
1/01/2005	**31/12/2005**	-1	0	0	0	1500	0	5500	3000		
1/01/2006	**31/12/2006**	1	0.75	36150	14800	2900	0	5500	3000		
1/01/2007	**31/12/2007**	2	1.75	35530	14800	2900	0	5500	3000		
1/01/2008	**31/03/2009**	3.25	3	27870	11720	2900	3950	18000	3000		
1/04/2009	**31/12/2009**	4	3.75	3950	10000	2900	3950	18000	3000	6000	7160
1/01/2010	**31/03/2011**	5.25	5	16142	9720	2900	3950	18000	3000		
1/04/2011	**29/02/2012**	6	5.75	12190	2900	2900	3950	18000	3000	6760	3000
1/03/2012	**28/02/2013**	7	6.75	12190	2900	2900	3950	18000	3000	6760	3000
1/03/2013	**28/02/2014**	8	7.75	16000	0	0	3950	18000	3000	3950	2000
1/03/2014	**28/02/2015**	9	8.75	16000	0	0	3950	18000	3000	3950	2000
1/03/2015	**29/02/2016**	10	9.75	16000	0	0	3950	18000	3000	3950	2000
1/03/2016	**28/02/2017**	11	10.75	16000	0	0	3950	18000	3000	3950	2000
1/03/2017	**28/02/2018**	12	11.75	16000	0	0	3950	18000	3000	3950	2000
1/03/2018	**28/02/2019**	13	12.75	16000	0	0	3950	18000	3000	3950	2000
1/03/2019	**29/02/2020**	14	13.75	16000	0	0	3950	18000	3000	3950	2000
1/03/2020	**28/02/2021**	15	14.75	16000	0	0	3950	18000	3000	3950	2000
1/03/2021	**28/02/2022**	16	15.75	16000	0	0	3950	18000	3000	3950	2000
1/03/2022	**28/02/2023**	17	16.75	16000	0	0	3950	18000	3000	3950	2000
1/03/2023	**29/02/2024**	18	17.75	16000	0	0	0	18000	3000	2000	
1/03/2024	**28/02/2025**	19	18.75	16000	0	0	0	18000	3000	2000	
1/03/2025	**28/02/2026**	20	19.75	16000	0	0	0	18000	3000	2000	
1/03/2026	**28/02/2027**	21	20.75	16000	0	0	0	18000	3000	2000	
1/03/2027	**29/02/2028**	22	21.75	16000	0	0	0	18000	3000	2000	
1/03/2028	**28/02/2029**	23	22.75	16000	0	0	0	18000	3000	2000	
1/03/2029	**28/02/2030**	24	23.75	16000	0	0	0	18000	3000	2000	

Scenario B - Predominantly Ophthalmia wellfield Abstraction after OB23/25 Dewatering

From	To	Dewatering Year	Years of Mining (completed)	OB23 Dewatering (kL/d)	OB25 Dewatering (kL/d)	OB25 Water Use (kL/d)	OB24 Water Use (kL/d)	Newman Hub Water Use (kL/d)	H-Line Abstraction (kL/d)	Abstraction from K Bores (kL/d)	Abstraction from E Bores (kL/d)
1/01/2005	**31/12/2005**	-1	0	0	0	1500	0	5500	3000	0	0
1/01/2006	**31/12/2006**	1	0.75	36150	14800	2900	0	5500	3000	0	0
1/01/2007	**31/12/2007**	2	1.75	35530	14800	2900	0	5500	3000	0	0
1/01/2008	**31/03/2009**	3.25	3	27870	11720	2900	3950	18000	3000	0	0
1/04/2009	**31/12/2009**	4	3.75	3950	10000	2900	3950	18000	3000	6000	7160
1/01/2010	**31/03/2011**	5.25	5	3950	9720	2900	3950	18000	3000	6000	7160
1/04/2011	**29/02/2012**	6	5.75	3950	2900	2900	3950	18000	3000	7000	11000
1/03/2012	**28/02/2013**	7	6.75	3950	2900	2900	3950	18000	3000	7000	11000
1/03/2013	**28/02/2014**	8	7.75	3950	0	0	3950	18000	3000	7000	11000
1/03/2014	**28/02/2015**	9	8.75	3950	0	0	3950	18000	5667	4333	11000
1/03/2015	**29/02/2016**	10	9.75	3950	0	0	3950	18000	5667	4333	11000
1/03/2016	**28/02/2017**	11	10.75	3950	0	0	3950	18000	5667	4333	11000
1/03/2017	**28/02/2018**	12	11.75	3950	0	0	3950	18000	5667	4333	11000
1/03/2018	**28/02/2019**	13	12.75	3950	0	0	3950	18000	5667	4333	11000
1/03/2019	**29/02/2020**	14	13.75	3950	0	0	3950	18000	5667	4333	11000
1/03/2020	**28/02/2021**	15	14.75	3950	0	0	3950	18000	5667	4333	11000
1/03/2021	**28/02/2022**	16	15.75	3950	0	0	3950	18000	5667	4333	11000
1/03/2022	**28/02/2023**	17	16.75	3950	0	0	3950	18000	5667	4333	11000
1/03/2023	**29/02/2024**	18	17.75	0	0	0	0	18000	5667	4333	11000
1/03/2024	**28/02/2025**	19	18.75	0	0	0	0	18000	5667	4333	11000
1/03/2025	**28/02/2026**	20	19.75	0	0	0	0	18000	5667	4333	11000
1/03/2026	**28/02/2027**	21	20.75	0	0	0	0	18000	5667	4333	11000
1/03/2027	**29/02/2028**	22	21.75	0	0	0	0	18000	5667	4333	11000
1/03/2028	**28/02/2029**	23	22.75	0	0	0	0	18000	5667	4333	11000
1/03/2029	**28/02/2030**	24	23.75	0	0	0	0	18000	5667	4333	11000

Note: Blue shaded periods represent times of dewatering. Refer to Figures 12 ,F4 and Tables 3.6,F1 for more detail.

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Dewatering and Water Supply Abstraction
Summary for Scenarios A and B

Figure E15

Scenario C - Recovery Scenario, no abstraction from yr 3.25 onwards for OB 23 and yr 5.25 onwards for OB 25.

From	To	Dewatering Year	Years of Mining (completed)	OB23 Dewatering (kL/d)	OB25 Dewatering (kL/d)	OB25 Water Use (kL/d)	OB24 Water Use (kL/d)	Newman Hub Water Use (kL/d)	H-Line Abstraction (kL/d)	Abstraction from K Bores (kL/d)	Abstraction from E Bores (kL/d)
1/01/2005	31/12/2005	-1	0	0	0	1500	0	5500	3000		
1/01/2006	31/12/2006	1	0.75	36150	14800	2900	0	5500	3000		
1/01/2007	31/12/2007	2	1.75	35530	14800	2900	0	5500	3000		
1/01/2008	31/03/2009	3.25	3	27870	11720	2900	3950	18000	3000		
1/04/2009	31/12/2009	4	3.75	0	10000	2900	3950	18000	4943	8000	7160
1/01/2010	31/03/2011	5.25	5	0	9720	2900	3950	18000	3982	8000	7160
1/04/2011	29/02/2012	6	5.75	0	0	2900	3950	18000	9850	8000	10000
1/03/2012	28/02/2013	7	6.75	0	0	2900	3950	18000	9850	8000	10000
1/03/2013	28/02/2014	8	7.75	0	0	0	3950	18000	6950	8000	10000
1/03/2014	28/02/2015	9	8.75	0	0	0	3950	18000	6950	8000	10000
1/03/2015	29/02/2016	10	9.75	0	0	0	3950	18000	6950	8000	10000
1/03/2016	28/02/2017	11	10.75	0	0	0	3950	18000	6950	8000	10000
1/03/2017	28/02/2018	12	11.75	0	0	0	3950	18000	6950	8000	10000
1/03/2018	28/02/2019	13	12.75	0	0	0	3950	18000	6950	8000	10000
1/03/2019	29/02/2020	14	13.75	0	0	0	3950	18000	6950	8000	10000
1/03/2020	28/02/2021	15	14.75	0	0	0	3950	18000	6950	8000	10000
1/03/2021	28/02/2022	16	15.75	0	0	0	3950	18000	6950	8000	10000
1/03/2022	28/02/2023	17	16.75	0	0	0	3950	18000	6950	8000	10000
1/03/2023	29/02/2024	18	17.75	0	0	0	0	18000	3000	8000	10000
1/03/2024	28/02/2025	19	18.75	0	0	0	0	18000	3000	8000	10000
1/03/2025	28/02/2026	20	19.75	0	0	0	0	18000	3000	8000	10000
1/03/2026	28/02/2027	21	20.75	0	0	0	0	18000	3000	8000	10000
1/03/2027	29/02/2028	22	21.75	0	0	0	0	18000	3000	8000	10000
1/03/2028	28/02/2029	23	22.75	0	0	0	0	18000	3000	8000	10000
				0	0	0	0	18000	3000	8000	10000

Scenario D- No pit dewatering or pitvoid pumping for OB 23 and 25. (Assumes all pits are above water table.)

From	To	Dewatering Year	Years of Mining (completed)	OB23 Dewatering (kL/d)	OB25 Dewatering (kL/d)	OB25 Water Use (kL/d)	OB24 Water Use (kL/d)	Newman Hub Water Use (kL/d)	H-Line Abstraction (kL/d)	Abstraction from K Bores (kL/d)	Abstraction from E Bores (kL/d)
1/01/2005	31/12/2005	-1	0	0	0	3000	0	5500	3000	3000	5500
1/01/2006	31/12/2006	1	0.75	0	0	5800	0	5500	3000	4800	6500
1/01/2007	31/12/2007	2	1.75	0	0	5800	0	5500	3000	4800	6500
1/01/2008	31/03/2009	3.25	3	0	0	5800	3950	18000	12750	8000	10000
1/04/2009	31/12/2009	4	3.75	0	0	5800	3950	18000	12750	8000	10000
1/01/2010	31/03/2011	5.25	5	0	0	5800	3950	18000	12750	8000	10000
1/04/2011	29/02/2012	6	5.75	0	0	5800	3950	18000	12750	8000	10000
1/03/2012	28/02/2013	7	6.75	0	0	5800	3950	18000	12750	8000	10000
1/03/2013	28/02/2014	8	7.75	0	0	0	3950	18000	6950	8000	10000
1/03/2014	28/02/2015	9	8.75	0	0	0	3950	18000	6950	8000	10000
1/03/2015	29/02/2016	10	9.75	0	0	0	3950	18000	6950	8000	10000
1/03/2016	28/02/2017	11	10.75	0	0	0	3950	18000	6950	8000	10000
1/03/2017	28/02/2018	12	11.75	0	0	0	3950	18000	6950	8000	10000
1/03/2018	28/02/2019	13	12.75	0	0	0	3950	18000	6950	8000	10000
1/03/2019	29/02/2020	14	13.75	0	0	0	3950	18000	6950	8000	10000
1/03/2020	28/02/2021	15	14.75	0	0	0	3950	18000	6950	8000	10000
1/03/2021	28/02/2022	16	15.75	0	0	0	3950	18000	6950	8000	10000
1/03/2022	28/02/2023	17	16.75	0	0	0	3950	18000	6950	8000	10000
1/03/2023	29/02/2024	18	17.75	0	0	0	0	18000	3000	8000	10000
1/03/2024	28/02/2025	19	18.75	0	0	0	0	18000	3000	8000	10000
1/03/2025	28/02/2026	20	19.75	0	0	0	0	18000	3000	8000	10000
1/03/2026	28/02/2027	21	20.75	0	0	0	0	18000	3000	8000	10000
1/03/2027	29/02/2028	22	21.75	0	0	0	0	18000	3000	8000	10000
1/03/2028	28/02/2029	23	22.75	0	0	0	0	18000	3000	8000	10000
1/03/2029	28/02/2030	24	23.75	0	0	0	0	18000	3000	8000	10000

vatering. Refer to Figures 12 ,F4 and Tables 3.6,F1 for more detail

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Dewatering and Water Supply Abstraction

Summary for Scenarios C and D

Figure E16

Scenario E - Aim to get all water supply from OB23 / OB25 pit lakes (OB23 priority)

From	To	Dewatering Year	Years of Mining (completed)	OB23 Dewatering (kL/d)	OB25 Dewatering (kL/d)	OB25 Water Use (kL/d)	OB24 Water Use (kL/d)	Newman Hub Water Use (kL/d)	H-Line Abstraction (kL/d)	Abstraction from K Bores (kL/d)	Abstraction from E Bores (kL/d)
1/01/2005	31/12/2005	-1	0	0	0	1500	0	5500	3000		
1/01/2006	31/12/2006	1	0.75	35312	14800	2900	0	5500	3000	Aim to have no abstraction from Ophthalmia Bores	
1/01/2007	31/12/2007	2	1.75	36235	14800	2900	0	5500	3000		
1/01/2008	31/03/2009	3.25	3	34036	12802	2900	0	18000	3000		
1/04/2009	31/12/2009	4	3.75	0.0	9140	2900	0	18000	3000		
1/01/2010	4/03/2010	4.17	3.92	4178.0	10100	2900	0	18000	3000		
5/03/2010	3/05/2010	4.33	4.08	11195.2	10100	2900	0	18000	3000		
4/05/2010	3/07/2010	4.50	4.25	11242.9	10100	2900	0	18000	3000		
4/07/2010	3/04/2011	5.25	5	11242.9	10045	2900	0	18000	3000		
4/04/2011	1/01/2012	6	5.75	12437.3	9220	2900	0	18000	3000		
2/01/2012	22/03/2013	7.25	7	15903.1	5500	2900	0	18000	3000		
23/03/2013	28/02/2014	8	7.75	16000	2000	0	0	18000	3000		
1/03/2014	28/02/2015	9	8.75	16000	2000	0	0	18000	3000		
1/03/2015	29/02/2016	10	9.75	16000	2000	0	0	18000	3000		
1/03/2016	28/02/2017	11	10.75	16000	2000	0	0	18000	3000		
1/03/2017	28/02/2018	12	11.75	18000	0	0	0	18000	3000		
1/03/2018	28/02/2019	13	12.75	18000	0	0	0	18000	3000		
1/03/2019	29/02/2020	14	13.75	18000	0	0	0	18000	3000		
1/03/2020	28/02/2021	15	14.75	18000	0	0	0	18000	3000		
1/03/2021	28/02/2022	16	15.75	18000	0	0	0	18000	3000		
1/03/2022	28/02/2023	17	16.75	18000	0	0	0	18000	3000		
1/03/2023	29/02/2024	18	17.75	18000	0	0	0	18000	3000		
1/03/2024	28/02/2025	19	18.75	18000	0	0	0	18000	3000		
1/03/2025	28/02/2026	20	19.75	18000	0	0	0	18000	3000		
1/03/2026	28/02/2027	21	20.75	18000	0	0	0	18000	3000		
1/03/2027	29/02/2028	22	21.75	18000	0	0	0	18000	3000		
1/03/2028	28/02/2029	23	22.75	18000	0	0	0	18000	3000		
1/03/2029	28/02/2030	24	23.75	18000	0	0	0	18000	3000		

Scenario F - Backfill OB25 & Aim to get all water supply from OB23 pit lakes (shortfall from Ophthalmia Bores)

From	To	Dewatering Year	Years of Mining (completed)	OB23 Dewatering (kL/d)	OB25 Dewatering (kL/d)	OB25 Water Use (kL/d)	OB24 Water Use (kL/d)	Newman Hub Water Use (kL/d)	H-Line Abstraction (kL/d)	Abstraction from K Bores (kL/d)	Abstraction from E Bores (kL/d)
1/01/2005	31/12/2005	-1	0	0	0	1500	0	5500	3000		
1/01/2006	31/12/2006	1	0.75	35312	14800	2900	0	5500	3000	Get maximum water supply from OB23 before abstracting from Ophthalmia Bores	
1/01/2007	31/12/2007	2	1.75	36235	14800	2900	0	5500	3000		
1/01/2008	31/03/2009	3.25	3	34036	12802	2900	0	18000	3000		
1/04/2009	31/12/2009	4	3.75	0.0	9140	2900	0	18000	3000		
1/01/2010	2/03/2010	4.17	3.92	4178.0	10100	2900	0	18000	3000		
3/03/2010	1/05/2010	4.33	4.08	11195.2	10100	2900	0	18000	3000		
2/05/2010	1/07/2010	4.50	4.25	11242.9	10100	2900	0	18000	3000		
2/07/2010	31/03/2011	5.25	5	11242.9	10045	2900	0	18000	3000		
1/04/2011	29/02/2012	6	5.75	12437.3	9220	2900	0	18000	3000		
1/03/2012	28/02/2013	7.25	7	15903.1	5500	2900	0	18000	3000		
1/03/2013	28/02/2014	8.25	8	16000	BACKFILL	0	0	18000	3000	2000	
1/03/2014	28/02/2015	9.25	9	16000	0	0	0	18000	3000	2000	
1/03/2015	29/02/2016	10.25	10	16000	0	0	0	18000	3000	2000	
1/03/2016	28/02/2017	11.25	11	16000	0	0	0	18000	3000	2000	
1/03/2017	28/02/2018	12.25	12	18000	0	0	0	18000	3000		
1/03/2018	28/02/2019	13.25	13	18000	0	0	0	18000	3000		
1/03/2019	29/02/2020	14.25	14	18000	0	0	0	18000	3000		
1/03/2020	28/02/2021	15.25	15	18000	0	0	0	18000	3000		
1/03/2021	28/02/2022	16.25	16	18000	0	0	0	18000	3000		
1/03/2022	28/02/2023	17.25	17	18000	0	0	0	18000	3000		
1/03/2023	29/02/2024	18.25	18	18000	0	0	0	18000	3000		
1/03/2024	28/02/2025	19.25	19	18000	0	0	0	18000	3000		
1/03/2025	28/02/2026	20.25	20	18000	0	0	0	18000	3000		
1/03/2026	28/02/2027	21.25	21	18000	0	0	0	18000	3000		
1/03/2027	29/02/2028	22.25	22	18000	0	0	0	18000	3000		
1/03/2028	28/02/2029	23.25	23	18000	0	0	0	18000	3000		
1/03/2029	28/02/2030	24.25	24	18000	0	0	0	18000	3000		

Note: Blue shaded periods represent times of dewatering. Refer to Figures 12 ,F4 and Tables 3.6,F1 for more detail.

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Dewatering and Water Supply Abstraction
Summary for Scenarios E and F
Figure E17

Scenario E - Aim to get all water supply from OB23 / OB25 pit lakes (OB23 priority)

From	To	Dewatering Year	Years of Mining (completed)	OB23 Dewatering (kL/d)	OB25 Dewatering (kL/d)	OB25 Water Use (kL/d)	OB24 Water Use (kL/d)	Newman Hub Water Use (kL/d)	H-Line Abstraction (kL/d)	Abstraction from K Bores (kL/d)	Abstraction from E Bores (kL/d)
1/01/2005	31/12/2005	-1	0	0	0	1500	0	5500	3000		
1/01/2006	31/12/2006	1	0.75	35373	14800	2900	0	5500	3000	Aim to have no abstraction from Ophthalmia Bores	
1/01/2007	31/12/2007	2	1.75	36769	14800	2900	0	5500	3000		
1/01/2008	31/03/2009	3.25	3	37301	14526	2900	0	18000	3000		
1/04/2009	31/12/2009	4	3.75	0.0	11752	2900	0	18000	3000		
1/01/2010	4/03/2010	4.17	3.92	8856.3	12835	2900	0	18000	3000		
5/03/2010	3/05/2010	4.33	4.08	8856.3	12574	2900	0	18000	3000		
4/05/2010	3/07/2010	4.50	4.25	8837.2	12550	2900	0	18000	3000		
4/07/2010	3/04/2011	5.25	5	10973.9	12232	2900	0	18000	3000		
4/04/2011	1/01/2012	6	5.75	11450.1	9580	2900	0	18000	3000		
2/01/2012	22/03/2013	7.25	7	11503.6	9395	2900	0	18000	3000		
23/03/2013	28/02/2014	8	7.75	16000	2000	0	0	18000	3000		
1/03/2014	28/02/2015	9	8.75	16000	2000	0	0	18000	3000		
1/03/2015	29/02/2016	10	9.75	16000	2000	0	0	18000	3000		
1/03/2016	28/02/2017	11	10.75	16000	2000	0	0	18000	3000		
1/03/2017	28/02/2018	12	11.75	18000	0	0	0	18000	3000		
1/03/2018	28/02/2019	13	12.75	18000	0	0	0	18000	3000		
1/03/2019	29/02/2020	14	13.75	18000	0	0	0	18000	3000		
1/03/2020	28/02/2021	15	14.75	18000	0	0	0	18000	3000		
1/03/2021	28/02/2022	16	15.75	18000	0	0	0	18000	3000		
1/03/2022	28/02/2023	17	16.75	18000	0	0	0	18000	3000		
1/03/2023	29/02/2024	18	17.75	18000	0	0	0	18000	3000		
1/03/2024	28/02/2025	19	18.75	18000	0	0	0	18000	3000		
1/03/2025	28/02/2026	20	19.75	18000	0	0	0	18000	3000		
1/03/2026	28/02/2027	21	20.75	18000	0	0	0	18000	3000		
1/03/2027	29/02/2028	22	21.75	18000	0	0	0	18000	3000		
1/03/2028	28/02/2029	23	22.75	18000	0	0	0	18000	3000		
1/03/2029	28/02/2030	24	23.75	18000	0	0	0	18000	3000		

Scenario F - Backfill OB25 & Aim to get all water supply from OB23 pit lakes (shortfall from Ophthalmia Bores)

From	To	Dewatering Year	Years of Mining (completed)	OB23 Dewatering (kL/d)	OB25 Dewatering (kL/d)	OB25 Water Use (kL/d)	OB24 Water Use (kL/d)	Newman Hub Water Use (kL/d)	H-Line Abstraction (kL/d)	Abstraction from K Bores (kL/d)	Abstraction from E Bores (kL/d)
1/01/2005	31/12/2005	-1	0	0	0	1500	0	5500	3000		
1/01/2006	31/12/2006	1	0.75	35373	14800	2900	0	5500	3000	Get maximum water supply from OB23 before abstracting from Ophthalmia Bores	
1/01/2007	31/12/2007	2	1.75	36769	14800	2900	0	5500	3000		
1/01/2008	31/03/2009	3.25	3	37301	14526	2900	0	18000	3000		
1/04/2009	31/12/2009	4	3.75	0.0	11752	2900	0	18000	3000		
1/01/2010	2/03/2010	4.17	3.92	8856.3	12835	2900	0	18000	3000		
3/03/2010	1/05/2010	4.33	4.08	8856.3	12574	2900	0	18000	3000		
2/05/2010	1/07/2010	4.50	4.25	8837.2	12550	2900	0	18000	3000		
2/07/2010	31/03/2011	5.25	5	10973.9	12232	2900	0	18000	3000		
1/04/2011	29/02/2012	6	5.75	11450.1	9580	2900	0	18000	3000		
1/03/2012	28/02/2013	7.25	7	11503.6	9395	2900	0	18000	3000		
1/03/2013	28/02/2014	8.25	8	16000	BACKFILL	0	0	18000	3000	2000	
1/03/2014	28/02/2015	9.25	9	16000	0	0	0	18000	3000	2000	
1/03/2015	29/02/2016	10.25	10	16000	0	0	0	18000	3000	2000	
1/03/2016	28/02/2017	11.25	11	16000	0	0	0	18000	3000	2000	
1/03/2017	28/02/2018	12.25	12	18000	0	0	0	18000	3000		
1/03/2018	28/02/2019	13.25	13	18000	0	0	0	18000	3000		
1/03/2019	29/02/2020	14.25	14	18000	0	0	0	18000	3000		
1/03/2020	28/02/2021	15.25	15	18000	0	0	0	18000	3000		
1/03/2021	28/02/2022	16.25	16	18000	0	0	0	18000	3000		
1/03/2022	28/02/2023	17.25	17	18000	0	0	0	18000	3000		
1/03/2023	29/02/2024	18.25	18	18000	0	0	0	18000	3000		
1/03/2024	28/02/2025	19.25	19	18000	0	0	0	18000	3000		
1/03/2025	28/02/2026	20.25	20	18000	0	0	0	18000	3000		
1/03/2026	28/02/2027	21.25	21	18000	0	0	0	18000	3000		
1/03/2027	29/02/2028	22.25	22	18000	0	0	0	18000	3000		
1/03/2028	28/02/2029	23.25	23	18000	0	0	0	18000	3000		
1/03/2029	28/02/2030	24.25	24	18000	0	0	0	18000	3000		

Note: Blue shaded periods represent times of dewatering. Refer to Figures 12 ,F4 and Tables 3.6,F1 for more detail.

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Dewatering and Water Supply Abstraction
Summary for Scenarios E and F
Figure E18

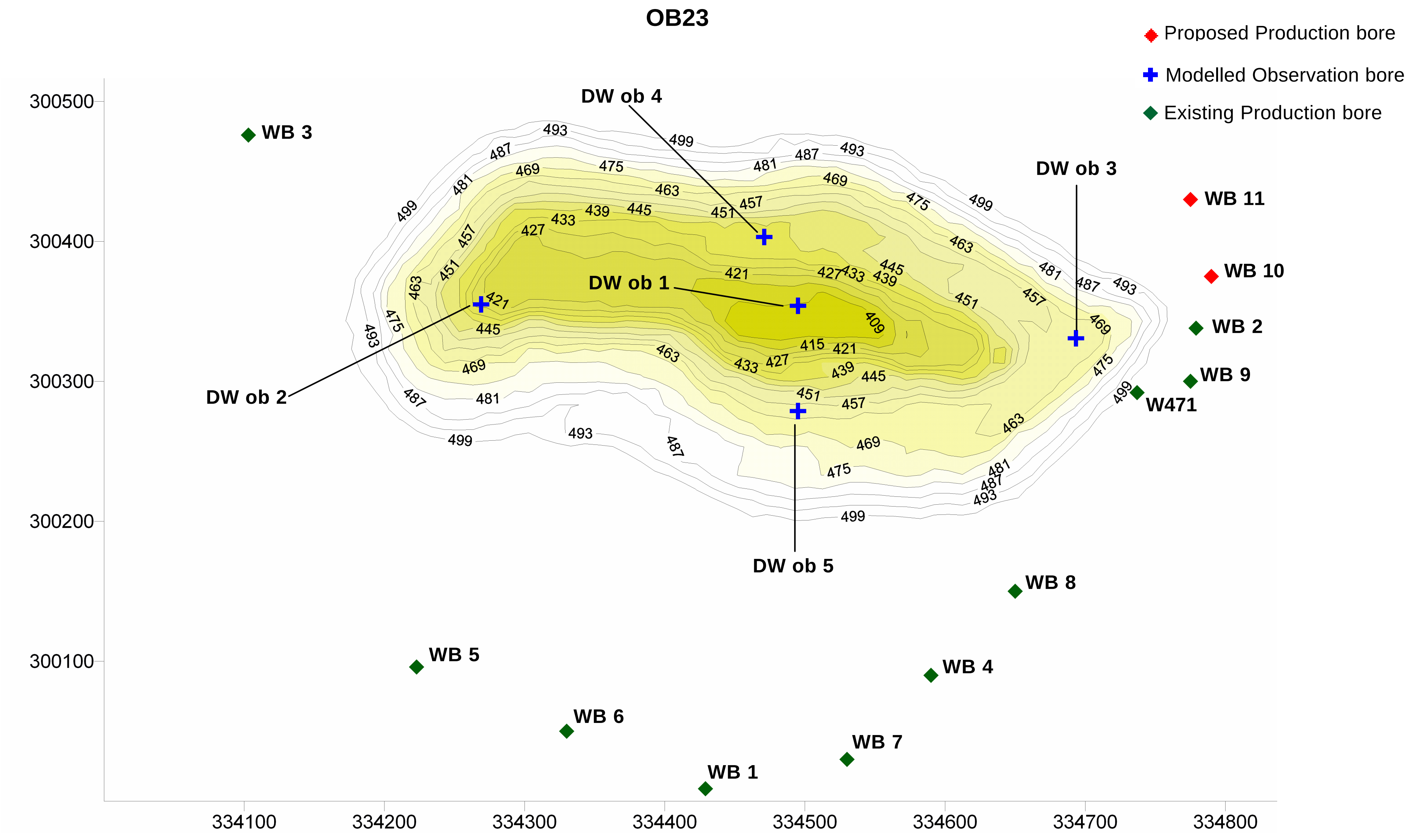
APPENDIX F

OB23

MODELLED PREDICTION PLOTS

Table F1
Predicted Dewatering Abstraction Rates

Time (Years)	OB23		
	Bench Level (mRL)	Dewatering Abstraction Dry Scenario (kL/d)	Dewatering Abstraction Wet Scenario (kL/d)
0 → 0.25	-	34660	34510
0.25 → 0.38	499	35270	35260
0.38 → 0.5	493	35270	35260
0.38→0.75	487	35780	35970
0.75→1	481	36150	36510
1→1.25	475	36520	36950
1.25→1.5	469	36240	36770
1.5→1.75	463	35920	36360
1.75→2	457	35530	36170
2→2.25	451	35590	36890
2.25→2.45	445	36190	37960
2.45→2.65	433	35870	38020
2.65→2.85	421	33760	37070
2.85→3.05	415	32060	36540
3.05→3.25	409	27870	34750
3.25→4.25	-	-	-
4.25→4.42	-	-	-
4.42→4.59	-	-	-
4.59→4.75	-	-	-
4.75→4.92	-	-	-
4.92→5.09	-	-	-
5.09→5.25	-	-	-



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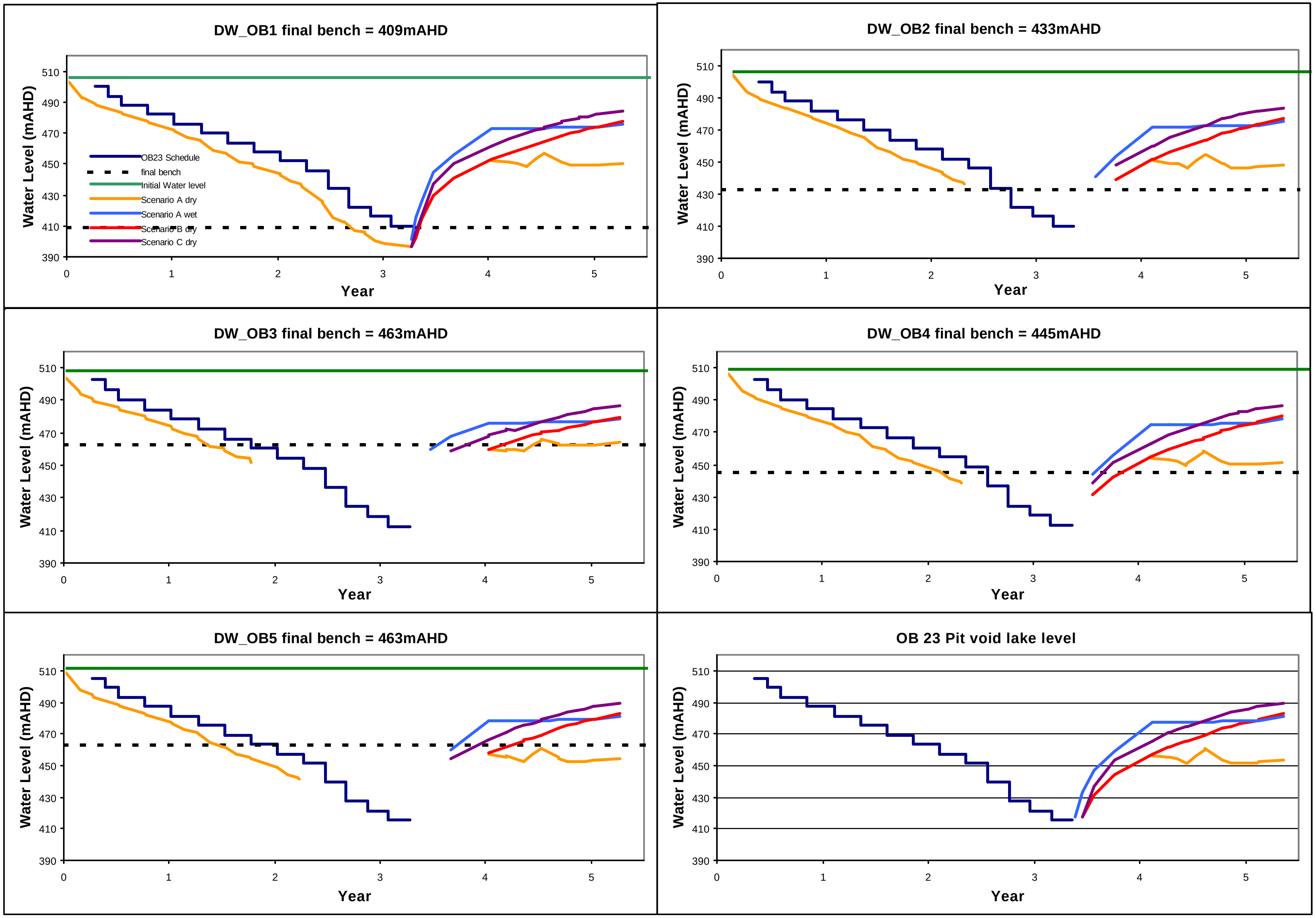
Pit Design for OB 23
Figure F1



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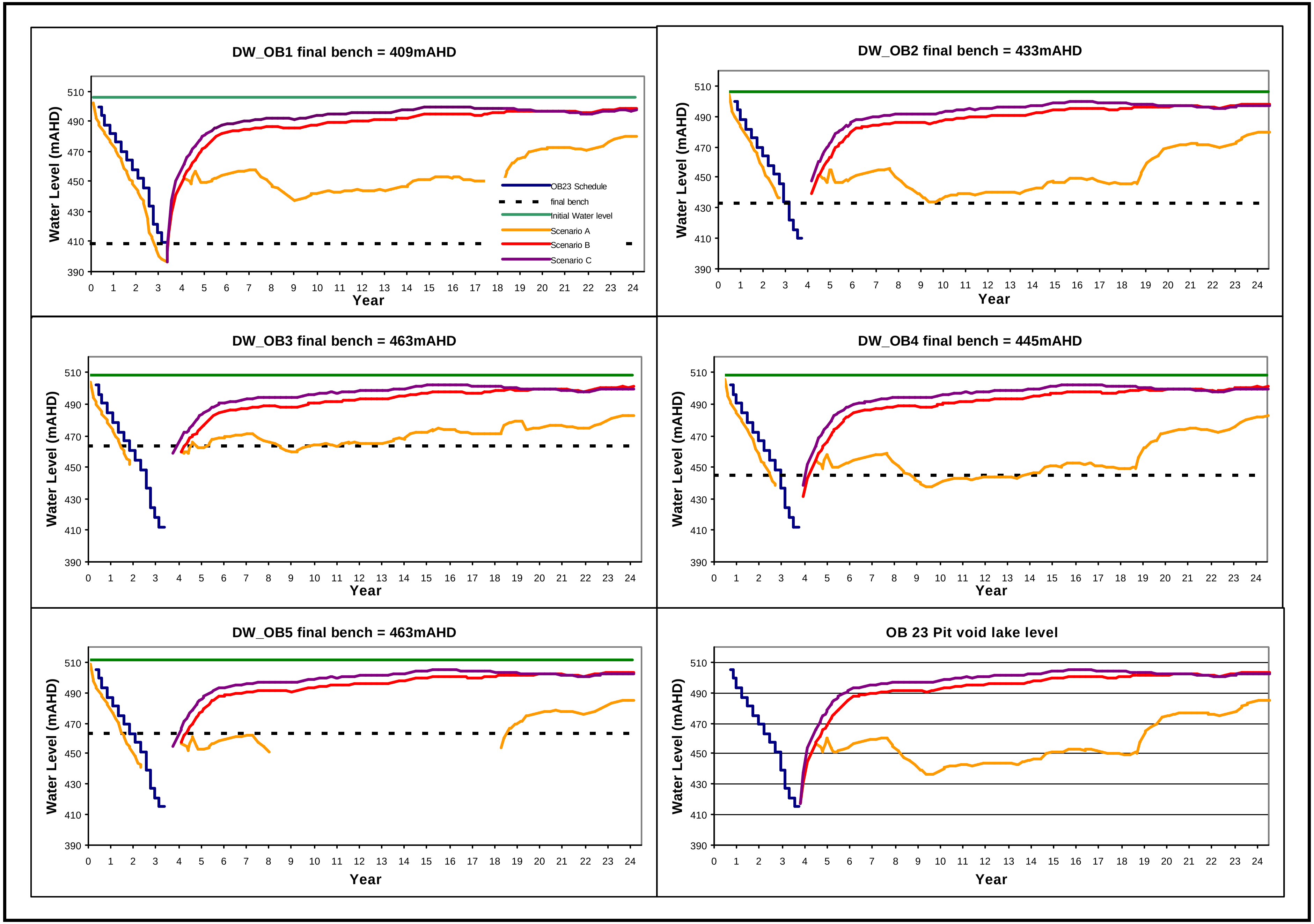
OB23 In-Pit Hydrographs during Dewatering Period

Figure F2



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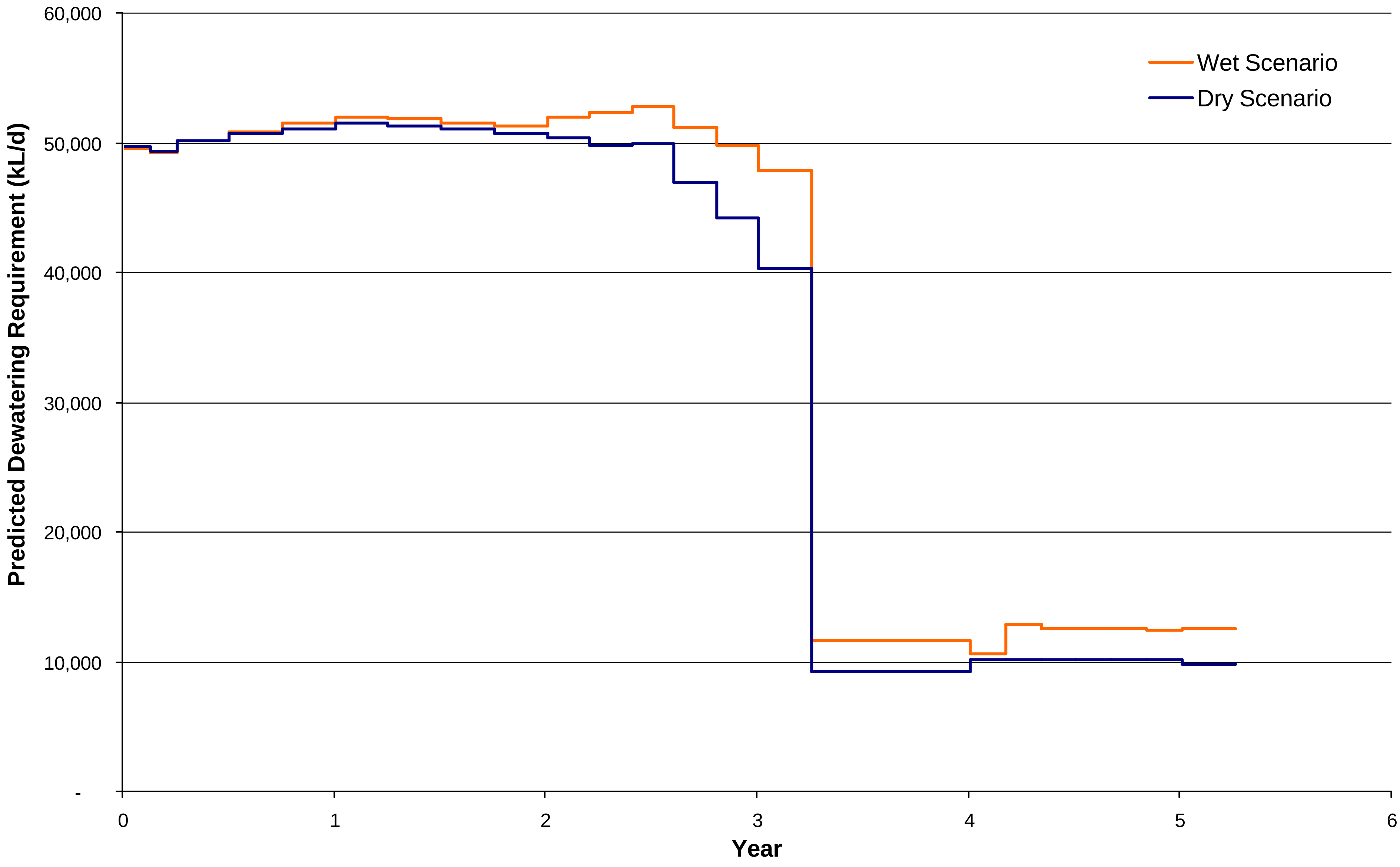
OB23 In-Pit Hydrographs Long Term

Figure F3



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Predicted Total Dewatering Requirements (OB23 and OB25)

Figure F4

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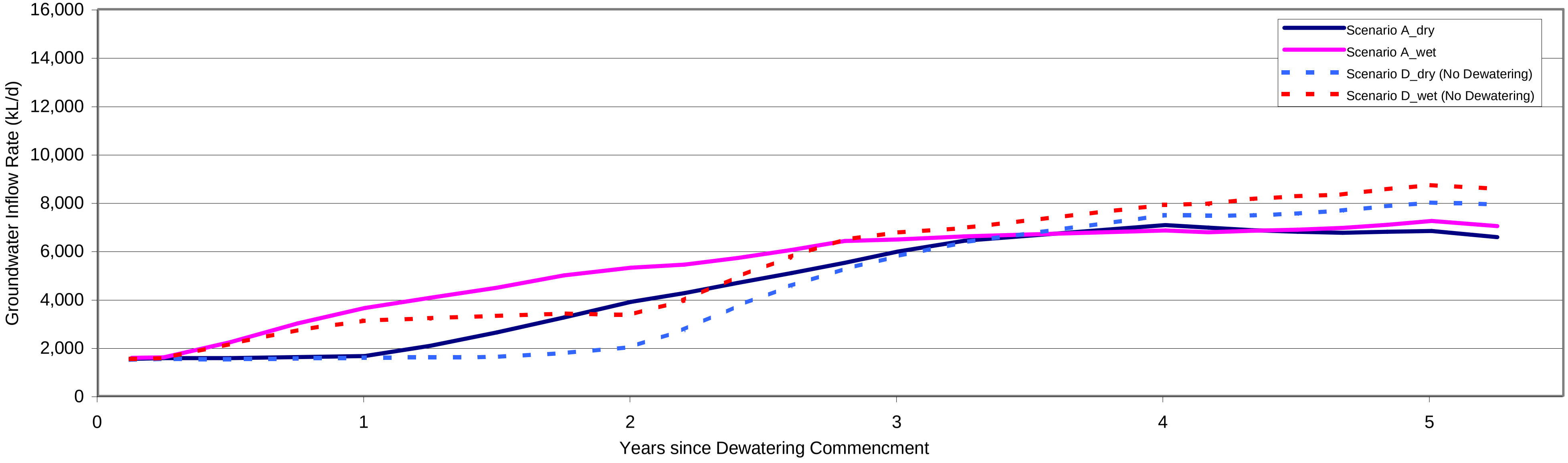
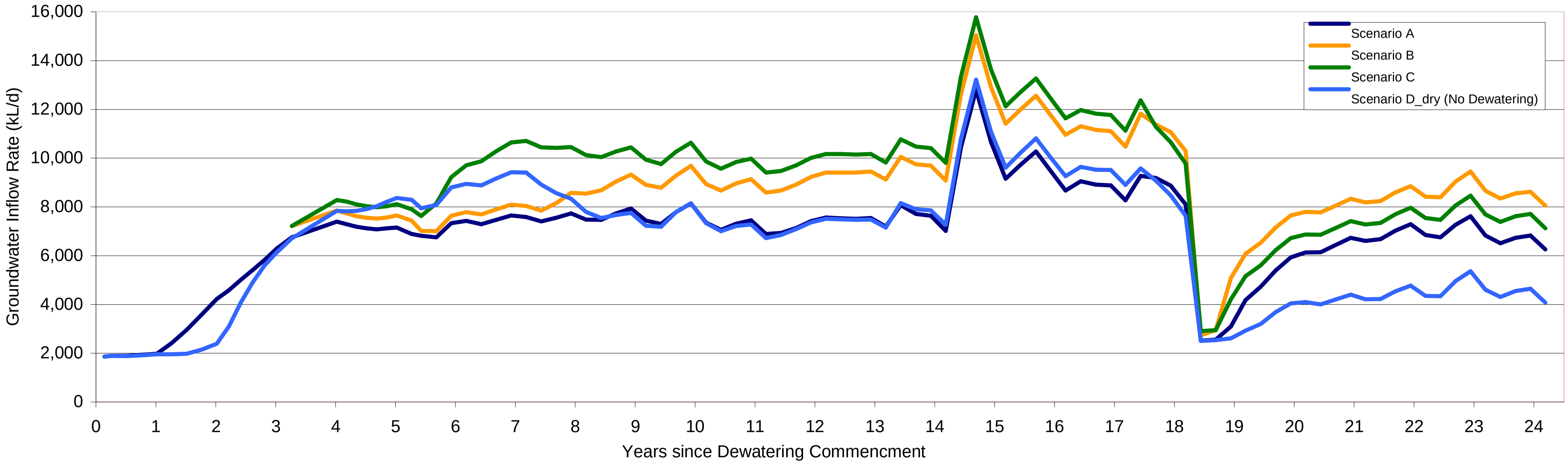
APPENDIX G

PREDICTED IMPACT ON SELECTED ELEMENTS OF THE MODELLED WATER BALANCE

Dewatering Period



Dewatering and Pit Closure Period



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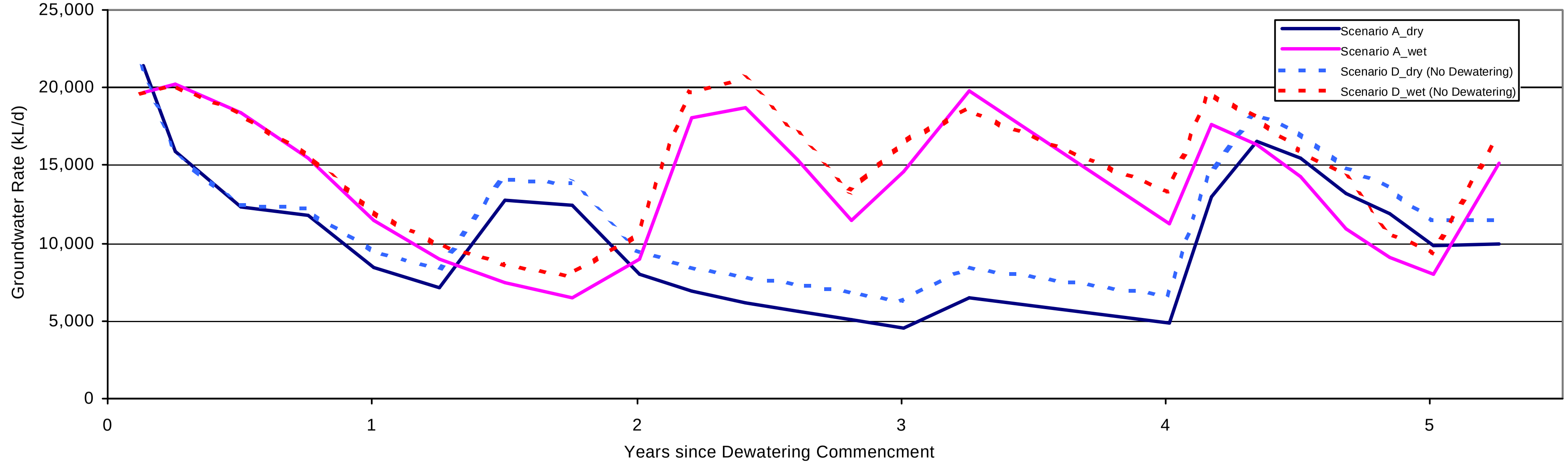
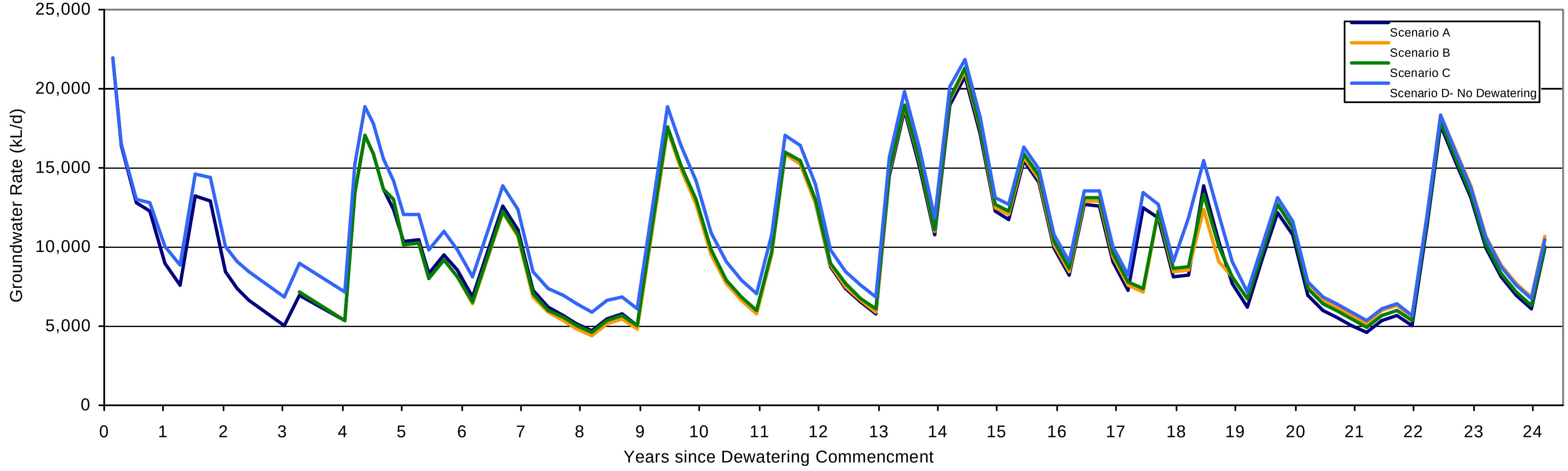
Predicted Impact of Dewatering on Groundwater Inflow

Figure G1



Dewatering Period



Dewatering and Pit Closure Period

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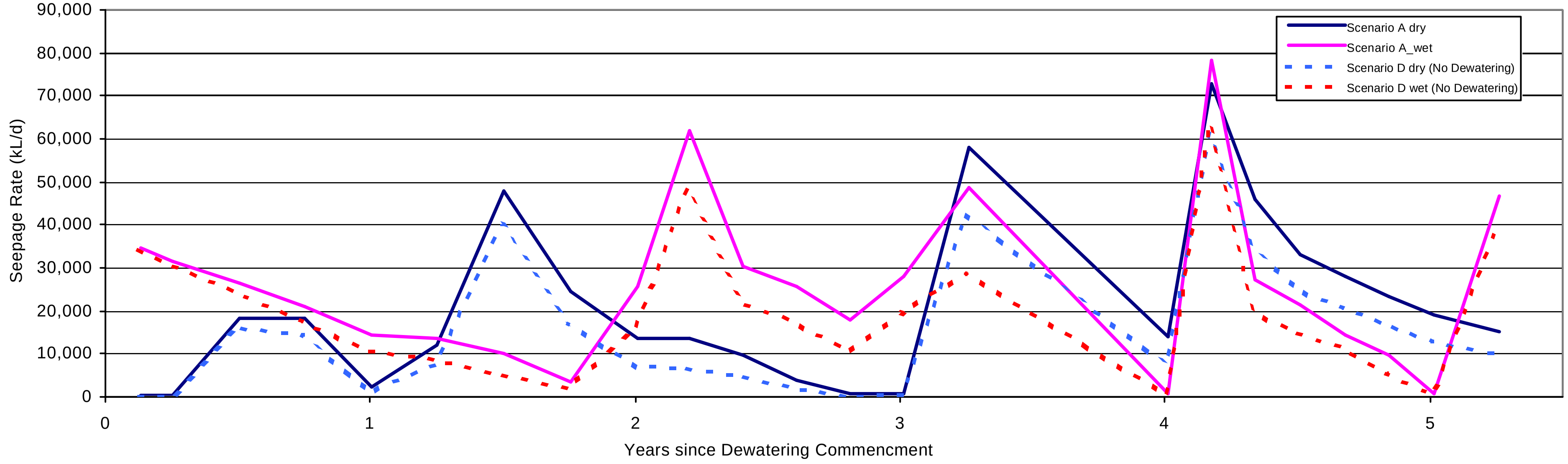
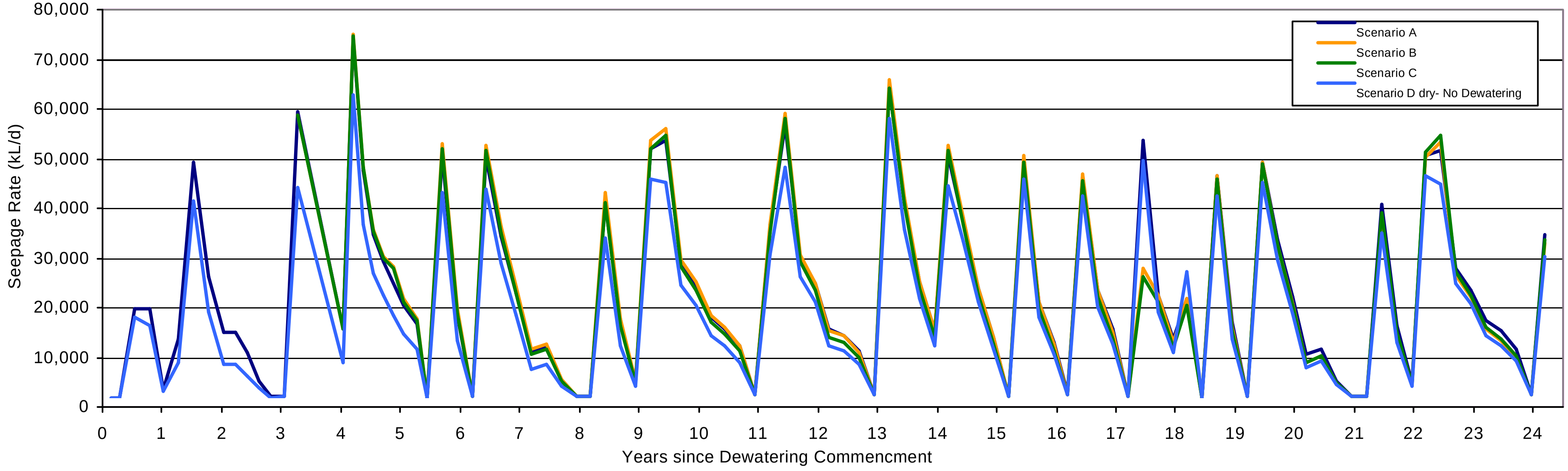
Predicted Impact of Dewatering on Groundwater Outflow

Figure G2

Dewatering Period



Dewatering and Pit Closure Period



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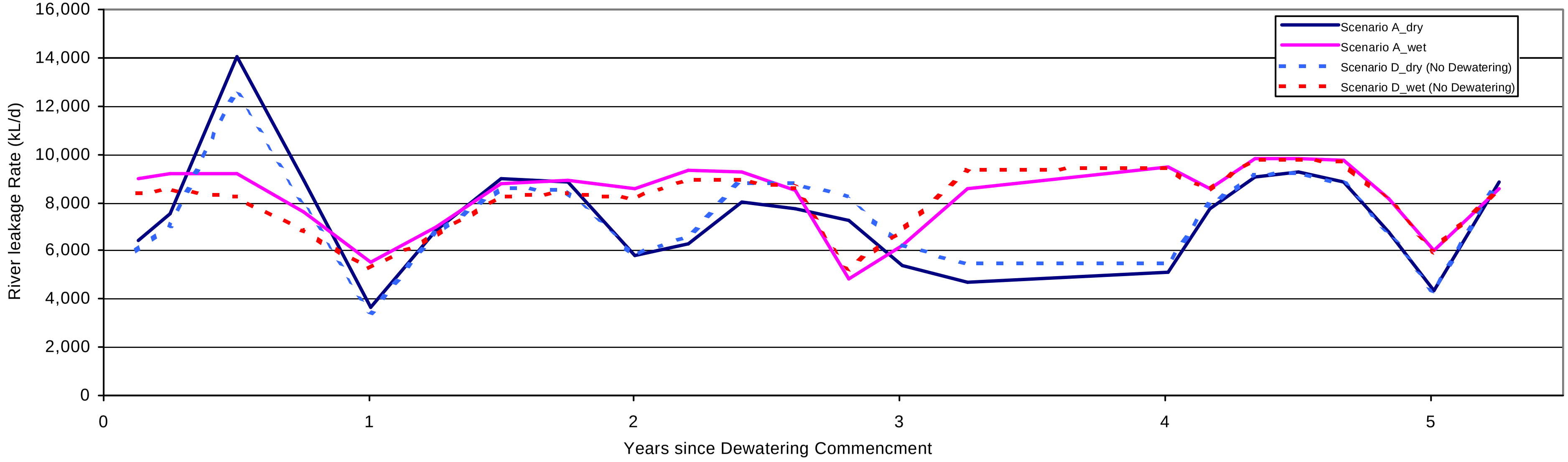
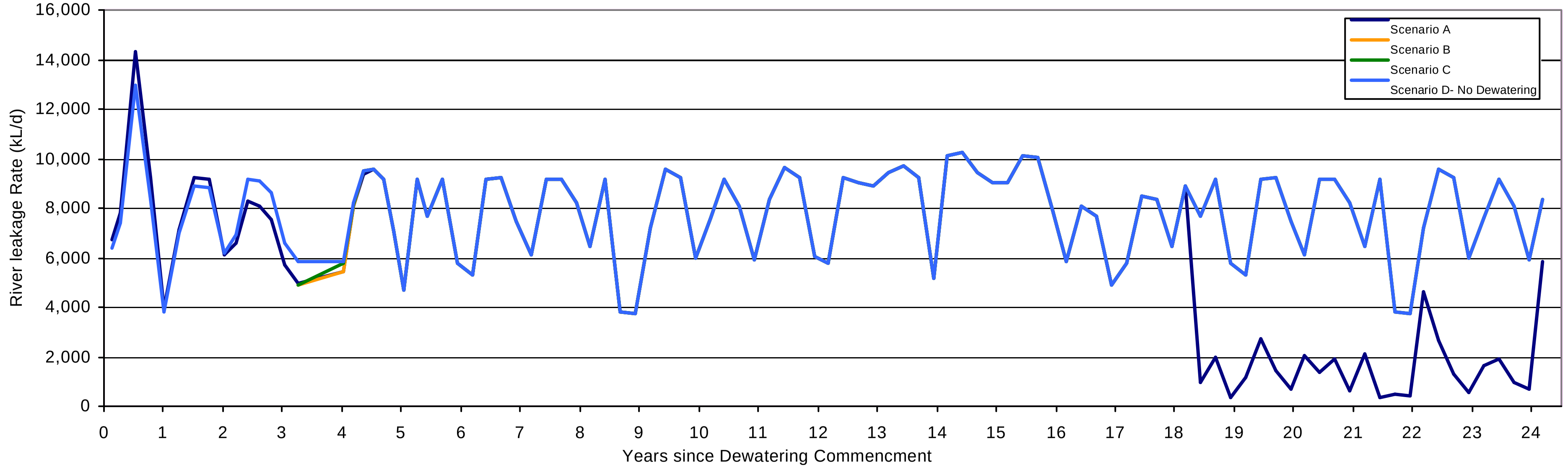
Predicted Impact of Dewatering on Seepage from Ophthalmia Dam

Figure G3

Dewatering Period



Dewatering and Pit Closure Period



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Predicted Impact of Dewatering on River Leakage from Homestead & Shovelanna Creeks into Alluvial Aquifer

Figure G4

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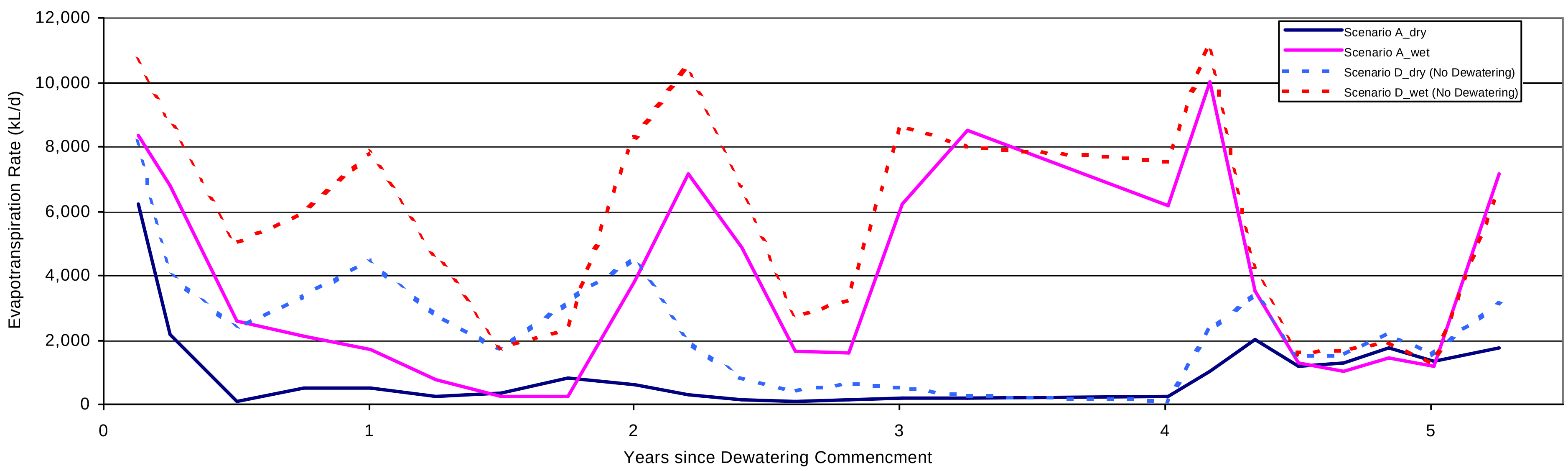
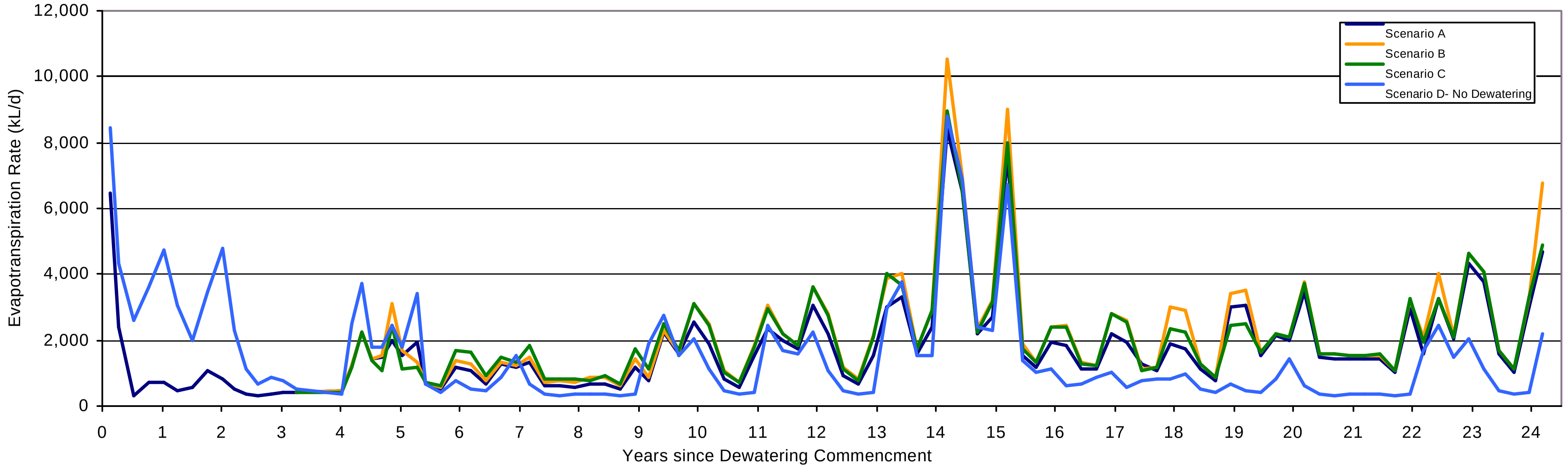
Dewatering period



Dewatering and Pit Closure Period



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Predicted Impact of Dewatering on Evapotranspiration (Vegetation Water Use)

Figure G5

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