2014 Hunter Valley Operations Annual Environmental Review

March 2015

Slashing cover crop on Cheshunt Rehabilitation

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Name of Mine	Hunter Valley Operations
Titles/Mining Leases	Contained within Section 1.4 of this report
Annual Review Commencement Date	01/01/2014
Annual Review End Date	31/12/2014
Name of Leaseholder	Coal and Allied Operations Pty Limited Novacoal Australia Pty Limited
Name of Mine Operator	Coal & Allied Operations Pty Limited
Reporting Officer	Mr Tom Lukeman
Title	General Manager Operations
Signature:	
Date:	25 March 2015

Executive Summary

This Annual Environmental Review (Annual Review) reports on the environmental performance of Hunter Valley Operations (HVO) during the 2014 calendar year and satisfies the requirements of the Hunter Valley Operations (HVO) Development Consents and Mining Leases. The structure of the 2014 Annual Review intends to align with the NSW Department of Trade and Investment *EDG03 Guidelines to the Mining, Rehabilitation and Environmental Management Process* and the NSW Department of Planning and Infrastructure Draft *Guideline for Preparation of Annual Environmental Management Review (AEMR) December 2012*.

HVO produced 17.99 million tonnes of run-of-mine (ROM) coal during 2014, and 13.81 million tonnes of saleable coal, against an approved ROM coal production rate of 28 million tonnes per annum (mtpa).

Noise

HVO manages noise to ensure compliance with permissible noise limits at nearby private residences. During the reporting period no non-compliances where recorded against HVO's development consent limits. An additional five haul trucks were fitted with sound attenuating equipment to reduce noise output. A total of 2,476 hours of mine stoppage was recorded due to proactive and reactive measures to minimise noise.

Blasting

During the reporting period 281 blast events were initiated at HVO. One blast event on 25th July 2014 recorded an airblast overpressure result of 120.2dB(L), against a limit of 120 dBL. No community complaints were received in relation to this blast. HVO complied with all other blasting related consent and licence conditions during the reporting period, including ground vibration. HVO employs a blast fume management protocol to mitigate generation of post blast fume emissions. Only four category 3 fume events were recorded in 2014 and no category 4 or 5 events. Figures 18 to 22 detail all valid blasts received by the five HVO compliance blast monitors.

Air Quality

Air quality monitoring at HVO is undertaken in accordance with the HVO Air Quality Monitoring Programme. This comprises an extensive network of monitoring equipment which is utilised to assess performance against the relevant conditions of HVO's approvals. During 2014, HVO complied with all short term and annual average air quality criteria. A total of 3,066 hours of mine stoppage was recorded due to proactive and reactive measures to minimise dust. HVO achieved a haul dust control efficiency of 96% against a target of 80% required by the EPA's dust pollution reduction programme. A total of 313 ha of land was aerial seeded during autumn to minimise wind eroded dust from overburden areas not yet available for rehabilitation.

Surface Water

Surface water monitoring activities continued in 2014 in accordance with the HVO Water Management Plan and HVO Surface Water Monitoring Programme. HVO maintains a network of surface water monitoring sites for mine site dams, discharge points and surrounding natural watercourses. Two incidents involving water leaving the mine premise required notification to government agencies. Both incidents were due to rupture of a pipeline during transfer of mine water. Each incident was thoroughly investigated with corrective and preventative actions implemented.

During 2014 significant upgrade works were completed to the sediment basins on the north side of the Hunter River bridge to improve water management and sediment control in this area. HVO did not extract any water from the Hunter River in 2014.

Groundwater

Groundwater monitoring activities were undertaken in 2014 in accordance with the HVO Water Management Plan and Groundwater Monitoring Programme. The monitoring results are used to establish and monitor trends in physical and geochemical parameters of surrounding groundwater potentially influenced by mining. No adverse water quality issues were identified in 2014. Work continued on installation of a deep bore in the in Alluvial Lands area with a network of piezoemeters installed ahead of drilling and construction of the bore in 2015.

Heritage

During the reporting period there were 70 GDPs assessed for Cultural Heritage considerations regarding mining development disturbance activities at HVO. In all cases the ground disturbance works were conducted on an Aboriginal cultural heritage sites avoidance basis so that no extant cultural sites were impacted up on by these activities.

The Stage One Chain of Ponds Stabilisation Programme commenced in November 2014. These works are being conducted under an approval granted by the Heritage Council of NSW & pursuant to Section 63 of the NSW Heritage Act 1977. These initial works aim to provide immediate structural integrity to the buildings to ensure their continued stability & safety in the short term.

Visual amenity

No complaints were received in relation to lighting during the reporting period. Training programmes, signage on the lighting plants and angle exclusion zones are in place to reduce the potential of light impacting on neighbouring residents.

Rehabilitation and Land Management

A total of 192.5 ha of mined land was rehabilitated in 2014 against a target of 188 ha and land disturbance of 128.2 ha. Rehabilitation quality improvements were progressed including the use of mixed waste compost to improve soil fertility, direct drilling of seed, cover crops and utilising seed harvesting areas to facilitate use of locally sourced seed.

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List of Symbols

<	Less than
>	Greater than
dB(A)	Decibels (“A” weighted)
dB (L)	Decibels (Linear)
g/m^2	grams per square metre
bcm	bank cubic meters
Kbcm	kilo bank cubic meters
kg	kilogram
t	tonne
kt	Kilotonnes
kL	Kilolitre
L/s	Litres per second
L/t	Litres per tonne
m	metre
µ	micron
µg	micrograms
mg	milligrams
mg/L	Milligrams per litre
µS/cm	microsiemens per centimetre
m	metre
m2	square metre
m3	cubic metre
mm	millimetres
mg/L	milligrams/litre
mm/s	millimetres/second
ML	Mega litre
t	tonnes
Mtpa	Million tonnes per annum
Ha	Hectares
MWh	Mega Watt hours
GJ	Giga Joules
tCO2-e	Tonnes Carbon Dioxide equivalent

List of Abbreviations

ACARP	Australian Coal Association Research Programme	EEO Act	*Energy Efficiency Opportunities Act 2006*
AHCS	Aboriginal Heritage Conservation Strategy	EIS	Environmental Impact Statement
ADCC	Aboriginal Development Consultative Committee	EPA	Environmental Protection Agency
AEMR	Annual Environmental Management Report	EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
AHIMS	Aboriginal Heritage Information Management System	EPL	Environment Protection Licence
AS	Australian Standard	FFMP	Flora and Fauna Management Plan
CCL	Consolidated Coal Lease	GDP	Ground Disturbance Permit
CHAG	Community Heritage Advisory Group	GIS	Geographic Information System
CHPP	Coal Handling Preparation Plant	HMA	Habitat Management Area
CHWG	Cultural Heritage Working Group	HMP	Heritage Management Plan
CL	Coal Lease	HRSTS	Hunter River Salinity Trading Scheme
CO2CRC	The Cooperative Research Centre for Greenhouse Gas Technologies	HSEQ MS	Health, Safety, Environment & Quality Management System
DA	Development Application	HVAS	High Volume Air Samplers
DC	Development Consent	HVO	Hunter Valley Operations
DECC	NSW Department of Environment and Climate Change	INP	NSW EPA Industrial Noise Policy
DPI	NSW Department of Primary Industries	ML	Mining Lease
DP&E	NSW Department of Planning & Environment	MLA	Mining Lease Application
DRE	NSW Division of Resources and Energy	MOP	Mining Operations Plan
DSEWPaC	Commonwealth Department of Sustainability, Environment, Water, Population and Communities	MTIE	Mount Thorley Industrial Estate

EA	Environmental Assessment	MTO	Mount Thorley Operations
EC	Electrical Conductivity	MTJV	Mount Thorley Joint Venture
EEC	Endangered Ecological Community	MTW	Mount Thorley Warkworth
NCCSC	Australian National Carbon Capture and Storage Council	RL	Reduced Level
NSWCCC	New South Wales Clean Coal Council	ROM	Run of Mine
NDA	Non-Disturbance Area	RMS	NSW Department of Roads and Maritime Services
NGER Act	*National Greenhouse and Energy Reporting Act 2007*	SCADA	Supervisory Control and Data Acquisition
NHMRC	National Health and Medical Research Council	TEOM	Tapered Element Oscillating Microbalance
NOW	NSW Office of Water	TSP	Total Suspended Particulates
NPWS	National Parks and Wildlife Service	TSS	Total Suspended Solids
OCE	Open Cut Examiner	UHAQMN	Upper Hunter Air Quality Monitoring Network
OEH	Office of Environment & Heritage	UNE	University of New England
PA	Project Approval	WAL	Water Access Licence
pH	Measure of the hydrogen ion concentration, [H+]	WML	Warkworth Mining Limited
PM_{10}	Particulate Matter < 10 micron units	WSW	Warkworth Sands Woodland

1 INTRODUCTION

1.1 Document purpose

This Annual Review is written to satisfy the requirements of the Hunter Valley Operations (HVO) Development Consents and conditions of mining lease for events occurring within the 2014 calendar year. The Annual Review has been written in accordance with the NSW Department of Trade and Investment *EDG03 Guidelines to the Mining, Rehabilitation and Environmental Management* and the NSW Department of Planning and Infrastructure Draft *Guideline for Preparation of Annual Environmental Management Review (AEMR) December 2012.*

This report is distributed to:

- NSW Department of Planning and Environment (DP&E);
- NSW Department of Trade and Investment, Division of Resources and Energy (DRE)
- Singleton Council and Singleton Library;
- Muswellbrook Shire Council (MSC) and Muswellbrook Library;
- HVO Community Consultative Committee (CCC); and
- Singleton and Muswellbrook Coal & Allied Shop fronts

1.2 Background Development

HVO is situated in the Upper Hunter Valley between Singleton and Muswellbrook, approximately 24 km northwest of Singleton, and approximately 100 km northwest of Newcastle. The Hunter River geographically divides HVO into HVO North and HVO South; however they are integrated operationally with personnel, equipment and materials utilised as required. This improves operational efficiency, rationalisation of infrastructure and improved resource utilisation. Hunter Valley Operations is 100 per cent owned by Coal & Allied Operations Pty Limited. Rio Tinto Coal Australia has an agreement to provide management services to Coal & Allied Operations Pty Limited.

Table 1 outlines the integration of pits and facilities at HVO over time. The layout of the HVO pits and facilities is shown in Figure 1.

Table 1: Integration of Pits and facilities at HVO

Area	Incorporating	Description
West Pit (previously Howick Pit)	West CPP (formerly known as Howick Coal Preparation Plant (HCPP)), Newdell Coal Preparation Plant (NCPP) and Newdell Load Point (NLP);	West Pit is one of the oldest established pits in the Hunter Valley, with mining first commencing in 1952. Rio Tinto Coal assumed management of the pit in 1997 following the merger of Rio Tinto Zinc and Conzinc Rio Tinto of Australia. Seven seams (with up to 21 splits) are mined, with consent to mine up to 12 mtpa ROM coal. Seams dip at an average of 7.5 degrees to the south east with an overburden to product coal ratio average of 8.2:1.
North Pit and Alluvial Lands (previously Hunter Valley Number 1)	Hunter Valley Load Point (HVLP) and the Hunter Valley Coal Preparation Plant (HVCPP);	North Pit commenced coal recovery in 1979 and mining was extended to the alluvial floodplain in 1993, until its conclusion in 2003. Rehabilitation of the area between the Hunter River and the final void was completed in 2008 with the filling of the final void with tailings to be completed in approximately 2020.
Carrington Pit		Carrington Pit is located on the western boundary of North Pit and commenced operations in November 2000. The seams mined are the Broonies and Bayswater. The pit has consent to mine up to 10 mtpa ROM coal, with all seams dipping at an average of three degrees to the south east. The overburden to product coal ratio averages 5.8:1.
South Pit (previously Lemington Pit and South Pit or Hunter Valley Number 2)	Incorporating the new Cheshunt Development and the former Lemington Pit, as well as the Riverview Pit	Cheshunt Pit incorporates the former Lemington North Pit, where the new strip alignment commenced in November 2001. Seams mined in the Cheshunt Pit are Warkworth, Mt Arthur, Piercefield and Vaux seams and the pit has a combined consent with the Riverview Pit to mine up to 8 mtpa ROM coal. Seams predominantly dip at two degrees to the south east with an overburden to product coal ratio of around 9.3:1. Following the grant of the HVO South consent in 2009, the Deep Cheshunt development was commenced. This involves the extraction of Piercefield, Broonies and Bayswater seams with the first strip of Bayswater coal being extracted during the second half of 2011 Riverview Pit commenced mining operations in 1991 and a modification to consent in 2001 allowed for the introduction of a dragline. Coal is extracted from the Glen Munro, Woodlands Hill, Arrowfield and Bowfield seams. The combined consent with Cheshunt Pit allows annual ROM coal production of up to eight mtpa. Predominantly, seams dip at three degrees to the south east and the current overburden to product coal strip ratio is approximately 7.3:1.
Lemington South Pit.		Lemington South Pit is located on the southern side of the Wollombi Brook and is consented to produce up to 4.4 mtpa of product coal. Mining operations are currently suspended within the Lemington South Pit.

Figure 1: Site Layout

1.3 Statement of Compliance (quick reference table)

Table 2 is a brief summary of the conditions of the consent relevant to this Annual Review, and a reference to where each aspect is addressed within this Annual Review.

Table 2: Brief Summary of Conditions of the Consent Related to this Annual Review

Environmental Performance Condition	Compliance with PA06_0261(HVO South) Conditions and MOP	Compliance with EA/EIS prediction	Compliance with DA 450-10-2003 (HVO North) Conditions and MOP	Compliance with EA/EIS prediction
Meteorological monitoring	🟩 3.1	n/a	🟩 3.1	n/a
Noise	🟩 3.2	🟥 3.2.2	🟩 3.2	🟩 3.2.2
Blasting	🟩 3.3	🟩 3.3.2	🟥 3.3.2	🟩 3.3.2
Air quality	🟩 3.4	🟩 3.4.3.5	🟩 3.4.3	🟩 3.4.3.5
Surface water	🟥 3.6.2.1	🟩 3.6.2.4	🟩 3.6.2.4	🟩 3.6.2.4
Ground water	🟩 3.7.2.1	🟩 3.7.2.1	🟩 3.7.2.1	🟩 3.7.2.1
Aboriginal heritage	🟩 2.2.1	🟩 2.2.9	🟩 2.2.9	🟩 2.2.9
Transport and utilities	🟩 2.1.4	🟩 2.1.4	🟩 2.1.4	🟩 2.1.4
Visual amenity	🟩 3.9	🟩 3.9	🟩 3.9	🟩 3.9
Greenhouse & energy efficiency	🟩 3.8	🟩 3.8.2	🟩 3.8.2	🟩 3.8.2
Waste	🟩 3.11	🟩 3.11	🟩 3.11	🟩 3.11
Hazardous Substances	🟩 3.11.2	n/a	🟩 3.11.2	n/a
Rehabilitation and landscape	🟩 5.2	🟩 5.2	🟩 5.2*	🟩 5.2

Legend

Compliant	🟩
Condition/impact criteria non-compliance	🟥
Administrative Non-Compliance	🟦

*Comparison determined against annual MOP targets (see Section 5.2).

1.4 Approvals, Leases and Licenses

1.4.1 Current Approvals

The status of HVO development consents, licenses and relevant approvals are listed in the following tables:

- Table 3: HVO Major Approvals
- Table 4: HVO Mining Tenements
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- Table 5: HVO Licences and Permits
- Table 6: Water Related Approvals
- Table 7: Water Access Licence

Table 3: HVO Major Approvals

Approval Number	Description	Issue Date	Expiry Date
HVO North DA 450-10-2003 MOD 3	Carrington Pit extension between Lemington Rd and the existing operation. Covers West Pit (approved production limit of 12mtpa), Carrington Pit (approved production limit of 10mtpa), HVCHPP (approved processing limit of 20mtpa) and WCHPP (approved processing limit of 6mtpa).	12/06/2004	12/06/2025
HVO South PA 06_0261	Hunter Valley Operations – South Coal Project & associated modifications Covers Riverview Pit, Cheshunt, Deep Cheshunt, and Lemington South, with a combined production limit of 16mtpa.	24/03/2009	24/03/2030

The HVO Environmental Protection Licence (EPL 640) Annual Return was completed and submitted to the EPA in May 2014. Six non-compliances were reported against the conditions of EPL 640. Three of these non- compliances related to incidents which occurred in 2013, and therefore not within the reporting period for this report. The remaining three were technical non-compliances relating to instances of monitoring system failure.

No section 90 or section 87 permits were sought or obtained in the 2014 reporting period.

The mining tenements are summarised in Table 4(HVO mining tenements).

Table 4: Summary of Mining Tenements

Title	Mining Tenement	Purpose	Grant Date	Expiry Date	Status
AUTH 435	Authorisation	Prospecting	08/05/1991	08/05/2015	Granted
AUTH 72	Authorisation	Prospecting	08/03/1977	24/03/2018	Granted
(Part) CCL 708	Sub-Lease	Prospecting and Mining Coal	17/05/1990	29/12/2023	Granted
CCL 714	Consolidated Coal Lease	Prospecting and Mining Coal	23/05/1990	30/08/2030	Granted
CCL 755 (HV1 Consolidation)	Consolidated Coal Lease	Prospecting and Mining Coal	24/01/1990	05/03/2030	Granted
CL 327 (Hunter Valley No.2)	Coal Lease	Prospecting and Mining Coal	06/03/1989	06/03/2031	Granted
CL 359 (Former Lemington Road)	Coal Lease	Prospecting and Mining Coal	21/05/1990	21/05/2032	Granted
CL 360 (Additional Area – HV1)	Coal Lease	Prospecting and Mining Coal	29/05/1990	29/05/2032	Granted
CL 398 (West Corners of Riverview)	Coal Lease	Prospecting and Mining Coal	04/06/1992	04/06/2034	Granted
CL 584 (Newdell CPP)	Coal Lease	Prospecting and Mining Coal	01/01/1982	31/12/2023	Granted
CML 4 (Howick Consolidation)	Consolidated Mining Lease	Prospecting and Mining Coal	02/03/1993	03/06/2033	Granted
EL 5291	Exploration Licence	Prospecting	28/04/1997	23/09/2015	Granted
EL 5292	Exploration Licence	Prospecting	28/04/1997	27/04/2015	Granted
EL 5417	Exploration Licence	Prospecting	23/12/1997	08/05/2015	Granted
EL 5418	Exploration Licence	Prospecting	23/12/1997	08/05/2017	Granted
EL 5606	Exploration Licence	Prospecting	11/08/1999	10/08/2014	Renewal Pending
EL 8175	Exploration Licence	Prospecting	23/09/2013	22/09/2018	Granted

Title	Mining Tenement	Purpose	Grant Date	Expiry Date	Status
ML 1324 (Alluvial Lands)	Mining Lease	Prospecting and Mining Coal	19/08/1993	19/08/2014	Renewal Pending
ML 1337 (Belt Line road)	Mining Lease	Prospecting and Mining Coal	01/02/1994	09/09/2014	Renewal Pending
ML 1359 (Access Roads HVCPP Coal Loader)	Mining Lease	Prospecting and Mining Coal	01/11/1994	01/11/2015	Renewal Pending
ML 1406 (East of D/L Erection Pad)	Mining Lease	Prospecting and Mining Coal	27/02/1997	10/02/2027	Granted
ML 1428 (Mitchell & Carrington Pits)	Mining Lease	Prospecting and Mining Coal	15/04/1998	14/04/2019	Granted
ML 1465 (Lemington)	Mining Lease	Prospecting and Mining Coal	21/02/2000	21/02/2021	Granted
ML 1474 (Carrington Pit)	Mining Lease	Prospecting and Mining Coal	24/11/2000	23/11/2021	Granted
ML 1482 (Carrington Dams)	Mining Lease	Prospecting and Mining Coal	19/03/2001	14/04/2019	Granted
ML 1500 (Mitchell 1 Road)	Mining Lease	Prospecting and Mining Coal	21/12/2001	20/12/2022	Granted
ML 1560 (West Pit Extension Area)	Mining Lease	Prospecting and Mining Coal	28/01/2005	27/01/2026	Granted
ML 1589 (Carrington Extended)	Mining Lease	Prospecting and Mining Coal	02/11/2006	01/11/2027	Granted
ML 1622	Mining Lease	Prospecting and Mining Coal	22/10/2010	10/03/2027	Granted
ML 1634	Mining Lease	Prospecting and Mining Coal	31/07/2009	30/07/2030	Granted
ML 1682	Mining Lease	Prospecting and Mining Coal	16/12/2012	15/12/2033	Granted

Title	Mining Tenement	Purpose	Grant Date	Expiry Date	Status
MLA 397	Mining Lease Application	Prospecting and Mining Coal	Mining Lease Application lodged 2nd March 2011		Offer of Grant- Pending Determination
MLA 398	Mining Lease Application	Mining Purposes	Mining Lease Application lodged 10th September 2012		Application Pending
ALA 52	Assessment Lease Application	Prospecting	Mining Lease Application lodged 10th September 2012		Offer of Grant – Pending Determination
MLA 435	Mining Lease Application	Mining Purposes	Mining Lease Application lodged 14th September 2012		Offer of Grant – Pending Determination
MLA 436	Mining Lease Application	Prospecting and Mining Coal	Mining Lease Application lodged 14th September 2012		Offer of Grant – Pending Determination

Table 5: HVO Leases and Permits

Licence No.	Description	Authority	Expiry Date
Environmental Protection Licence			
EPL 640	Environment Protection Licence	EPA	N/A
Dangerous Goods / Explosives			
35/037852	Notification of Dangerous Goods on Premise	Workcover	9/07/2014 (after which, incorporated into the Radiation Management Licence)
RR12709	Licence to Store	Workcover	06/7/2017
Radiation Licence			
RL28724	Radiation Licence	EPA	15/08/2014 (after which, incorporated into the Radiation Management Licence)
RML5061121	Radiation Management Licence	EPA	05/09/2015
Aboriginal Heritage Permits			
2863	Care and Control Permit (Renewed & extended until 16 January 2016)	OEH	16/01/2016
Road Closure Permits			
8986 – Extension 5	Road Occupancy Licences– Golden Highway	RMS	31/12/2014
	Road Occupancy Licences– Jerrys Plains Rd	SC	31/12/2014

Table 6: Water Related Approvals

Licence Number	Type of License	Purpose	Legislation	Description	Renewal Date
20BL030566	Bore	Well	Part 5 Water Act 1912	East Open Cut	Perpetuity
20BL141584	Bore	Monitoring Bore		HVO North – Carrington Work Licence	Perpetuity
20BL166637	Bore	Monitoring Bore	Part 5 Water Act 1912	No Current Bores	Perpetuity
20BL167860	Bore	Excavation - Mining	Part 5 Water Act 1912	HVO North – Carrington Pit	11/05/2015
20BL168820	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO North – Bores: CGW39, CGW45a, CGW46,CGW47, CGW47a, CGW48, CGW49, P50/38.5, ,CGW56, 4036C, 4035P, 4032P, 4034P, 4033P, 4053P, 4052P, 4051C, 4040P, 4038C, 4037P Destroyed:CGW7,CGW50, CGW57, CGW58, CGW59, CGW60, CGW61, CGW62, CGW63	Perpetuity
20BL169241	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO North – Bores: DM1, , HF3, HF7 Destroyed DM2	Perpetuity
20BL169962	Bore	Excavation - Mining	Part 5 Water Act 1912	HVO West – West Pit Excavation	23/12/2015
20BL170000	Bore	Excavation - Mining	Part 5 Water Act 1912	HVO North – Pit Excavation	11/05/2016
20BL170010	Bore	Excavation - Mining	Part 5 Water Act 1912	HVO South – Cheshunt/Riverview Extended Excavation	26/11/2016

Licence Number	Type of License	Purpose	Legislation	Description	Renewal Date
20BL170496	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO South – Bores: BZ10 (CHPZ 2A), BZ11 (CHPZ 3A), BZ18 (CHPZ 10A), BZ20 (CHPZ 12A), BZ21 (CHPZ 13D) , BZ21A (CHPZ 13A), BZ20A (CHPZ 12D), BZ11A (CHPZ 3D) Destroyed AP50/47.5, AQ52, AV50/56.5, AS50/62.5, AR55, Bunc 3, BZ25 (Bunc 12) , BZ23 (Bunc 14), BZ24 (Bunc 13),	Perpetuity
20BL170497	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO South – Bores: BZ15 (CHPZ 7A), BZ16 (CHPZ 8D), BZ17 (CHPZ 9A), BZ19 (CHPZ 11A), BZ16A (CHPZ 8A), Bunc 46D Destroyed Bunc 39 (Shallow & Deep), Bunc 44D	Perpetuity
20BL170498	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO South – Bores: BZ12 (CHPZ 4A), BZ13 (CHPZ 5A), BZ14, BZ9 (CHPZ 1A), BC1, BC1a, BZ8-1, BZ8-2, BZ8-3, HG1, HG2, HG2a, HG3, S4, S6, BZ22 (CHPZ14D), BZ22A (CHPZ 14A), BZ5-1, BZ5-2 Destroyed S2, S3, S9, S11	Perpetuity
20BL173589	Bore	Dewatering Bore	Part 5 Water Act 1912	HVO North – DM7 Dewatering Bore	13/10/2015
20BL173587	Bore	Dewatering Bore	Part 5 Water Act 1912	HVO North – DM9 Dewatering Bore	13/10/2015
20BL173588	Bore	Dewatering Bore	Part 5 Water Act 1912	HVO North – DM8 Dewatering Bore	13/10/2015

Licence Number	Type of License	Purpose	Legislation	Description	Renewal Date
20BL171423	Bore	Monitoring Bore	Part 5 Water Act 1912	E1.5	Perpetuity
20BL171424	Bore	Monitoring Bore	Part 5 Water Act 1912	Destroyed GW9711	Perpetuity
20BL171425	Bore	Monitoring Bore	Part 5 Water Act 1912	Bores: GW9701, GW9710	Perpetuity
20BL171426	Bore	Monitoring Bore	Part 5 Water Act 1912	Bores: GW9702 Destroyed D2(WH236),	Perpetuity
20BL171427	Bore	Monitoring Bore	Part 5 Water Act 1912	Bores: C335, C630 (BFS)	Perpetuity
20BL171428	Bore	Monitoring Bore	Part 5 Water Act 1912	D807	Perpetuity
20BL171429	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO South – Bores: B925 (BFS), C122 (BFS), C122 (WDH)	Perpetuity
20BL171430	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO South – Bores: C613 (BFS), C809 (GM/WDH)	Perpetuity
20BL171431	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO South – Bores: B631 (BFS), B631 (WDH)	Perpetuity
20BL171432	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO South – Bores: C130 (AFSH1), C130 (ALL), C130(BFS), C130 (WDH)	Perpetuity
20BL171433	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO South – Bore B334 (BFS)	Perpetuity
20BL171434	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO South – Bores: C317 (BFS), C317 (WDH)	Perpetuity
20BL171435	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO South – Bores: BZ3-1, BZ3-2, BZ3-3	Perpetuity
20BL171436	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO South – Bores: BZ4A(1), BZ4A(2), BZ4B	Perpetuity
20BL171437	Bore	Monitoring Bore	Part 5 Water Act 1912	Bores: WG1, WG2, WG3	Perpetuity

Licence Number	Type of License	Purpose	Legislation	Description	Renewal Date
20BL171438	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO North – Bores: CGW5, CGW51A, CGW52, CGW53, CGW54, CGW55A, CGW53A, CGW52A, CGW54A, CGW6, CFW55, CFW57, CFW57A, CFW59, and CFW55R. Destroyed CGW1, CGW2, CGW3, CGW5, CGW8,CGW9, CGW10, CGW12, CGW13, CGW14, CGW30, CGW33, CGW34, CGW35, CGW36, CGW37, CGW38, CGW40, CGW41, CGW42, CGW43, CGW44, CFW56, CFW56A, CFW58	Perpetuity
20BL171439	Bore	Monitoring Bore	Part 5 Water Act 1912	Bores: BRN, E012	Perpetuity
20BL171492	Bore	Monitoring Bore	Part 5 Water Act 1912	Bores: C1(WJ039), GW9704, North, GWAR981	Perpetuity
20BL171681	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO South – Bores: Bunc 45A, Bunc 45D	Perpetuity
20BL171725	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO South – Bores: B425 (WDH), BRS, C621 (BFS), C919 (ALL), D317 (BFS), D317(ALL), D317(WDH) Destroyed D420, D425, D621, PB02	Perpetuity
20BL171726	Bore	Monitoring Bore	Part 5 Water Act 1912	Bores: SR002, SR003, SR004, SR005, SR006, SR007	Perpetuity
20BL171727	Bore	Monitoring Bore	Part 5 Water Act 1912	SR001	Perpetuity

Licence Number	Type of License	Purpose	Legislation	Description	Renewal Date
20BL171728	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO South – Bores: BZ2B, BZ1-1, BZ1-2, BZ1-3, BZ2-1, BZ2-2	Perpetuity
20BL171762	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO South – Bores: C817, D010 (BFS), D214 (BFS), D406 (BFS) (AFS), D510 (BFS), PB01 (ALL), D510 (AFS), D010 (GM), D010 (WDH), D406 (BFS) (AFS), D612 (AFS), D612 (BFS)	Perpetuity
20BL171851	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO North/South – Bores: HV2, PZ1CH200, PZ2CH400, PZ3CH800, 4118P, 4119P	Perpetuity
20BL171852	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO North – PZ4CH1380	Perpetuity
20BL171853	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO North – DM3	Perpetuity
20BL171854	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO North – Bores: DM5, PZ6CH2450	Perpetuity
20BL171855	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO North – PZ5CH1800	Perpetuity
20BL171856	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO North – Bores: HV6, HV3, DM6, HV2 (2), 4113P, 4114P. 4116P, 4117P	Perpetuity
20BL171857	Bore	Monitoring Bore	Part 5 Water Act 1912	Bores: HV4, HV4 (2) (GA3), GA3,	Perpetuity
20BL171858	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO North – DM4	Perpetuity
20BL171895	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO West – NPZ4	Perpetuity
20BL171896	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO West – NPZ2	Perpetuity
20BL171897	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO West – Bores: NPZ5, NPZ1	Perpetuity
20BL171898	Bore	Monitoring Bore	Part 5 Water Act 1912	HVO West – NPZ3	Perpetuity
20BL173392	Bore	Production Bore	Part 5 Water Act 1912	HVO South – LUG Bore	22/09/2015

Licence Number	Type of License	Purpose	Legislation	Description	Renewal Date
20BL173065	Bore	Monitoring Bore	Part 5 Water Act 1912	HQ11	Perpetuity
20BL173062	Bore	Monitoring Bore	Part 5 Water Act 1912	RC14	Perpetuity
20BL173063	Bore	Monitoring Bore	Part 5 Water Act 1912	RC07, RC08	Perpetuity
20BL173064	Bore	Monitoring Bore	Part 5 Water Act 1912	RC06	Perpetuity
20BL173069	Bore	Monitoring Bore	Part 5 Water Act 1912	RC11	Perpetuity
20BL173847	Bore	Dewatering Bore	Part 5 Water Act 1912	WB15HVO01	04/11/2015
20CA201247	Works Approval	Pumping Plant	Water Management Act 2000	Associated with WAL965	28/12/2017
20CW802613	Controlled Work	Levee	Part 8 Water Act 1912	HVO South – Barry Levee	05/09/2016
20CW802603	Controlled Work	Controlled Work	Part 8 Water Act 1912	HVO South – Hobden Gully Levee	27/03/2016
20CW802604	Controlled Work	Controlled Work	Part 8 Water Act 1912	HVO North – North Pit Levee 3	25/07/2015
20CW802612	Controlled Work	Controlled Work	Part 8 Water Act 1912	HVO North – Carrington Levee 5	04/09/2016
20WA210991 (see WAL 18307) Formerly 20SL050903	Stream Diversion	Stream Diversion	Water Management Act 2000	HVO West – Parnells Creek Dam	09/01/2023
20WA211427 Formerly 20SL061290	Stream Diversion	Cutting (Diversion Drain)	Section 10 Water Act 1912	Pikes Gully Creek Stream Diversion	07/09/2023
20WA210984 (see WAL 18327) 20SL042746	Diversion Works	Industrial	Water Management Act 2000	HV Loading Point Pump Bayswater Creek	08/09/2022
20WA211428 20SL061594	Stream Diversion	Cutting (Diversion Drain)	Water Management Act 2000	HVO North – Carrington Stream Diversion	31/7/2022
20WA201238 (see WAL 962)	Diversion Works	Pumping Plant	Water Management Act 2000	HVCPP River Pump	16/03/2018
20WA201257 (see WAL 970)	Diversion Works	Pumping Plant	Water Management Act 2000	HVO South – LCPP River Pump	Perpetuity

Licence Number	Type of License	Purpose	Legislation	Description	Renewal Date
20WA201338 (see WAL 1006)	Diversion Works	Pumping Plant	Water Management Act 2000	HVO South – LCPP River Pump	Perpetuity
20WA201501 (see WAL 1070)	Diversion Works	Pumping Plant	Water Management Act 2000	HVO South – LCPP River Pump	Perpetuity
20WA201685 (see WAL 13387)	Diversion Works	Pumping Plant	Water Management Act 2000	HVO West – "Lake Liddell" Licence	Perpetuity

Table 7: Water Access Licence

Licence Number	Purpose	Legislation	Description	Renewal Date	Approved Extraction (ML)	Actual Extraction 2014 (ML)
20AL201237 (see WAL 962)	Water Access Licence	Water Management Act 2000	HVO North – HVCPP River Pump – Water Access Licence	Perpetuity	3,165	916.2*
20AL201254 (see WAL 969)	Water Access Licence	Water Management Act 2000	HVO South – Former Riverview pump	Perpetuity	39	0
20AL201256 (see WAL 970)	Water Access Licence	Water Management Act 2000	HVO South – LCPP River Pump – Water Access Licence	Perpetuity	500	0
20AL201337 (see WAL 1006)	Water Access Licence	Water Management Act 2000	HVO South – LCPP River Pump – Water Access Licence	Perpetuity	500	0
20AL201500 (see WAL 1070)	Water Access Licence	Water Management Act 2000	HVO South - LCPP River Pump – Water Access Licence	Perpetuity	500	0
20AL201684 (see WAL 13387)	Water Access Licence	Water Management Act 2000	Macquarie Generation Hunter River Pump Station	Perpetuity	20	0
20AL201895 (see WAL 13391)	Water Access Licence	Water Management Act 2000	HVO North – Alluvial Rehabilitation Irrigation.	Perpetuity	420	0
TOTAL					5,144	916.2

* this represents a temporary license allocation assignment to the MTJVS, for abstraction by MTW.

1.4.2 Management Plans, Programmes and Strategies

Under the Project Approvals, HVO is required to develop and submit a range of environmental management plans for approval prior to implementation. Issued in 2009, the HVO South Coal Project Approval (PA06_0261) required submission of a number of monitoring programmes, strategies and some management plans, while the March 2013 modification to the HVO North Consent (DA 450-10-2003) contains a contemporary list of comprehensive management plan requirements. Where possible, the HVO South conditions, commitments and obligations have been included in the Management Plans which have been submitted for HVO North, allowing for a single plan to detail management measures which will be employed across the site. Once approved, management plans are made publically available via the Rio Tinto website (www.riotinto.com.au). The status of these management plans is shown in Table 8 and Table 9.

Table 8: Management plans and MOPs required for HVO North

Management Plan	Due Date	Date approved
Water management plan	30/09/2013 (Extension approved until 31/12/2013)	19/05/2014
A rehabilitation management plan and an agricultural reinstatement management plan	30/09/2013	Reviewed by DP&E and DRE, updated version to be included in new HVO North MOP in 2015
Aboriginal Heritage Management Plan	30/06/2013 (Extension approved until 31/12/2013)	12/02/2014
Fire management plan	N/A	No submission required
Noise Management Plan (including Noise Monitoring Programme)	30/06/2013	Revised Plan submitted to DP&E 30/09/2014. Approval pending.
Blast Management Plan (including Blast Monitoring Programme)	30/09/2013	4/4/2014
Air Quality and Greenhouse Gas Management Plan (including Air Quality Monitoring Programme)	30/06/2013	12/02/2014
Environmental Management Strategy	12/12/2004 (Latest version submitted 31/01/2013)	31/01/2013
Mining Operations Plan (MOP) HVO North 2012-2018	N/A	05/06/2012
Mining Operations Plan (MOP) Newdell 2002-2009	N/A	29/07/2002
Rehabilitation management plan	30/09/2013	30/09/2013
Agricultural reinstatement management plan	30/09/2013	30/09/2013
Rehabilitation and restoration Strategy for Carrington Billabong	30/06/2007	30/06/2007
Landscape and Rehabilitation Management Strategy	30/06/2007	30/06/2007

Table 9: Management Plans and MOPs required for HVO South

Management Plan	Due Date	Date Approved
River Red Gum Restoration Strategy	24/03/2010	24/03/2010
Rehabilitation and Landscape Management Plan; including • Rehabilitation and Biodiversity Management Plan; • Final Void Management Plan and • Mine Closure Plan	24/03/2010	24/03/2010
Amenity Management Plan for Hunter Valley Glider Club facilities (Blast Training Procedure HVGC)	6 months prior to mining in Riverview South East Extension area	22/01/2013
Water management plan	30/09/2013 (Extension approved until 31/12/2013)	19/05/2014
Aboriginal Heritage Management Plan	30/06/2013 (Extension approved until 31/12/2013)	12/02/2014
Fire management plan	N/A	No submission required
Noise Management Plan (including Noise Monitoring Programme)	30/06/2013	Revised Plan submitted to DP&E 30/09/2014. Approval pending.
Blast Management Plan (including Blast Monitoring Programme)	30/09/2013	4/04/2014
Air Quality and Greenhouse Gas Management Plan (including Air Quality Monitoring Programme)	30/06/2013	12/02/2014
Environmental Management Strategy	12/12/2004 (Latest version submitted 31/01/2013)	31/01/2013
Mining Operations Plan (MOP) HVO South 2008-2015	N/A	29/10/2009

1.5 Mine Contacts

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Or call:

Coal & Allied Information Line 1800 727 745 (free call)

1.6 Response to Actions from 2013 Annual Review Inspection

The DRE and DP&E both conducted an annual inspection of HVO on the 31 March and 27 June 2014, respectively, to review mining activities as reported in the 2013 Annual Environmental Review. Both Departments were generally satisfied with the contents of the report, however a number of actions were identified as part of the inspection and review of the document. The actions and response are shown in Table 10 and Table 11.

Table 10: Response to actions from Previous HVO AEMR Inspection by the DRE

Issue/Observation	Action	Response
Section 5	Provide DRE with an AEMR addendum for approval that addresses Section 5 (Rehabilitation) of the AEMR 2006 guidelines	An addendum addressing the action was submitted to the DRE on 26 September 2014
Performance Criteria	Report on monitoring results from the reference sites against the performance criteria.	Refer to section 5 Rehabilitation and Land Management
Tailings	Provide an update on how tailings management is tracking to meet the schedule for decommissioning and rehabilitation of tailings facilities.	Refer to Section 5.9 Tailings Management
AEMR- Section 6	Section 6 to be included in the AEMR	Refer to Section 6 of this report.

Table 11: Responses to Actions from the Previous HVO AEMR Inspection by the DP&E

Issue / Observation	Response
Noise Management Plan – the HVO Noise Management Plan has been provided to the Department but not approved. There is yet to be agreement on the sound power limits for the Jerry's Plains village. We were advised negotiations between C&A and the Department's Sydney assessment office are still underway. C&A advised that this will be investigated so the Noise Management Plan can be finalised.	HVO met with Department of Planning and Environment Compliance Officer's on 6 February 2015 to progress the development of the Noise Management Plan. At the time of submission of this Annual Review, HVO is incorporating DP&E feedback into the Plan, for resubmission during Quarter Two 2015
Access to water monitoring points – Table 38 of the 2013 report identifies issues with safe access at 3 water monitoring locations, preventing measurements being taken. If this issue is to continue then the access needs to be improved of the monitors re-sited so they can be accessed	Access was possible during 2014 to these monitoring locations. In addition, some of the locations have been re-sited for 2015 sampling to remove any access issues.

Issue / Observation	Response
Carrington Billabong – it was noted that the AEMR report stated that regeneration of the Carrington Billabong was less than satisfactory and C&A have undertaken to modify rehabilitation methods to hopefully achieve an improved result. Future AEMR reports need to report on the success of this work.	Refer to Section 5.3
Section 6 – There was no Section 6 in the report. Section 6 covers improvements and initiatives planned for the next reporting year. It should be noted that continual improvements were mentioned briefly in some other sections of the report. Next years AEMR report will require a Section 6.	Refer to Section 6 of this report
Alluvial Lands drainage bore – it was agreed that the Alluvial Lands drainage bore would be completed and operational by June 2015. This will need to be reported on in future AEMR reports.	Refer to Section 3.7.1 and 6.5 of this report.
Newdell Coal Pad Area - The Department could not determine where the storm water would drain to from this area and it appeared possible that the water could drain directly into Bayswater Creek.	An action plan for water management at the coal pad was developed and approved by the Department. Refer to section 3.7.1 of this report.
As a result of previous site inspections, it was agreed that there was need to improve the management of sediment containment on the Hunter River haul road crossing. Works were complete on the northern crossing and these were completed to a high standard. It was agreed that the southern works would be completed by the end of Q1 2015.	Refer to Section 3.5.1 and 6.5 of this report.
The HVLP sump was inspected, and it is known that this has been the point of dirty water loss from the site in the past. As a temporary measure the current pumps available on site is acceptable and it was agreed that this area is planned to have significant improvements to be undertaken by the end of Q1 2015.	An engineering design for the improvement works has been finalised. Works are currently on hold as a tenement matter is resolved. It is anticipated works will be able to commence in mid-2015, with a view to completing by the end of 2015.
Drainage from the Lemington workshop and wash bay were inspected. As a result of an earlier inspection it was identified that oil/water separation in this system requires significant improvement. However it was further agreed that the current system was suitable for the short term, and this area would be reported on in future AEMR report.	Refer to Section 3.11.1

2 OPERATIONS SUMMARY

2.1 2014 Reporting Period

2.1.1 Exploration

During the reporting period, pre-production and exploration drilling were conducted at HVO as part of a continuing regime to update and refine the geological models with new structural and coal quality data within the existing mining lease. In 2014, a total of 60 holes were drilled throughout HVO, illustrated in Table 12, consisting of 6 core holes and 54 open holes.

Table 12: Summary of HVO Exploration for 2014

Project	Tenement	Hole Type	Quantity of Holes	Meters Drilled (m)
West Pit – North	ML 1406 & ML 1560	Chip	5	1516.70
		Core	2	289.76
Riverview - West	ML 1634	Chip	11	2008.00
		Core	1	387.24
Cheshunt – Pit 1	ML 1634	Chip	14	2964.00
		Core	3	571.17
Cheshunt – Pit 2		Chip	1	256.00
Riverview - East	ML 1634	Chip	22	766.00
Lemington	ML 1634	Chip	1	568.00
TOTAL			**60**	**9,326.87**

2.1.1.1 Drilling and Rehabilitation

Fifty six sites were drilled in 2014. All of these sites were internal to the Mining Operations Plan (MOP) boundary. Rehabilitation techniques vary according to their location relative to the MOP area. An example of a drilling site during drilling and the completed rehabilitation of a drill site is shown in Figure 2 and Figure 3. The locations of drilling activities during 2014 are shown in Figure 4 and Figure 5.

External MOP Area Rehabilitation (EMAR): After a borehole has been drilled and all sampling and testing has been completed, the borehole is grouted to surface. All equipment and gravel is then removed from site (excluding installed piezometers) and the pad area is re-contoured to its original shape. Stockpiled top soil is placed back on the pad and the area is reseeded with suitable seed. Saplings felled to provide space or access for the pad are placed back on the pad and access tracks.

Internal MOP Area Rehabilitation (IMAR): After a borehole has been drilled and all sampling and testing has been completed, the borehole is grouted to the surface unless the hole has been drilled in spoil where the borehole is grouted to the base of casing. Casing is removed where possible or cut or backed off below surface where not possible to maximise casing recovery. All equipment and gravel is then removed from site (excluding installed piezometers) and where applicable the pad is re-contoured to its original shape. Stockpiled top soil is placed back on the pad and reseeded with suitable seed. Saplings felled to provide space or access for the pad are placed back on the pad and access tracks.
Rehabilitation progress of all exploration drill holes is tracked prior to internal sign off.

Figure 2: During Drilling

Figure 3: Rehabilitated Drill Site

Figure 4: Drilling locations Hunter Valley Operations West Pit

Figure 5: Drilling locations Hunter Valley Operations South Pit

2.1.2 Mining

Areas to be mined are geologically modelled, a mine plan is formed and the relevant mining locations are surveyed prior to mining. Figure 6 illustrates the mining process. HVO have no active underground workings.

No changes were made to the mining method during the reporting period. Mining progress deviated slightly from the schedule of the MOPs as a result of normal variations in productivity and utilisation.

The mining equipment fleet employed to carry out mining operations at HVO is detailed in Table 13, along with the fleet transformation from 2013 to 2015 predictions. Changes in the data appear in **bold**.

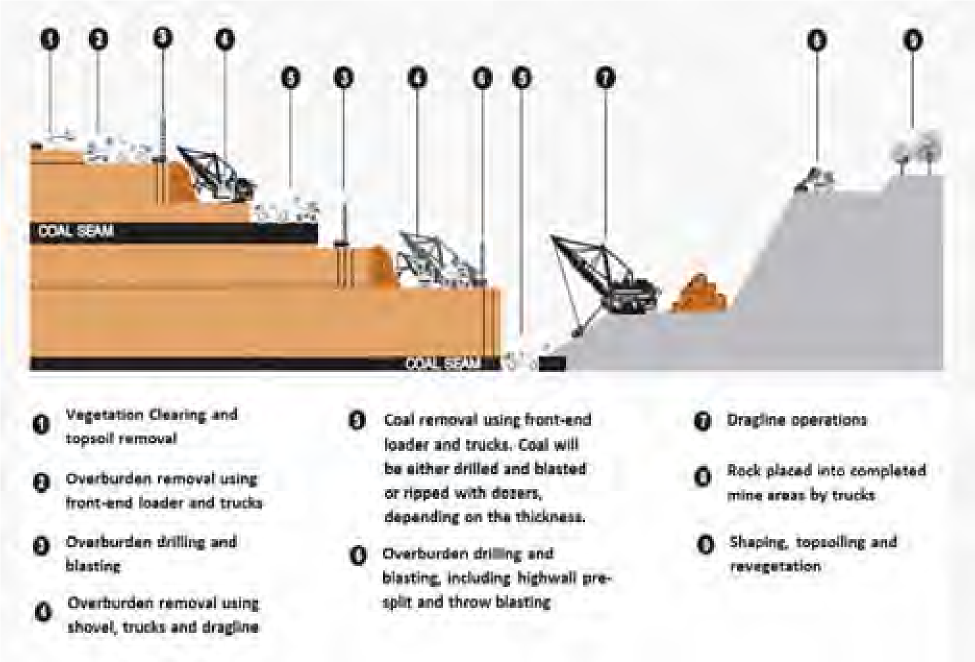


Figure 6: Mining Schematic

Table 13: HVO Equipment Used 2013-2015

Equipment Type	Number Used in 2013	Number Used in 2014	Forecast numbers in 2015
Scrapers	2	2	2
Drills	10	10	**9**
Draglines	2	2	2
Shovels	4	4	4
Excavators	7	7	7
Trucks	81	**85**	**87**
Loaders	7	7	7
Service Trucks	7	**5**	5
Track Dozers	33	33	**30**
Rubber Tyre Dozers	5	5	5
Graders	14	**11**	11
Surface Miner *	0	**1**	1
Water Trucks	12	**10**	10
Floats	1	1	1
Cable Reeler	2	**1**	1
Cable Tractors	9	**5**	5
Total	**196**	**189**	**187**

*In 2014, HVO commenced a trial of a surface miner. This trial is ongoing into 2015.

2.1.3 Mineral Processing

Coal is transported to one of two CHPPs from active mining areas, where it is crushed to size and processed to remove impurities. Processing produces saleable coal, along with coarse and fine reject materials. Coarse rejects are disposed of in pit, and fine rejects are placed in a tailings dam, according to commitments outlined in the MOP. Each different CHPP site has different storage facilities for processed (saleable) and unprocessed (ROM) coal. The capacity of each site is listed in Table 14. No changes or additions were made to process or facilities during the reporting period.

Table 14: Stockpile Capacities

Location	ROM stockpile(t)	Saleable stockpile (t)
Hunter Valley CHPP	100 000	300 000
West CHPP	15 000	30 000
Newdell CHPP	0	450 000

Processed, or product coal is transported to one of the two loading points via conveyor belt or road, detailed in Table 15. The coal from HVCHPP is transported to the Hunter Valley Load Point (HVLP) by means of overland conveyor whereas coal from West CHPP (Howick) is trucked to Newdell Load Point. After the coal has reached either HVLP or the Newdell Load Point, it is transported to Newcastle by rail.

Table 15: Methods of Coal Transportation

Category of Transport	Quantity (million tonnes)
Coal transported from the site via trains	13.91
Amount of coal received from Hunter Valley Operations South of the Hunter River	12.3
Amount of coal hauled by road to the Hunter Valley Loading Point	Nil
Coal hauled by road to the Newdell Load Point	2.06
Amount of coal hauled by road from the Newdell Loading Point to the Ravensworth Coal Terminal	Nil
Coal transferred from HVLP to Newdell Load Point via conveyor	1.58
Amount of coal hauled by road from the Hunter Valley Loading Point to the Ravensworth Coal Terminal	Nil
Number of coal haulage truck movements generated by the development. (includes -coal hauled to stockpile, coal hauled to bins, coal hauled from stockpile to bins)	164,229

2.1.4 Production statistics

Project approvals allow for the extraction of up to 22 million ROM tonnes from operations North of the Hunter River and 16 million ROM tonnes from operations South of the Hunter River. A summary of production and waste at HVO during 2014 in comparison to previous years is provided in Table 16.

Product coal includes low-ash, semi-soft and steaming coals. During 2014, total product coal increased on 2013 production. Table 17 outlines the tonnages produced by each CPP compared to Project Approval (PA) limits.

Table 16: Summary of Production and Waste at HVO in 2014

	HVO North MOP 2014	HVO South MOP 2014	Reporting Period 2014	Reporting Period 2013	Reporting Period 2012	Reporting Period 2011
Topsoil Stripped (ha)	97.4	30.8	128.2	132	148.7	86.9
Topsoil Used/ Spread (ha)	90.9	57.8	148.7	203.7	153.3	57.5
Prime Waste (Mbcm)	33.81	59.59	93.4	94.74	103.54	96.91
ROM (Mt) (mined)	6.1	11.9	18	18.17	15.98	16.99
Waste (Mt)	1.33	2.59	3.91	4.23	3.8	3.41
Product (Mt)	4.7	9.2	13.91	13.65	11.95	12.2

Table 17: Production Statistics and Correlating Project Approval Limits

Product Coal	Project Approval limits (mtpa)	2014 (Mt)	2013 (Mt)	2012 (Mt)	2011 (Mt)
Hunter Valley CHPP	20	11.66	11.53	10.50	11.00
West CHPP	6	2.25	2.12	1.45	1.20
Total HVO Product Coal	26	13.91	13.65	11.95	12.20

2.1.5 Resource Utilisation / Reserve

West Pit has an average stripping ratio of 5.8:1. This pit includes the Bayswater seam down to the Barrett seam; Carrington Pit has an average stripping ratio of 3.9:1. This pit includes the Broonies and Bayswater Seams; Riverview Pit has an average stripping ratio of 5.8:1. This pit includes the Glen Munro, Woodlands Hill, Arrowfield, Bowfield and to the middle section of the Warkworth seam; and Cheshunt Pit has an average stripping ratio of 4.1:1. This pit includes the Warkworth, Mt Arthur, Piercefield, Vaux, Broonie and Bayswater seams.

ROM reserves at HVO, as of 31 October 2014 total 606 million tonnes, of which 404 million tonnes is proved and 202 million tonnes probable reserves. In addition to the reserves, HVO has additional resources total of 1373 million tonnes. This is broken down by 1282 million tonnes in open cut and 91 million tonnes underground resources.

2.1.6 Summary of Changes (developments, equipment upgrades)

No land was acquired during 2014 in relation to the existing Project Approvals (HVO North footprint). There was one property acquired during the 2014 calendar year. This property is located outside, but in the vicinity of the approved HVO South footprint.

Consistent with the MOP and the EA's, additional machinery was used when compared to 2013, details are outlined in Table 13.

2.1.7 Compliance Audits

No Compliance Audits were undertaken during the reporting period.

2.2 Heritage Summary

2.2.1 Aboriginal Heritage

The Coal & Allied Upper Hunter Valley Aboriginal Cultural Heritage Working Group (CHWG) is the primary forum for Aboriginal community consultation on matters pertaining to cultural heritage. The CHWG is comprised of representatives from Rio Tinto Coal Australia and Aboriginal parties/stakeholders from Upper Hunter Valley Aboriginal community groups, corporations and individuals. The CHWG met on five occasions in 2014 - 19 February, 3 April, 7 May, 10 July and 30 October.

Aboriginal cultural heritage is managed under a separate Aboriginal Cultural Heritage Management Plan (ACHMP) for each development consent. Following consultation with the Office of Environment & Heritage (OEH) and the Aboriginal stakeholders, the HVO North ACHMP was approved by DP&E in February 2014. Additionally at HVO North, where mining or associated development activities may impact Aboriginal cultural heritage sites an Aboriginal Heritage Impact Permit (AHIP) must also be sought from the OEH under Part 6 of the National Parks and Wildlife Act on the basis of the management requirements established through the ACHMP process.

Aboriginal cultural heritage at HVO is managed in consultation with the Aboriginal community through the CHWG in accordance with the Rio Tinto Cultural Heritage Management Standard, RTCA Cultural Heritage Management System (CHMS) Work Procedures, ACHMPs, Development Consent conditions, the NPW Act (including the OEH Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010) and the EPA Act. The RTCA CHMS combines several elements to protect, manage and mitigate cultural heritage at MTW, including:

- Ongoing consultation and involvement of the local Aboriginal community in all matters pertaining to Aboriginal cultural heritage management;
- Compliance with existing ACHMP's and Development Consent conditions;
- A cultural heritage Geographic Information System (GIS) and Cultural Heritage Zone Plan (CHZP) incorporating cultural heritage spatial and aspatial data (site location, description, assessments, date recorded, associated reports, management provisions and various other details to assist with the management of sites);
- A Ground Disturbance Permit (GDP) system for the assessment and approval of ground disturbing activities to ensure these activities do not disturb cultural heritage places;
- Limit of Disturbance Boundary (LODB) procedures to demarcate approved disturbance areas and delineate areas not to be disturbed;
- Ongoing cultural heritage site inspections, monitoring and auditing along with regular compliance inspections of development works;
- Protective management measures such as fencing/barricading sites to avoid disturbance, protective buffer zones, cultural heritage off-set areas; and
- Communicating cultural heritage issues and site awareness to personnel via internal electronic and face to face processes.

In consultation with the CHWG and OEH, Coal & Allied established the Hunter Valley Services Cultural Heritage Storage Facility (CHSF) at Hunter Valley Services. The CHSF is a combined office and storage shed, with an adjacent sea container, fitted out to allow safe and secure storage of cultural materials such as stone artefacts and scarred trees. It is a central repository for all materials collected during community collection and salvage activities on all Coal& Allied mines and lands in the Hunter Valley including HVO. All cultural materials are deposited there under the authority of Care and Control Permit #2863 issued by OEH.

2.2.1.1 Aboriginal Archaeological and Cultural Heritage Investigations

Under the provisions of both the HVO South and HVO North ACHMPs, an ACHMP Compliance Inspection was conducted over both these areas in 2014. This compliance inspection was conducted by representatives of the Aboriginal community nominated by the CHWG assisted by RTCA/Coal & Allied personnel. The 2014 HVO South and North compliance inspection was conducted over three days in June, with 86 Aboriginal cultural heritage sites inspected. The purpose of the ACHMP compliance inspections is to afford the Aboriginal Stakeholders and Coal & Allied:

- the opportunity to visit mine operations and mine areas to inspect operational compliance with ACHMP provisions and GDP procedures;
- to inspect and monitor the condition and management of sites; and
- to review the effectiveness and performance of the ACHMP provisions in the management of cultural heritage at the mine.

In addition to this compliance inspection, an Aboriginal cultural heritage salvage collection Programme was undertaken in 2014. This was located at HVO South and in full compliance with the relevant provisions of the ACHMP. The community collection of 32 Aboriginal cultural heritage sites was conducted with four representatives of the Aboriginal stakeholders, as well as RTCA professional heritage staff, in October 2014.

2.2.1.2 Audits and Incidents

During the reporting period there were 70 GDPs assessed for Cultural Heritage considerations regarding mining development disturbance activities at HVO. In all cases the ground disturbance works were conducted on an Aboriginal cultural heritage sites avoidance basis so that no extant cultural sites were impacted up on by these activities.

Coal & Allied has continued a comprehensive desk top review and ground-truthing audit of all Aboriginal cultural heritage sites located on Coal & Allied lands, including HVO leases. The purpose of the process is to confirm or revise and update the Aboriginal sites data held in the OEH Aboriginal Heritage Information Management System (AHIMS) sites database. Coal & Allied and OEH agree that there are inconsistencies between the AHIMS data and ground truthed data verified by Coal & Allied. These inconsistencies generally relate to errors in site location recording conducted over the last 20 years resulting in incorrect information being recorded in the AHIMS database.

OEH have agreed that upon the completion of the sites auditing process, and subject to OEH auditing Coal & Allied's results. This data will be provided to OEH to update the AHIMS sites database for Coal & Allied lands. This audit process will continue in 2015.

2.2.2 Historic Heritage

2.2.2.1 Management

In 2012 RTCA established the Community Heritage Advisory Group (CHAG) as a community consultation forum for all matters pertaining to management of historic (non-Indigenous) heritage located on RTCA lands. The CHAG is comprised of community representatives with particular knowledge and interests in historic heritage of the region such as historical groups, individuals and local government. The CHAG met in April 2014 to discuss the Chain of Ponds Stage 1 stabilisation programme.

2.2.2.2 Historic Heritage Survey Studies

The Stage One Chain of Ponds Stabilisation Programme commenced in November 2014. These works are being conducted under an approval granted by the Heritage Council of NSW and pursuant to Section 63 of the NSW Heritage Act 1977. These initial works aim to provide immediate structural integrity to the buildings to ensure their continued stability and safety in the short term.

3 ENVIRONMENTAL MANAGEMENT AND PERFORMANCE

3.1 Meteorological data

The collection of meteorological data is carried out to assist in day to day operational decisions, planning, environmental management and to maintain a historic record. The meteorological (weather) stations record wind speed, wind direction, temperature, humidity, solar radiation and rainfall. The instruments are installed and calibrated according to the relevant Australian Standard; AS 3580.14:2011. HVO operates two real time weather stations; the HVO Corporate Meteorological Station and the Cheshunt Meteorological Station (refer to Figure 29 Air Quality Monitoring Location Plan). Meteorological data is available to staff in real-time via the Environmental Intranet.

3.1.1 Rainfall

Total rainfall recorded in 2014 was 602.6mm. Table 18 details the monthly breakdown for rainfall. A comparison on rainfall data for the last three years can be seen in Figure 7.

Table 18: Rainfall Summary 2014

2014	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm)	6.0	85.2	132.8	48.4	8.6	22.0	33.4	75.8	24.4	11.2	18.2	136.6
Cumulative Rainfall (mm)	6.0	91.2	224.0	272.4	281.0	303.0	336.4	412.2	436.6	447.8	466.0	602.6
Wet Days*	1	8	13	14	8	10	4	9	5	5	7	17

* Wet days are classified as days receiving rainfall greater than 0.2 mm

3.1.2 Temperature

Maximum and minimum temperatures recorded at the HVO Corporate Meteorological Station for 2014 are presented in Figure 8.

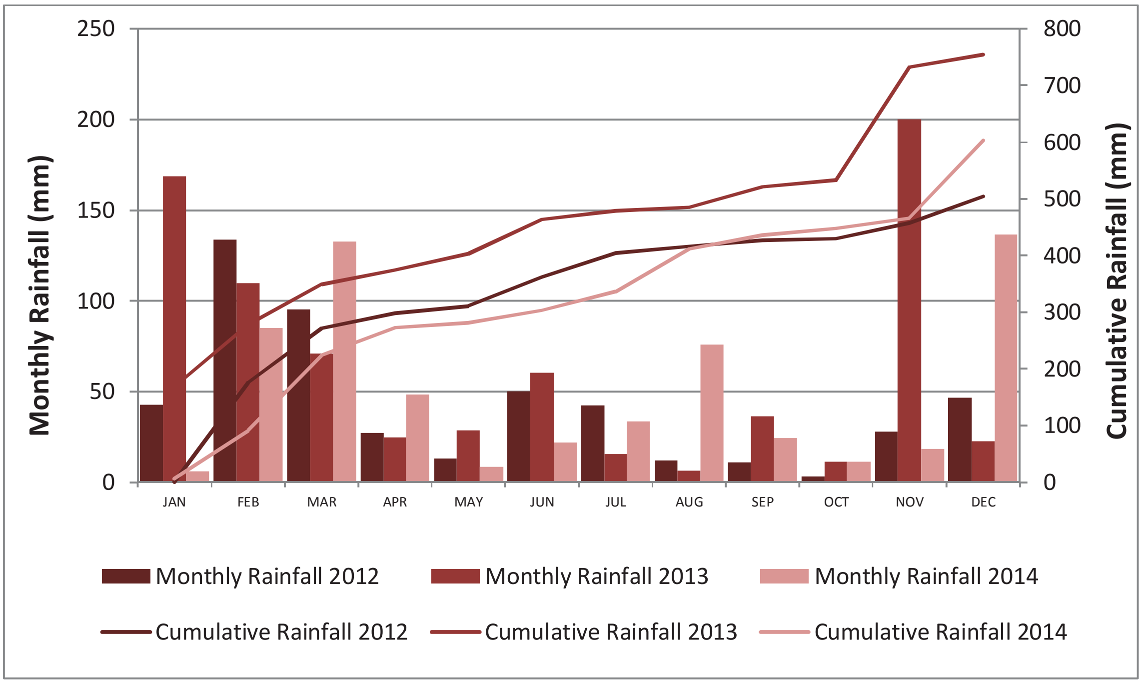


Figure 7: Rainfall Summary 2012 – 2014

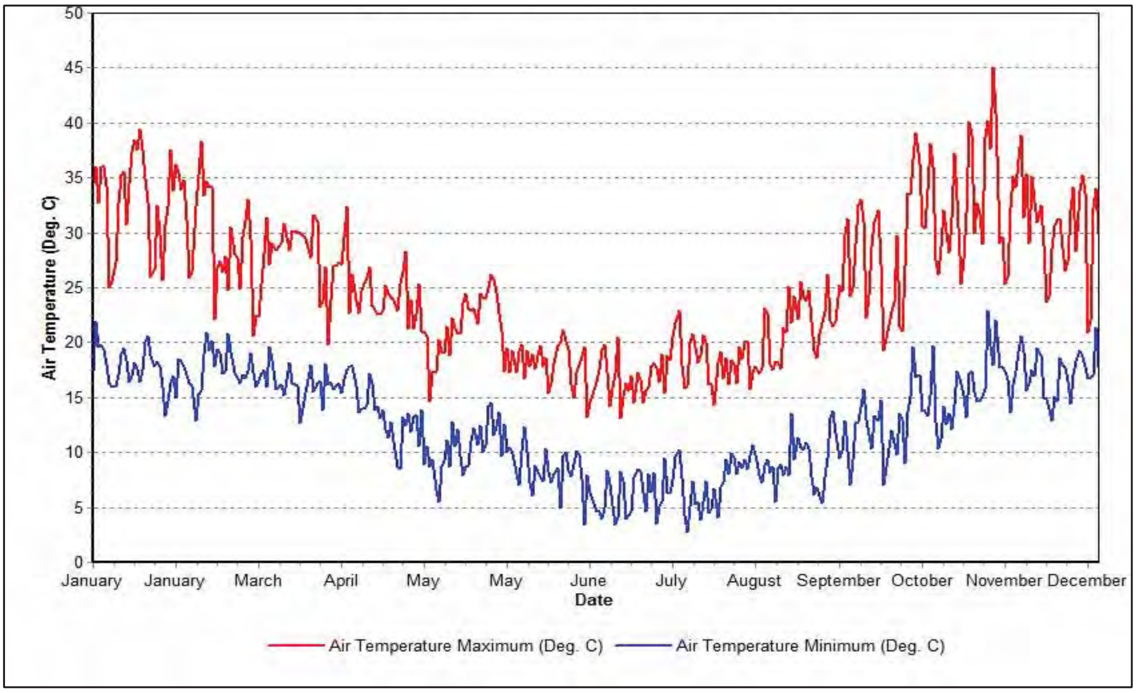
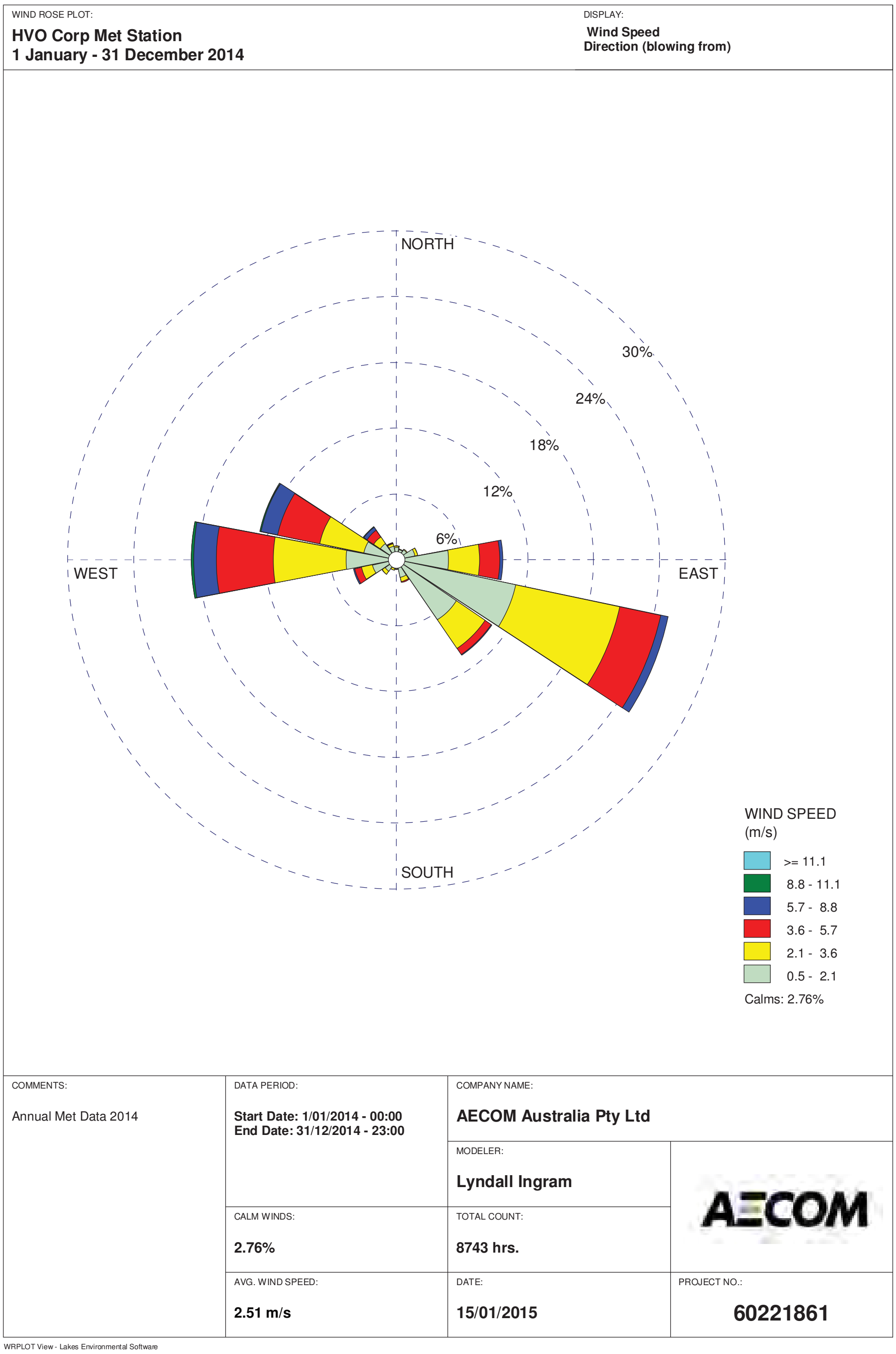


Figure 8: Minimum and Maximum Temperatures 2014

3.1.3 Wind Speed and Direction

During 2014 the wind direction at the HVO Corporate Meteorological Station was predominantly from the east and south-east (approximately 50 per cent of the time) and the west (approximately 20 per cent of the time). The annual wind rose is shown in Figure 9.



WIND ROSE PLOT:
HVO Corp Met Station
1 January - 31 December 2014

DISPLAY:
Wind Speed
Direction (blowing from)

COMMENTS:
Annual Met Data 2014

DATA PERIOD:
Start Date: 1/01/2014 - 00:00
End Date: 31/12/2014 - 23:00

COMPANY NAME:
AECOM Australia Pty Ltd

MODELER:
Lyndall Ingram

CALM WINDS:
2.76%

TOTAL COUNT:
8743 hrs.

AVG. WIND SPEED:
2.51 m/s

DATE:
15/01/2015

PROJECT NO.:
60221861

Figure 9: 2014 Annual Wind Rose - HVO Corporate Meteorological Station

3.2 Operational Noise

3.2.1 Management

Noise management activities are undertaken at HVO to minimise adverse impacts and ensure compliance with permissible noise limits at nearby private residences. A combination of both proactive and reactive control mechanisms are employed to ensure effective management of noise emissions.

3.2.1.1 Sound Attenuation of Heavy Equipment

During 2014, HVO continued to retrofit sound attenuation packages to the heavy equipment fleet with 4 Komatsu 830E-DC haul trucks being retrofitted with attenuated mufflers. On average, the installation of the attenuation resulted in a significant sound reduction of 5 dB(A) and 9dB(L), representing a halving of the sound energy from the engine exhaust. A further three Komatsu 830E-DC trucks are scheduled to receive the attenuation package in early 2015.

3.2.1.2 Real Time Noise Management

HVO operates a network of directional real-time noise monitors, used to ensure noise emissions remain below statutory limits and to minimise community impact. The real-time system generates alarms when elevated noise is measured, triggering the implementation of reactive controls to reduce noise levels. The real time noise monitoring network was modified during 2014, through the introduction of a new directional monitor in Jerrys Plains Village, and the relocation of the former Wandewoi monitor to the Moses Crossing area (Golden Highway, South of Jerrys Plains).

During 2014, the HVO Mine Monitoring and Control Team received and responded to 1694 noise alarms, recording a total of 2,476 hours of equipment stoppage in direct response to real-time alerts.

Figure 10 shows the equipment which experienced delays due to noise levels during 2014.

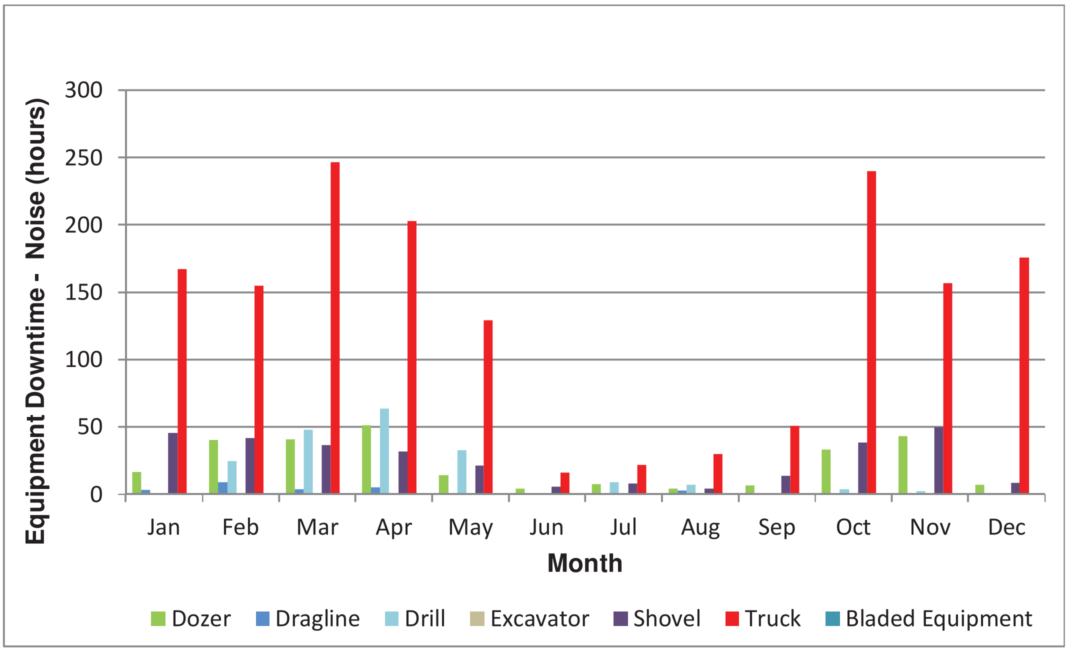


Figure 10: Environmental Delays Due to Noise 2014

Figure 11: HVO Attended Noise Monitoring Network

3.2.2 Operational Noise Performance

To assess compliance with the relevant Project Approval noise criteria, HVO engages Global Acoustics to undertake routine compliance monitoring at nearby private residences (Figure 11), in accordance with the HVO Noise Monitoring Programme. Monitoring is undertaken at a frequency of one night per month so as to ensure that noise impacts are adequately assessed under a range of meteorological conditions throughout the year. Monitoring data is presented on a monthly basis in the Hunter Valley Operations Monthly Environmental Monitoring Report, published on the Rio Tinto website.

A total of 75 measurements were taken during 2014. Each measurement involves an assessment of HVO mine noise against the various L_{Aeq} and $L_{A1, 1min}$ noise criteria in place under the HVO North and South Approvals (a total of 445 assessments). HVO complied with the relevant noise conditions of the HVO North and South Approvals during 2014. The noise monitoring results are presented in Table 19.

3.2.3 Noise Non-compliances

No noise non compliances were recorded in 2014. On two occasions noise levels were measured within 2 dB above the noise limit, which is considered a compliant measurement. On both occasions the mine was notified of the noise levels and actions were taken to reduce noise. Non-compliance is determined with reference to the applicable conditions of consent and the NSW Industrial Noise Policy.

A comparison of non-compliances and exceedances between years is used as a measure of the effectiveness of noise management measures employed on site, and the level to which risks are being adequately addressed. Details of this comparison are provided in Table 19.

Table 19: Comparison of 2014 noise monitoring results against previous years.

Year	Number of measurements	Number of measurements greater than allowable noise limits by 2dB or less (under applicable met conditions)*	Number of non-compliances*
2014	75	2	0
2013	85	5	2
2012	75	4	1
2011	95	7	5
2010	114	7	2
2009	71	3	1

* The Industrial Noise Policy allows for the measured result to be less than or equal to 2 dB above the applicable noise limit without constituting a non-compliance. A non-compliance is therefore classed as a result greater than 2 dB above the applicable noise limit.

3.2.4 Comparisons to EIS Predictions

Table 20 to Table 23 shows comparisons between 2014 LAeq attended noise monitoring results and the predictions made in the HVO Carrington West Wing EA (2010), HVO West Pit Extension and Minor Modifications EIS (2003) and the HVO South Coal Project Environmental Assessment (2006).

Comparisons against the predicted noise levels in the HVO Carrington West Wing EA (2010) have been made against the modelled scenario in Year 1 (including Carrington and West Pit operations mitigated predictions). It should be noted that while approval has been granted for the commencement of that project, works have not yet commenced.

Comparisons against the predicted noise levels in the HVO West Pit Extension and Minor Modifications EIS (2003) have been made against the modelled scenario for Year 8 of the development (including Carrington and Alluvial Lands dumping options), and also against the modelled scenario for Year 14 of the development (Table 5.2 of Part J – Hunter Valley Operations West Pit Extension and Minor Modifications Technical Reports Part 3).

Comparisons against the predicted noise levels in the HVO South Coal Project Environmental Assessment have been made against Mitigated Scenario B2 (indicative of mining operations in 2014), (Table 5.4 of Annexure H – Hunter Valley Operations South Coal Project Approval Environmental Assessment Report Volume 2). Where there are multiple predicted noise levels under scenario B2 (under different operating conditions), the comparison has been made against the lowest predicted noise level.

Comparisons have been made by averaging the results (where measureable) of the 2014 attended surveys conducted during each month (presented on a per quarter basis), and comparing directly with the predicted noise level at each monitoring location. The use of averaged results is considered most appropriate so as to provide an annualised comparison against the EA predictions, taking account of meteorological conditions experienced throughout the year. Where attended monitoring has determined HVO to be ‘inaudible’ or ‘not measurable’ during any of the surveys, these results have been excluded from the comparison.

Measured levels from 2014 were lower than predicted Year 1 levels from the Carrington West Wing EA for all monitoring locations (Table 20). It is noted that project works under this approval are yet to commence.

Table 20: Comparison of 2014 monitoring against HVO Carrington West Wing (EA, 2010) - Year 1 Predictions - Night Period for Carington and West Pit Operations:

Location	Units	EIS Prediction (INP)	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Knodlers Lane	dB(A)	30	Inaudible	Inaudible	Inaudible	Inaudible
Maison Dieu	dB(A)	28	Inaudible	Inaudible	<20*	Inaudible
Kilburnie South	dB(A)	38	33	33.5	34	<35*
Jerrys Plains	dB(A)	41	36	37	35	28
Warkworth Village	dB(A)	31	Inaudible	Inaudible	Inaudible	Inaudible

Measured levels from 2014 were lower than the year 8 (nominally 2010) predicted noise levels from the West Pit EIS (Year 8 night time L_{Aeq}, with Carrington still in operation).

* Where a '<' reading has been provided, this indicates that the highest recorded value at that location was less than this number. This is generally due to inability to ascertain a more accurate reading due to another dominant noise source, or if the audible noise was not constant during the recording period.

Table 21: Comparison of 2014 monitoring against HVO North (West Pit EIS, 2003) Year 8 Predictions - Night Period

Location	Units	EIS Prediction (INP)	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Knodlers Lane	dB(A)	30	Inaudible	Inaudible	Inaudible	Inaudible
Maison Dieu	dB(A)	30	Inaudible	Inaudible	<20*	Inaudible
Kilburnie South	dB(A)	41	33	33.5	34	<35*
Jerrys Plains	dB(A)	38	36	37	35	28
Warkworth Village	dB(A)	<35	Inaudible	Inaudible	Inaudible	Inaudible

* Where a '<' reading has been provided, this indicates that the highest recorded value at that location was less than this number. This is generally due to inability to ascertain a more accurate reading due to another dominant noise source, or if the audible noise was not constant during the recording period.

Comparison of measured results against the modelled predictions for Year 14 in the HVO West Pit EIS (2003) demonstrates noise levels equal to or lower than predicted at all monitoring locations with the exception of Jerrys Plains Village (quarters 1 and 2) and Kilburnie South (quarter 4). The modelling scenario for Year 14 of the West Pit Development does not include any noise generating activity in the Carrington Pit, which remained active (albeit in reduced capacity) during 2014 and would contribute to this minor variation in predicted versus actual noise levels.

It should be noted that of the six monitoring results recorded during this period, HVO North was recorded as "inaudible" on three occasions, demonstrating the variability in noise emissions on different nights due to the effects of meteorological conditions.

Measured noise was below or equal to predicted levels for all other monitoring locations in 2014.

Comparison of HVO South Pit area data measured through routine compliance assessment indicates good correlation with predicted noise levels for receptors to the West of HVO South with the exception of one reading at Jerry's Plains. The Jerrys Plains average measurement during Q2 is derived from one measurement only. Noise was noted as inaudible on the other two occasions. Measured levels for receptors in the Maison Dieu area are significantly lower than predicted levels, due to the progression of mining away from these receptors.

Table 22: Comparison of 2014 monitoring against HVO North (West Pit EIS, 2003) - Night Period

Location	Units	EIS Prediction (INP)	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Knodlers Lane	dB(A)	27	Inaudible	Inaudible	Inaudible	Inaudible
Maison Dieu	dB(A)	26	Inaudible	Inaudible	<20*	Inaudible
Kilburnie South	dB(A)	34	33	33.5	34	<35*
Jerrys Plains	dB(A)	<35	36	37	35	28
Warkworth Village	dB(A)	<35	Inaudible	Inaudible	Inaudible	Inaudible

* Where a '<' reading has been provided, this indicates that the highest recorded value at that location was less than this number. This is generally due to inability to ascertain a more accurate reading due to another dominant noise source, or if the audible noise was not constant during the recording period.

Table 23: Comparison of 2014 monitoring against HVO South (South Coal Project EA, 2006) - Scenario B2 (2014) - Night Period

Location	Units	EIS Prediction (INP)	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Knodlers Lane	dB(A)	37	33	33	36	29.5
Maison Dieu	dB(A)	39	30	32.5	30	29.5
Kilburnie South	dB(A)	35	35.3	33.6	34.3	32
Jerrys Plains	dB(A)	28	28	34*	28	26
Warkworth Village	dB(A)	36	29	Inaudible	Inaudible	Inaudible

*Jerrys Plains average measurement during Q2 derived from one result only. Noted as inaudible on the other two occasions

3.2.5 Operational Noise Complaints

During 2014, nine noise complaints were received compared to 14 in 2013. Seven of the nine complaints were received from residents on Jerrys Plains Road. The distribution of complaints is presented in Figure 12.

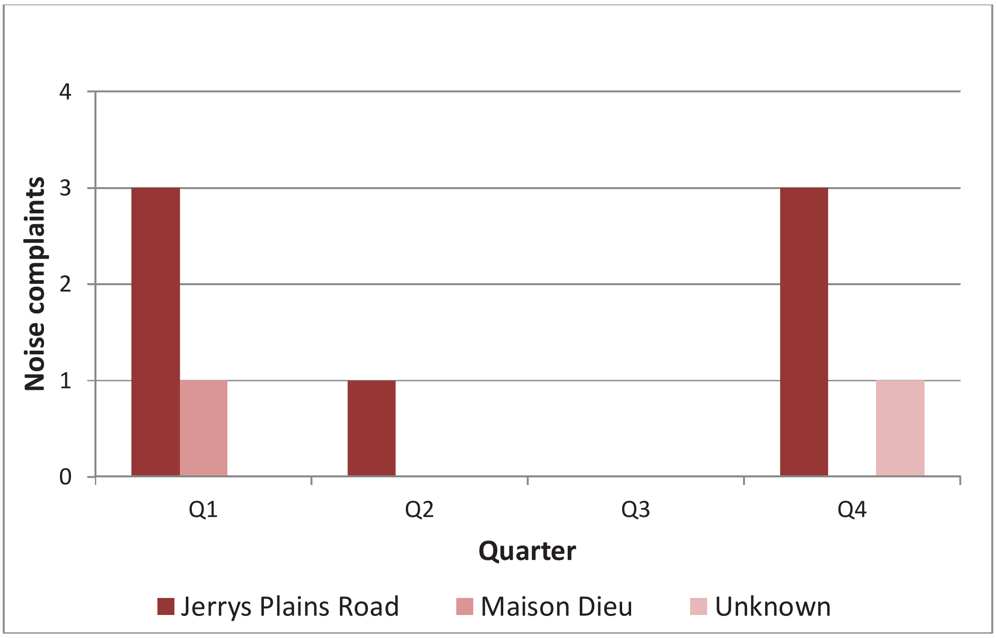


Figure 12: Distribution of noise complaints by location received by HVO in 2014

3.3 Blasting

3.3.1 Blasting Management

The objective of blasting operations is to ensure that optimal fragmentation is obtained whilst minimising dust and fume generation, adhering to safety standards and conforming to approvals criteria for vibration and overpressure.

During 2014, HVO operated a network of Dynamasters DV6 R4 and Datamasters Version 6 (V6) blast monitors. These are located at nearby privately owned residences and function as regulatory compliance monitors as shown in Figure 13. These monitors are located at:

- Jerrys Plains Village;
- Warkworth;
- Maison Dieu;
- Moses Crossing; and
- Knodlers Lane

HVO achieved 100% blast data capture during 2014. The increased data capture is the result of a monitor replacement project undertaken during 2012, and increased administrative oversight processes, ensuring capture and data integrity.

Figure 13: Blast Monitoring Network

3.3.1.1 Blasting Investigations

Within 24 hours of a blast being 'fired' the Drill and Blast Engineer interrogates the results across relevant blast monitors. Should any results on regulatory compliance monitors record a reading higher than 115 dB (L) or 5 mm/s an investigation is conducted.

The investigation analyses the results by correlating the distance from the blast with the relevant peaks in the vibration and overpressure wave forms. From this analysis, an assessment is made as to the monitor reading at the time of the arrival of the blast vibration and overpressure. Should the peak reading correspond to the arrival time of the blast this may be deemed to be a 'blast related exceedance' and further analysis may be performed to confirm that the result is representative of the blast and to determine the cause of the exceedance.

However, if the blast arrival time does not correlate with the peak reading on the blast wave form, a scale value is then calculated to determine the actual blast reading. The predominant cause of extraneous blast readings are high wind events or electrical interference with the blast monitor during the recording period. Strong winds can generate monitor readings above 120 dB (L) even in the absence of a blast.

3.3.1.2 Blasting and Community Considerations

All blasting on site is undertaken between 7 am and 6 pm Monday to Saturday inclusive. HVO runs a daily blasting hotline (1800 888 733) and publishes a weekly blast schedule on its website to ensure near neighbours are aware of blasting times.

HVO also liaises with drill and blast engineers at Wambo mine site in attempt to coordinate planned blasting times in order to offset impacts to the community. Near neighbours are advised before we fire blasts that may have more impact than standard blasts. For example large blasts fired in Riverview West pit, have the potential to impose longer or louder impacts.

To assist in minimising the impact of blasting on the surrounding community, HVO undertakes drill and blast design so as to minimise the airblast overpressure and ground vibration impacts on neighbouring communities.

HVO also use Blasting Permissions, which are internal wind speed and direction restrictions that limit blasting when these factors have the potential to cause offsite annoyance or impact. Where possible, blasts are delayed until favourable weather conditions exist to mitigate blasting impacts on public roads or privately owned dwellings. Permission to blast must be given by the Statutory Mining Manager if weather conditions are unfavourable but the shot has to be fired for safety reasons.

A road closure is required when blasting is within 500m of public roads or there is potential for a blast to impact a public road. During 2014, HVO continued road closures of Lemington Road due to the proximity of West Pit blasts and road closures of Jerrys Plains Road (the Golden Highway) during certain blasts in Riverview Pit. HVO undertook 23 road closures on Jerrys Plains Road (the Golden Highway) and 12 road closures on Lemington Road during the reporting period. Road closures were performed in accordance with the Singleton Council and the NSW Roads and Maritime Services approved Road Closure Management Plans.

3.3.2 Blasting Performance

During the reporting period 281 blast events were initiated at HVO. One blast event on 25th July 2014 recorded an airblast overpressure result of 120.2dB(L), against a limit of 120 dBL. HVO complied with all other blasting related consent and licence conditions during the reporting period. Figure 14 to Figure 18 detail all valid blasts received by the five HVO compliance blast monitors.

HVO received 24 complaints relating to blasting in 2014, the majority of which were regarding airblast overpressure or ground vibration from Jerrys Plains residents. The number of blast related complaints increased to 24 in 2014 compared to 10 in 2013. Of the 24 complaints, 16 were received from 2 households in Jerrys Plains. All blast measurements recorded in this area were below criteria in 2014 and no significant increase in overpressure or vibration is evident compared to 2013.

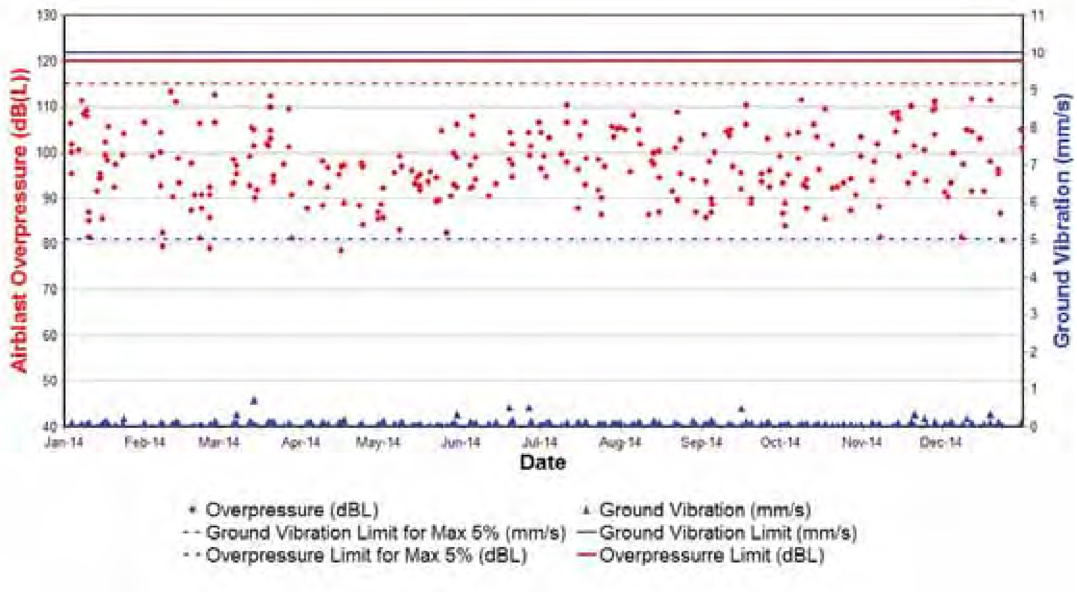


Figure 14: Jerrys Plains Blast Monitoring Results 2014

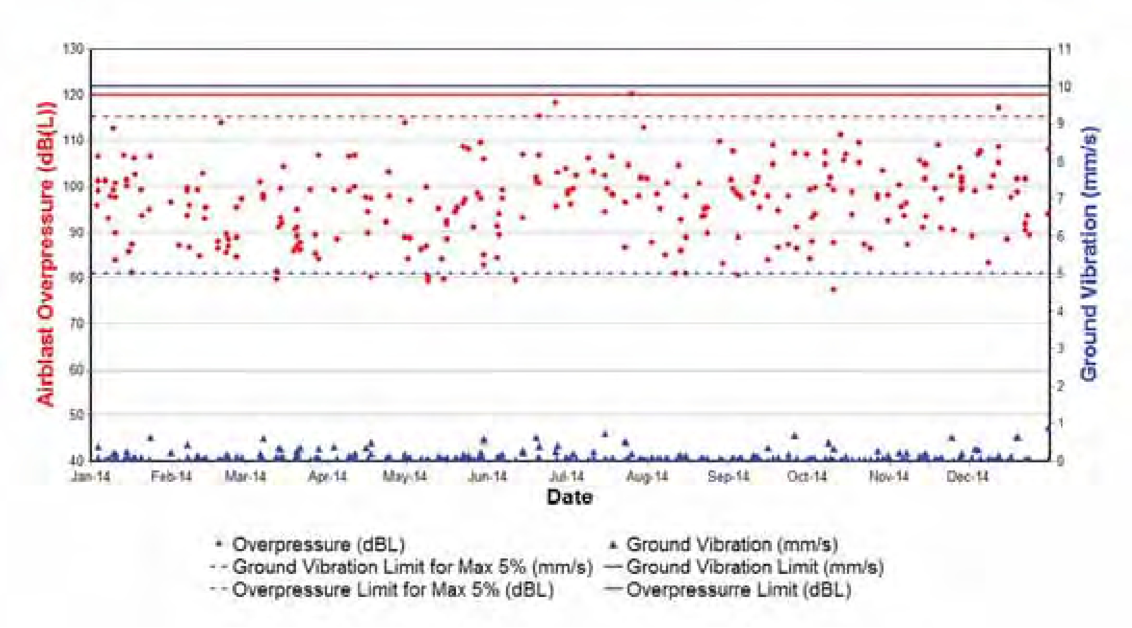


Figure 15: Knodlers Lane Blast Monitoring Results 2014

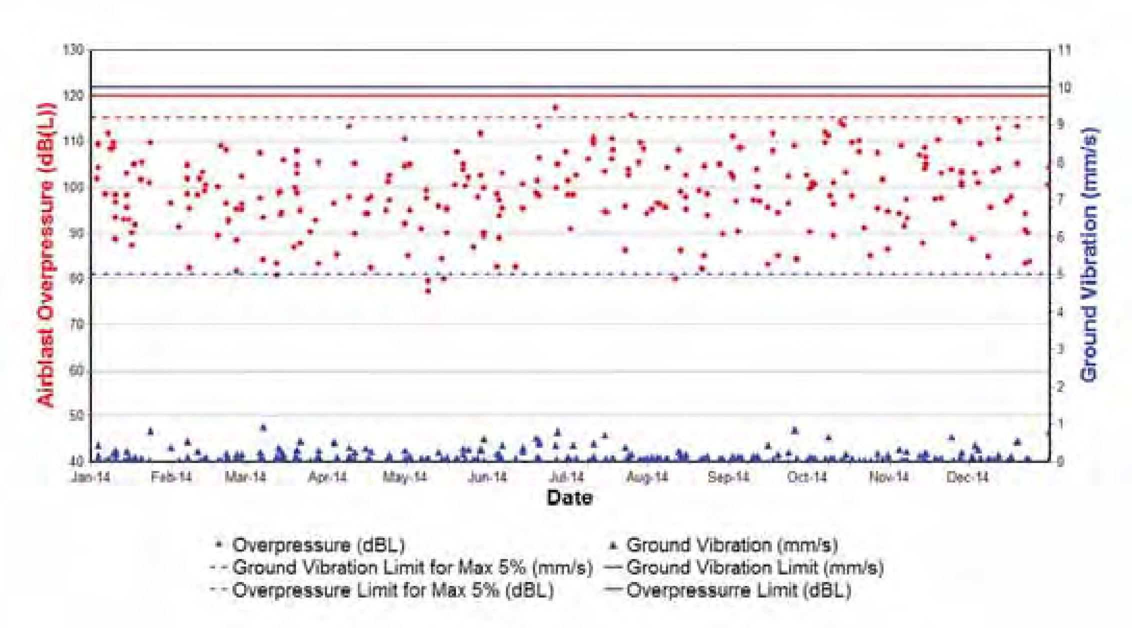


Figure 16: Maison Dieu Blast Monitoring Results 2014

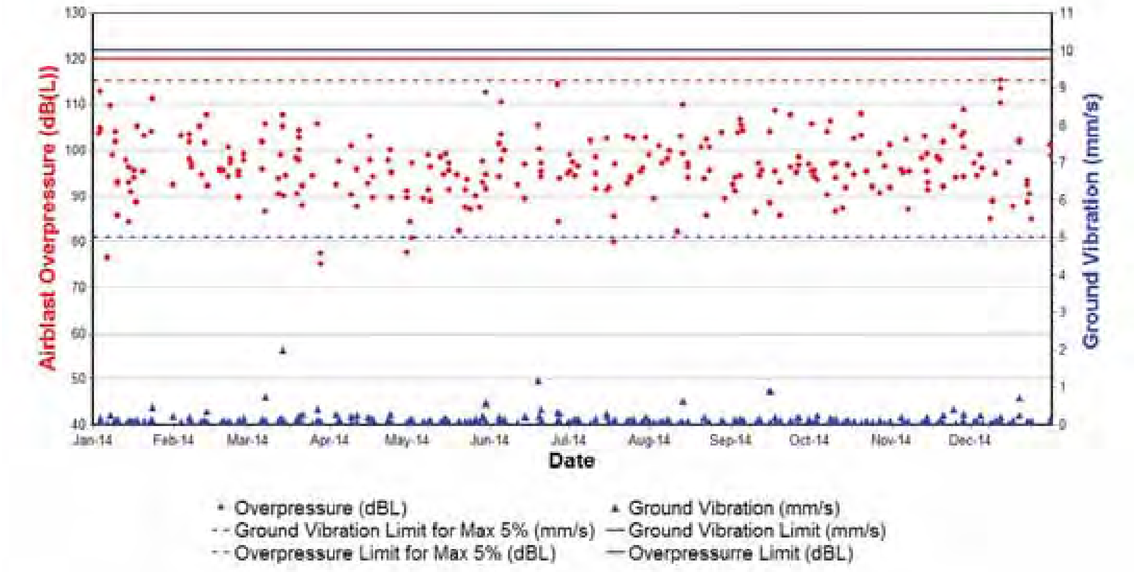


Figure 17: Moses Crossing Blast Monitoring Results 2014

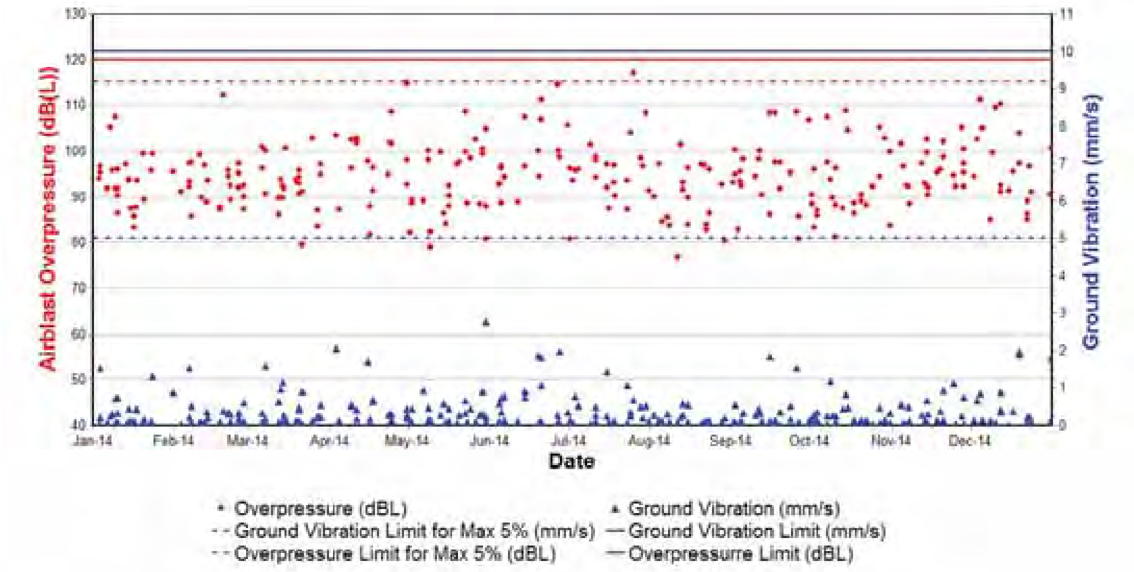


Figure 18: Warkworth Blast Monitoring Results 2014

3.3.3 Blast fume management

HVO operates under a Post Blast Fume Generation Mitigation and Management Plan. This document outlines the practices to be utilised to reduce generation of post blast fume, and reduce potential offsite impact from any fume which may be produced. This includes risk assessment of the likelihood of fume production, specialised blasting design, appropriate product selection, on-bench water management, implementation of fume management zones and use existing blasting permissions to identify likely path of any fume which may be produced.

All blasts are observed for fume and any fume produced is ranked according to the Australian Explosive Industry & Safety Group (AEISG) Scale.

During 2014, no blast produced visible post-blast fume ranking as Level 4 or Level 5 according to the AEISG Scale.

Rankings for visible blast fume according to the AEISG scale for shots fired during 2014 and comparison to rankings distribution during previous years is provided in Table 24.

Table 24: Visible blast fume rankings according to the AEISG colour scale

AEISG Ranking	2014	2013	2012
0	245	247	273
1	40	50	49
2	17	20	24
3	4	0	3
4	0	0	1
5	0	0	0
Total*	**306**	**317**	**350**

* Where a number of individual blasts were fired as a blast event, fume was assessed for each individual blast pattern rather than for the event as a whole.

3.3.4 Blasting Non-compliances during the Reporting Period

During 2014, there was one exceedance of the 120dB (L) overpressure criteria. A Cheshunt Pit blast, P120WK203A, recorded a reading of 120.2 dB(L) at the Knodlers Lane blast monitor. There were no exceedences of the 5 mm/s or 10 mm/s ground vibration criteria at any residence on privately-owned land.

There were a total of 13 blasts that recorded an initial overpressure reading greater than 115 dB (L) during the reporting period. Upon investigation, five of these blasts were found to be due to wind reinforcement and as such are not considered to constitute non-compliance with HVO's conditions of approval. The resulting eight readings over 115 dB (L) limit represents 2.85 % of blasts, which falls under the 5% limit over a period of 12 months specified in approval documents.

3.4 Air Quality

3.4.1 Air Quality Management

Air quality management initiatives are implemented at HVO so as to ensure that:

- air quality impacts on surrounding residents are minimised;
- all statutory requirements are adhered to; and
- local community and regulators are kept informed through prompt and effective response to issues and complaints.

Air quality control mechanisms employed at HVO are described in detail in the Hunter Valley Operations Air Quality and Greenhouse Gas Management Plan, publically available via the Rio Tinto website.

Figure 19 shows the air quality monitoring network at HVO.

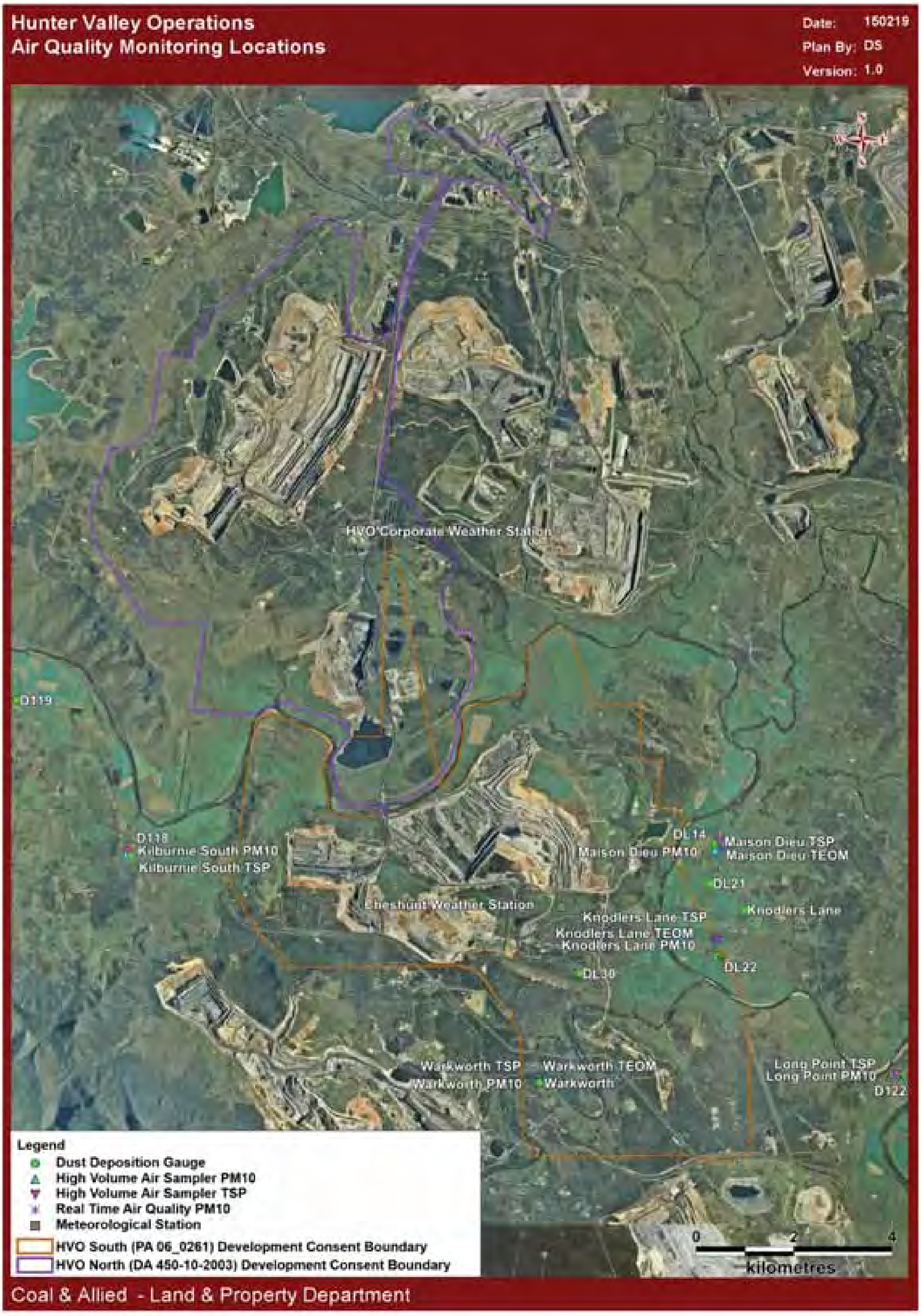


Figure 19: Air Quality Monitoring Network

3.4.2 Air Quality Performance

3.4.2.1 Real Time Air Quality Management

HVO's real time air quality monitoring stations continuously log information and transmit data to a central database, generating alarms when particulate matter levels exceed internal trigger limits.

A total of 367 real time alarms for air quality and wind conditions were received and acknowledged during 2014. In response, 3066 hours of equipment downtime was recorded due to air quality management. A detailed breakdown of air quality related equipment stoppages (per month, per equipment type) is presented in Figure 20.

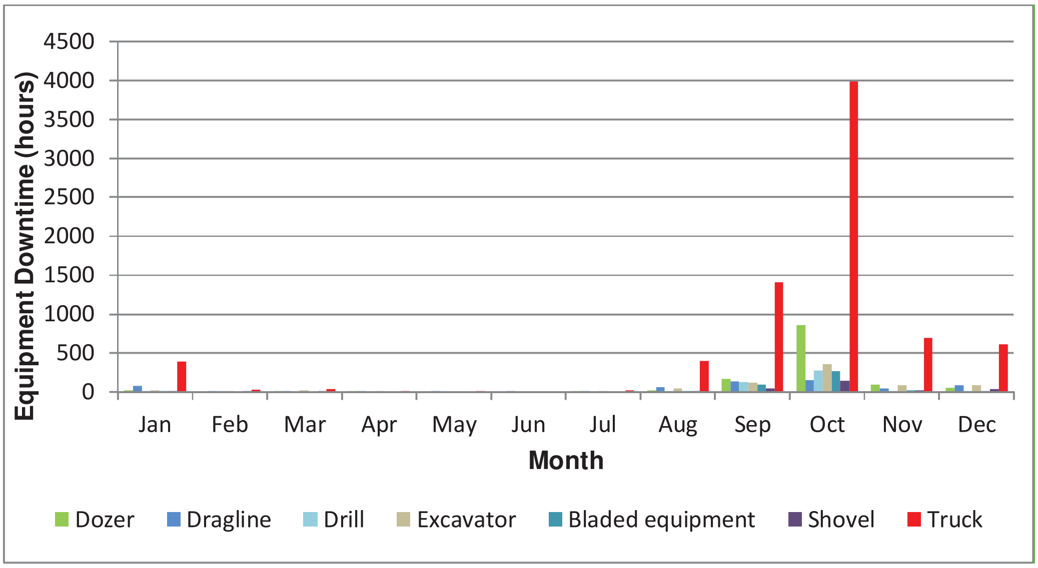


Figure 20: Equipment Downtime Hours for Air Quality Management 2014

3.4.2.2 Adverse Conditions / Wheel Generated Dust

In accordance with the requirements of Pollution Reduction Programmes U1 (Wheel Generated Dust) and U3 (Disturbing and Handling Overburden under Adverse Weather Conditions), Hunter Valley Operations submitted detailed reports to the Environment Protection Agency to satisfy the relevant conditions of the licence. Following submission, these reports were published to the Rio Tinto website, and are now publically available.

In a letter to HVO dated 17 September 2014, the EPA confirmed that the reports submitted demonstrated substantial compliance with the conditions, and that accordingly the conditions would be removed from HVO's Environment Protection Licence. For wheel generated dust HVO measured a dust control efficiency of 96% compared to the target of 80%.

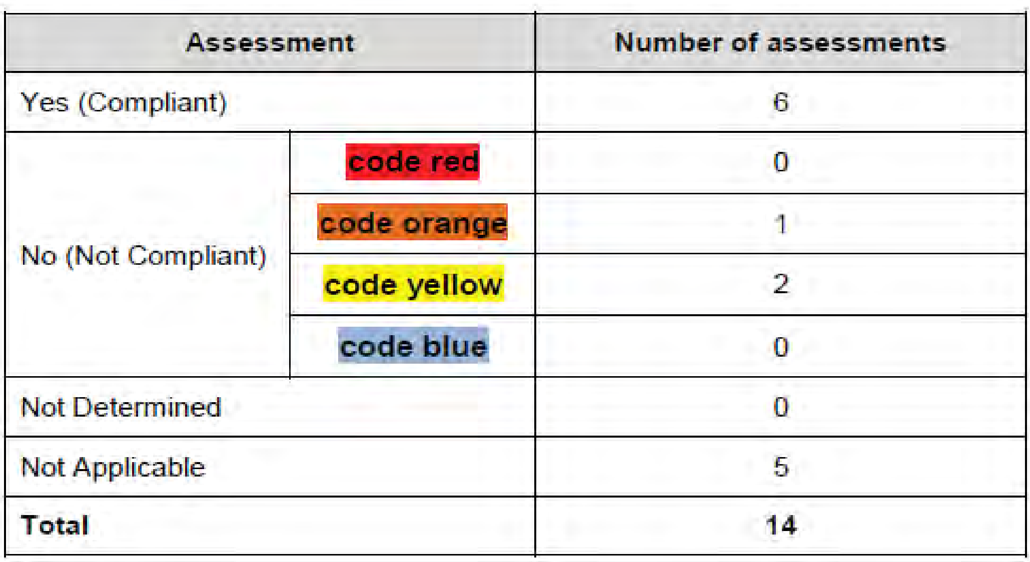
3.4.2.3 Compliance audits

During 2014, HVO's Newdell and Hunter Valley Load Point (HVLP) were the subject of a train load-out compliance audit, undertaken by the NSW EPA. The audit inspection was carried out by EPA Officers on 8 July 2014. In a final report issued to HVO in December 2014, three non-compliances were identified as listed in Figure 21.

The non-compliances related to the loading profile of coal within a number of wagons; broken shear plate deflectors at the Newdell Loading Point; and the presence of one (only) measure to ensure the prevention of leaks and spills of coal from wagon doors during rail transport.

In a response to the EPA in regards to the non-compliances identified, HVO has questioned the materiality of the non-compliances with respect to the risk posed to the people and the environment. Nonetheless HVO considers the findings improvement opportunities and has developed an action plan to address the non-compliances identified in the audit.

No further Independent Environmental Audits were undertaken in the reporting period.



Assessment		Number of assessments
Yes (Compliant)		6
No (Not Compliant)	code red	0
	code orange	1
	code yellow	2
	code blue	0
Not Determined		0
Not Applicable		5
Total		**14**

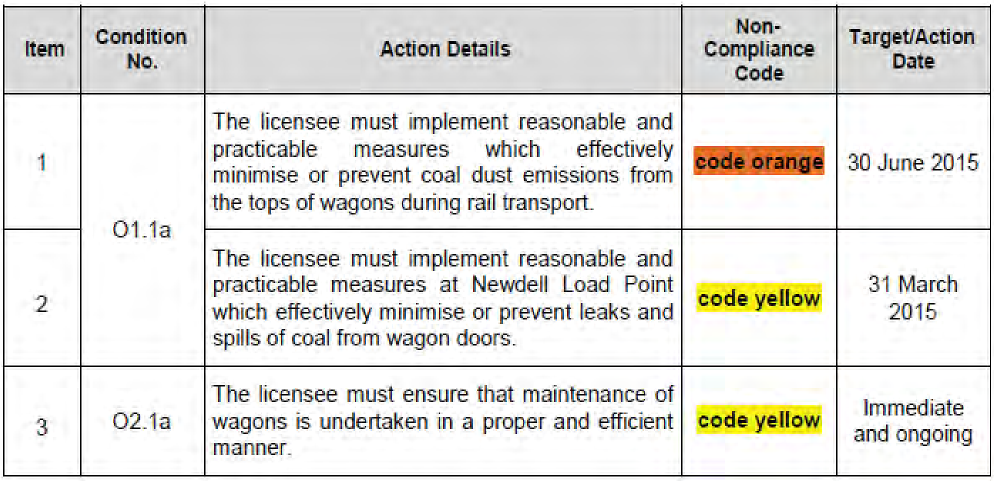
Figure 21: Summary of Compliance (excerpt from EPA report)

Code Red = a non-compliance of considerable environmental significance which must be dealt with as a matter of priority

Code Orange = a non-compliance of environmental significance however of a lower priority than a code red

Code Yellow = of lower importance than a Code Red or Orange, but is still important and must be addressed

Code Blue = a non-compliance relating to an administrative, monitoring or reporting requirement with no direct environmental significance



Item	Condition No.	Action Details	Non-Compliance Code	Target/Action Date
1	O1.1a	The licensee must implement reasonable and practicable measures which effectively minimise or prevent coal dust emissions from the tops of wagons during rail transport.	code orange	30 June 2015
2		The licensee must implement reasonable and practicable measures at Newdell Load Point which effectively minimise or prevent leaks and spills of coal from wagon doors.	code yellow	31 March 2015
3	O2.1a	The licensee must ensure that maintenance of wagons is undertaken in a proper and efficient manner.	code yellow	Immediate and ongoing

Figure 22 - Action Plan to address non-compliances (Excerpt from EPA audit report).

Note the dates for compliance are the subject of discussion with EPA.

The full audit report, along with HVO's response to the report can be viewed on the POEO Public Register (http://www.epa.nsw.gov.au/prpoeoapp/).

3.4.2.4 Temporary Stabilisation

Aerial Seeding was undertaken in early May by a fixed wing aircraft to provide a temporary vegetation cover to reduce area exposed to dust generation from wind. Waste dumps and exposed areas were selected for seeding if they were not planned to be disturbed within six months. Across the course of a day 458ha of dumps and exposed areas were aerially seeded at HVO, as shown in Figure 23. The seed mix used was variety of pasture grasses and legumes designed to ensure greatest germination success. A starter fertiliser was mixed with the seed prior to loading to provide sufficient nutrients for plant growth.

Figure 23: Areas Aerial Seeded in 2014

3.4.3 Air Quality Monitoring

Air quality monitoring at HVO is undertaken in accordance with the HVO Air Quality Monitoring Programme (available via the Rio Tinto website www.riotinto.com), comprising an extensive network of monitoring equipment which is utilised to assess performance against the relevant conditions of HVO's approvals. Air quality monitoring locations are shown in Figure 24. During 2014, HVO complied with all short term and annual average air quality criteria.

Air quality compliance criteria are shown in Table 25 and Table 26, along with a summary of HVO's performance against the criteria. HVO currently operates under two separate Planning Approvals (DA450-10-2003 – HVO North, and PA 06-0261 – HVO South). With the exception of the percentile frequency of short term PM_{10} non-compliance allowable under the HVO South Approval (Table 12 in Schedule 3, Condition 20 of PA 06_0261), the air quality criteria are identical in both approvals. As such it should be noted that the following compliance assessment has been undertaken on a 'whole of HVO site' basis, rather than individually assessing the contribution of each approval area to the measured results.

Regularly updated air quality monitoring data is made publically available through the HVO Monthly Environmental Monitoring Report, which can be viewed on the Rio Tinto website.

Figure 24: Air Quality Monitoring Locations 2014

Table 25: Air quality impact assessment criteria and 2014 compliance assessment (HVO North DA 450-10-2003 and HVO South PA 06_0261)

Pollutant	Criterion	Averaging Period	Compliance
Deposited Dust	4 g/m^2/month	Maximum total deposited dust level	100%
	2 g/m^2/month	Maximum increase in deposited dust level	100%
Total Suspended Particulate matter (TSP)	90 $\mu g/m^3$	Long Term (Annual)	100%
Particulate matter <10µm (PM_{10})	30 µg/m3	Long Term (Annual)	100%
	50 µg/m3	Short Term (24 hour)	100%

Table 26: Air quality land acquisition criteria and 2014 compliance assessment (HVO North DA 450-10-2003 and HVO South PA 06_0261)

Pollutant	Criterion	Averaging Period	Compliance
Deposited Dust	4 g/m2/month	Maximum total deposited dust level	100%
	2 g/m2/month	Maximum increase in deposited dust level	100%
Total Suspended Particulate matter (TSP)	90 µg/m3	Long Term (Annual)	100%
Particulate matter <10µm (PM10)	30 µg/m3	Long Term (Annual)	100%
	150 µg/m3 [a]	Short Term (24 hour)	100%
	50 µg/m3 [b]	Short Term (24 hour)	100%

a – Total impact (i.e. incremental increase in concentrations due to the development plus background concentrations due to all other sources);

b – Incremental impact (i.e incremental increase in concentrations due to the development on its own)

3.4.4 Deposited Dust

Deposited dust is monitored at nine locations on privately-owned land, in accordance with AS3580.10.1 (2003). The annual average insoluble matter deposition rates in 2014 compared with the depositional dust impact assessment criterion and previous years' data are shown in Figure 25. During 2014 all annual average insoluble matter deposition rates were compliant with the long term impact assessment and land acquisition criteria. All monitoring locations also demonstrated compliance with the maximum allowable insoluble solids increase criteria of 2g/m2.month (Figure 26).

During 2014 monthly dust deposition rates equal to or greater than the long term impact assessment criteria of 4g/m2.month were recorded at number of sites. Where field observations denote a sample as contaminated (typically with insects, bird droppings or vegetation), the results are excluded from Annual Average compliance assessment. Meteorological conditions and the results of nearby monitors for the sampling period are also considered when determining HVO's level of contribution to any elevated result. Details of excluded results are presented in the relevant HVO Monthly Environmental Monitoring Report.

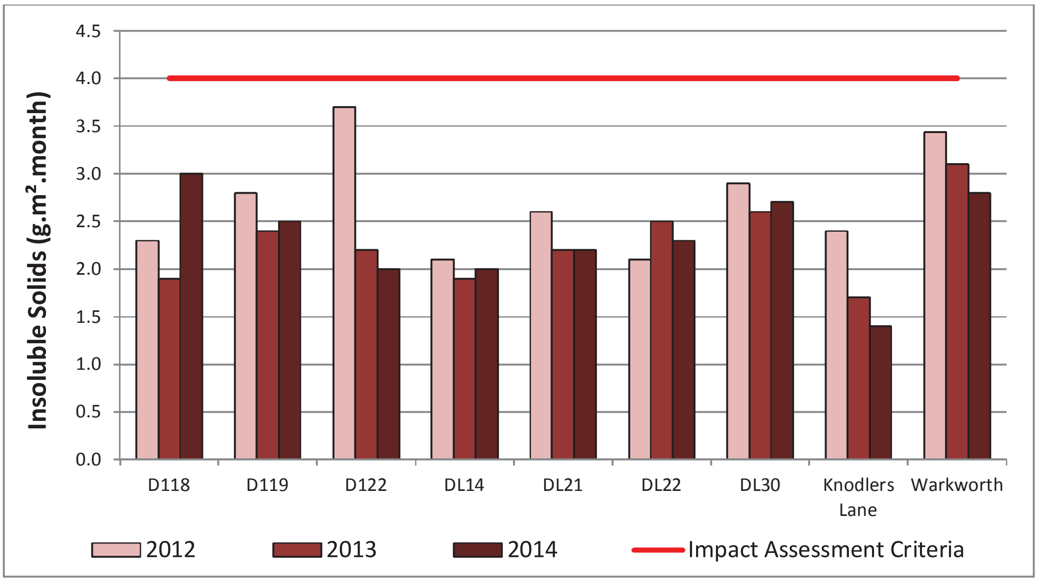


Figure 25: Annual average insoluble matter deposition rates 2012-2014

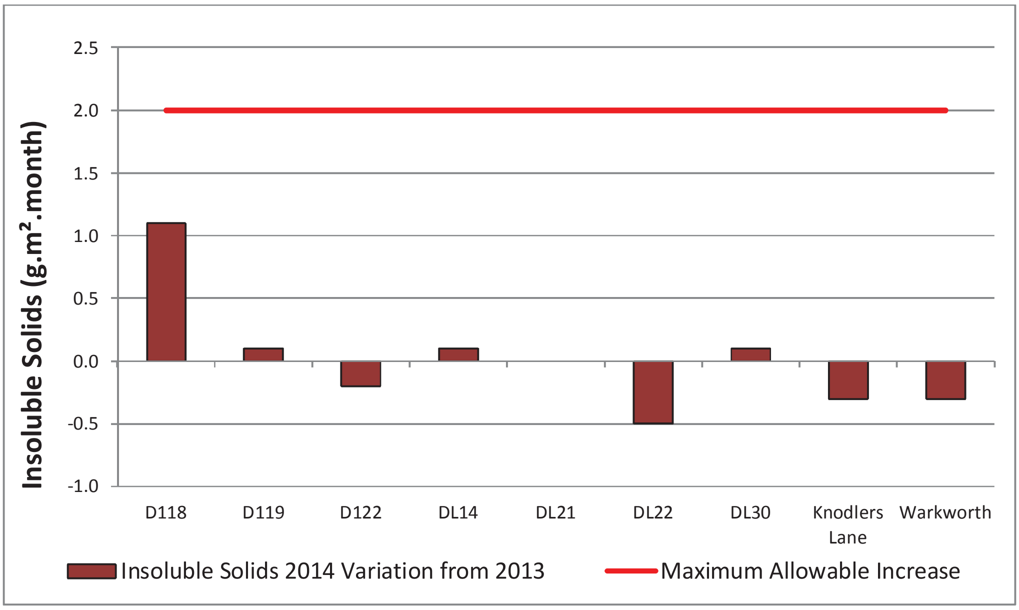


Figure 26: Annual average total insoluble solids variation, 2014 from 2013

3.4.5 Total Suspended Particulates (TSP)

Total Suspended Particulates (TSP) are measured at five locations on privately owned land in accordance with AS3580.9.3 (2003). Annual average TSP concentrations recorded in 2014 compared with the long term impact assessment criterion and previous years' data, are shown in Figure 27. During 2014 all annual average results were compliant with the impact assessment and land acquisition criteria.

The annual average TSP concentrations recorded in 2014 are generally consistent with those during previous years with the exception of Kilburnie South which recorded an increase on the 2013 TSP Annual Average of 8µg/m3, similar to results recorded in 2012. TSP concentrations at Knodlers Lane reduced by 14µg/m3, in line with results recorded in 2012, and comparable to the long term average of 62.3µg/m3 at this location.

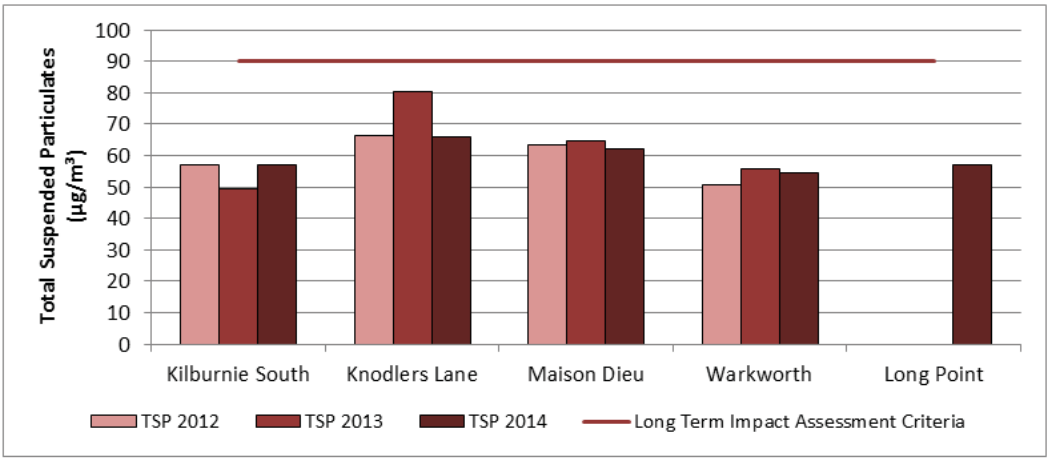


Figure 27: Annual average TSP concentrations 2012 to 2014

Note: the Long Point monitor was installed in late 2013. 2013 data is not shown here due to it not being a full years data set.

3.4.6 Particulate Matter <10µm (PM10)

In years' previous, compliance assessment with PM10 criteria has been undertaken through direct comparison of results recorded through the PM10 High Volume Air Sampler monitoring regime against the relevant criteria. The Department of Planning and Environment clarified reporting expectations to the industry in a directive dated 7 July 2014, requiring mines with real-time monitoring devices to report on the results for compliances purposes. Accordingly, PM10 results recorded by both the High Volume Air Samplers and TEOM's are reported here.

Compliance assessment for Particulate Matter <10µm (PM10) is measured at five locations on privately owned land in accordance with AS3580.9.6 (2003). During 2014 all short term and annual average results were compliant with the impact assessment and land acquisition criteria.

Routine monitoring of PM10 at the Hunter Valley Glider Club (HVGC) commenced on 24th November 2014 in accordance with the HVGC Amenity Management Plan, and following consultation with the HVGC. PM10 results from this location will be reported in the next annual review period, once a complete years' data has been collected.

3.4.6.1 Short term PM10 impact assessment criteria

Monitoring results for 2014 PM10 (24 hour) collected through the High Volume Air Sampler monitoring regime compared against the short term impact assessment criteria is shown in Figure 28. All 24hr average results recorded by HVO's surrounding network of TEOM monitors is presented on a quarterly basis in Figure 29 to Figure 32.

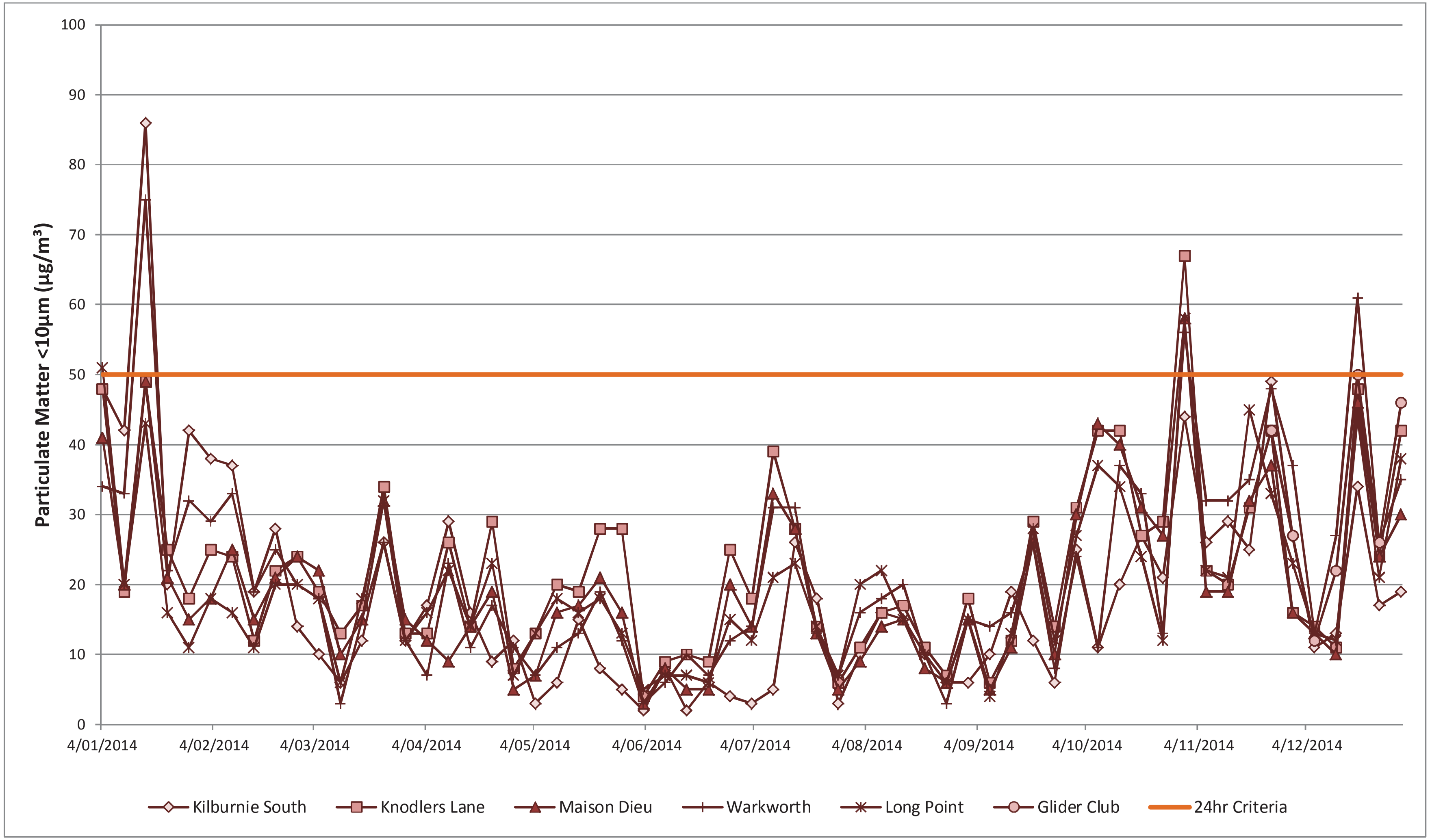


Figure 28: 2014 PM10 Results

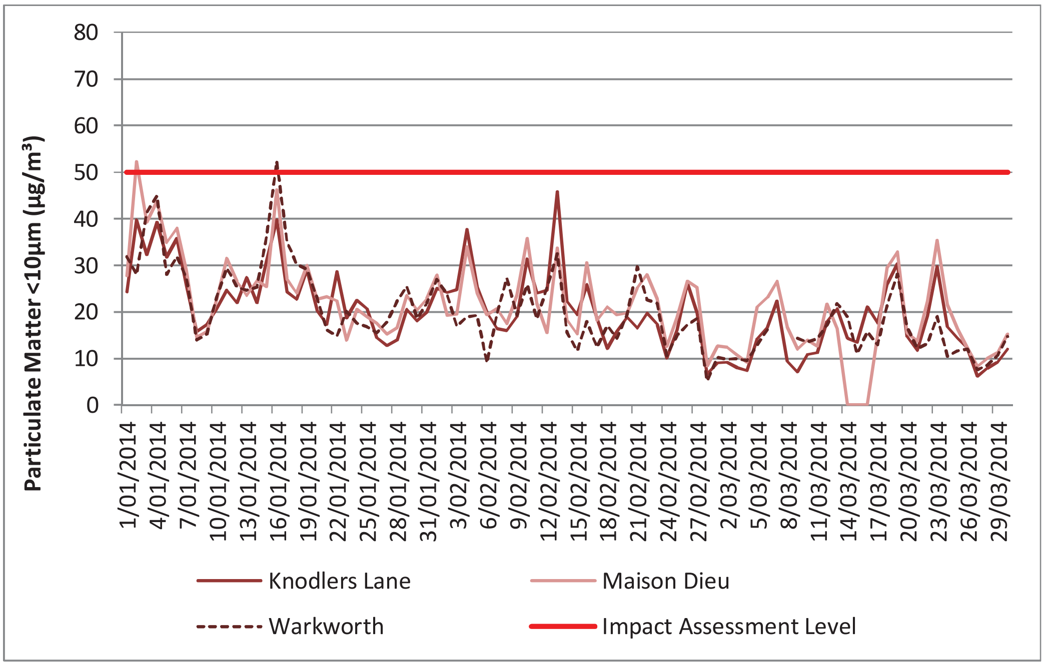


Figure 29: 24hr average PM$_{10}$ measured at TEOM monitors surrounding HVO - Quarter One 2014

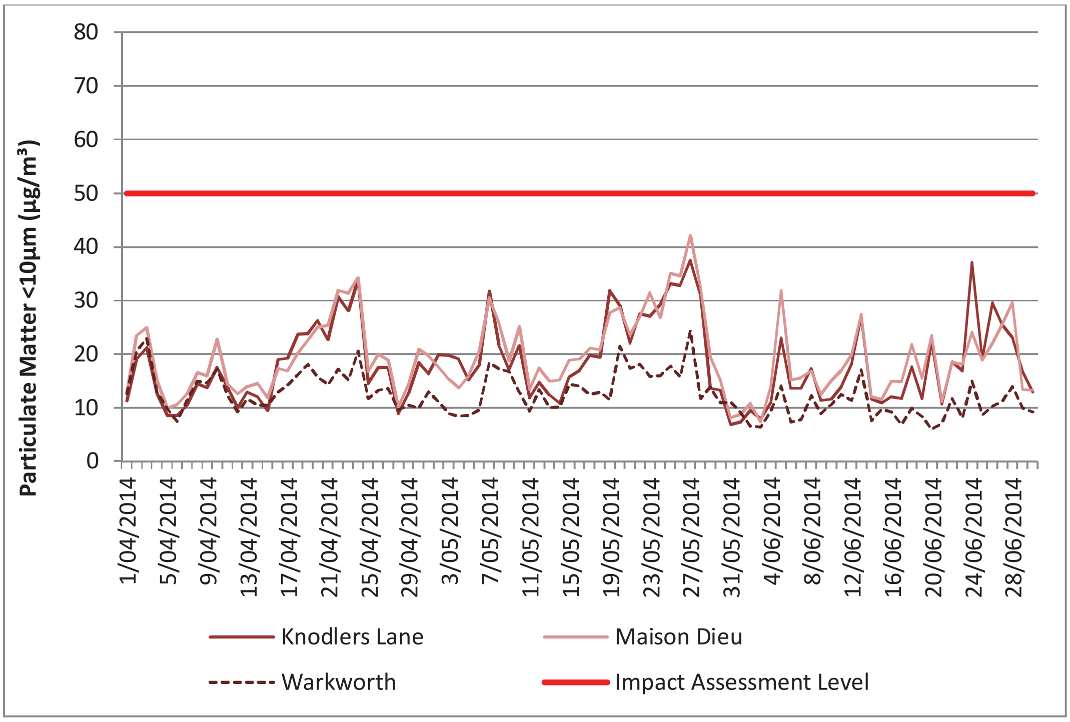


Figure 30: 24hr average PM10 measured at TEOM monitors surrounding HVO - Quarter Two 2014

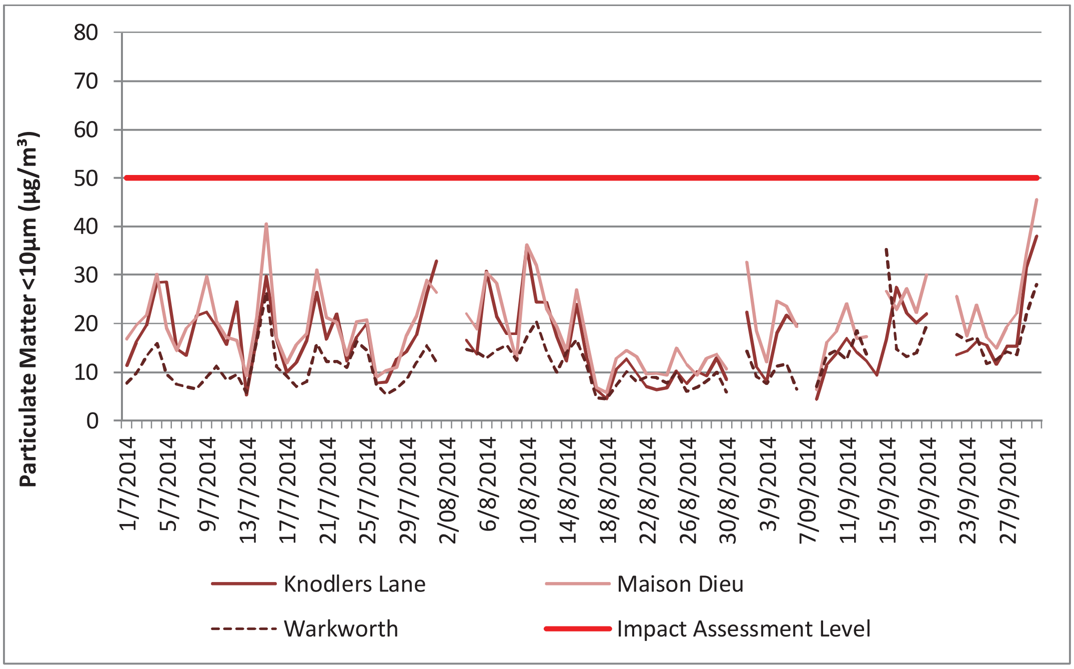


Figure 31: 24hr average PM10 measured at TEOM monitors surrounding HVO - Quarter Three 2014

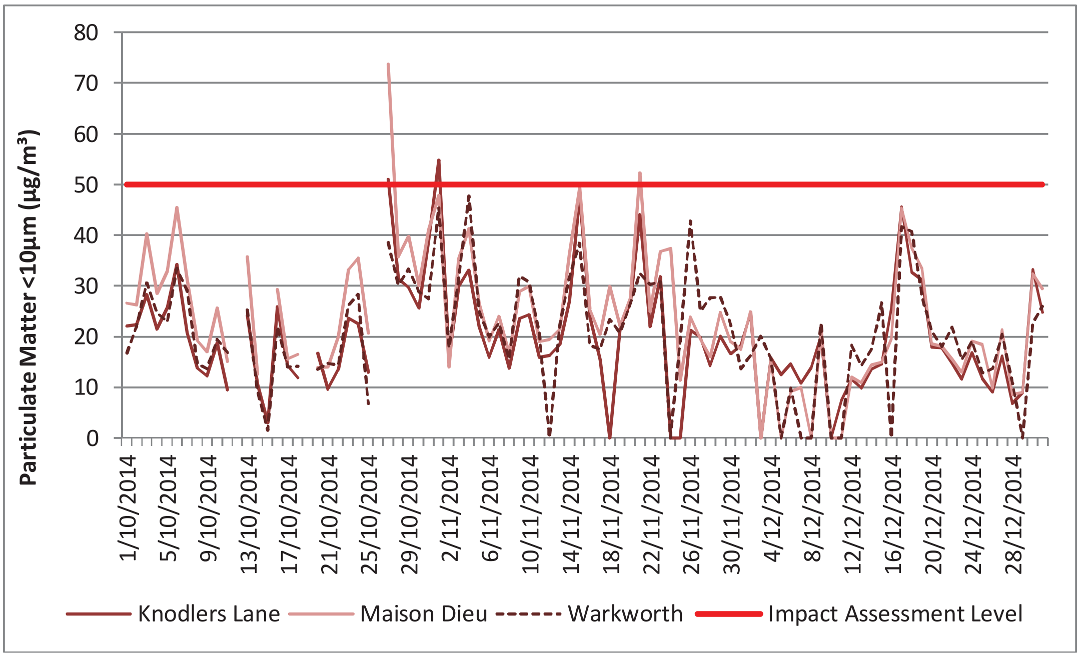


Figure 32: 24hr average PM10 measured at TEOM monitors surrounding HVO - Quarter Four 2014

Seven High Volume Air Sampler measurements and two TEOM PM$_{10}$ measurements exceeded the 24hr impact assessment criteria during the reporting period. Each was investigated to determine the level of contribution from HVO activities to the elevated result (Table 27). For each measurement, it was determined that HVO was not the predominant contributor hence compliant with the impact assessment criteria. DP&E were notified at the time of each exceedance, with follow-up notifications to confirm the outcome of the investigation undertaken. No further requests were received from the Department in relation to these events.

In July 2014, the Department of Planning and Environment made a formal request for operations to assess and report real-time air quality monitoring data as a measure of compliance. As such only real time PM$_{10}$ results greater than the short term criteria and after the July request date are listed below.

Table 27: 24 hour PM10 investigations - 2014

Date	Site	24hr Result (µg/m^3)	Estimated contribution from HVO (µg/m^3)	Discussion
04/01/2014	Long Point	51	16.3	Wind direction information confirms HVO could have only contributed to measured levels for approx 5 hours and 20 minutes. Corresponding data during this time indicates PM$_{10}$ increment of 12.5µg/m^3 (or approx 32% of measures levels at that monitor). Conservative estimation of HVO's contribution therefore of 16.3µg/m^3 on the day.
16/01/2014	Kilburnie South	86	-	Elevated results are the direct result of nearby bushfires.
16/01/2014	Warkworth	75		
31/10/2014	Knodlers Lane	67	37.1	Elevated dust levels throughout the Valley on the day (Muswellbrook - 34µg/m^3, Singleton – 46µg/m^3).
31/10/2014	Maison Dieu	58	38.9	
31/10/2014	Warkworth	56	20.2	
31/10/2014	Long Point	58	26.2	
01/11/2014	Knodlers Lane TEOM	54.8	17.3	Contribution estimation based on upwind – downwind assessment given consistent Westerly and Nor-westerly winds throughout the day. Analysis of upwind data (Wandewoi (39.3 µg/m^3), identifies elevated dust levels, supported by regional data (Muswellbrook – 26.3 µg/m^3).
21/11/2014	Maison Dieu TEOM	52.3	28.7	Winds predominantly from the South-West on the day. Periods of elevated dust at times when winds were blowing from both the South West, and later in the day from the North East. Elevated dust in both upstream and downstream regional centres (34µg/m^3 in Muswellbrook, 42µg/m^3 in Singleton) indicates regional dust event, supported by upwind HVO monitor at Wandewoi (30.6µg/m^3).

3.4.6.2 Long term PM10 impact assessment criteria

Annual average PM10 concentrations recorded at the five monitoring locations in 2014, compared with the long term PM10 impact assessment criterion and previous years' data, are shown on Figure 33. During 2014 all annual average PM10 concentrations recorded on privately owned land were compliant with the assessment criterion, and are consistent with annual average results measured in recent years.

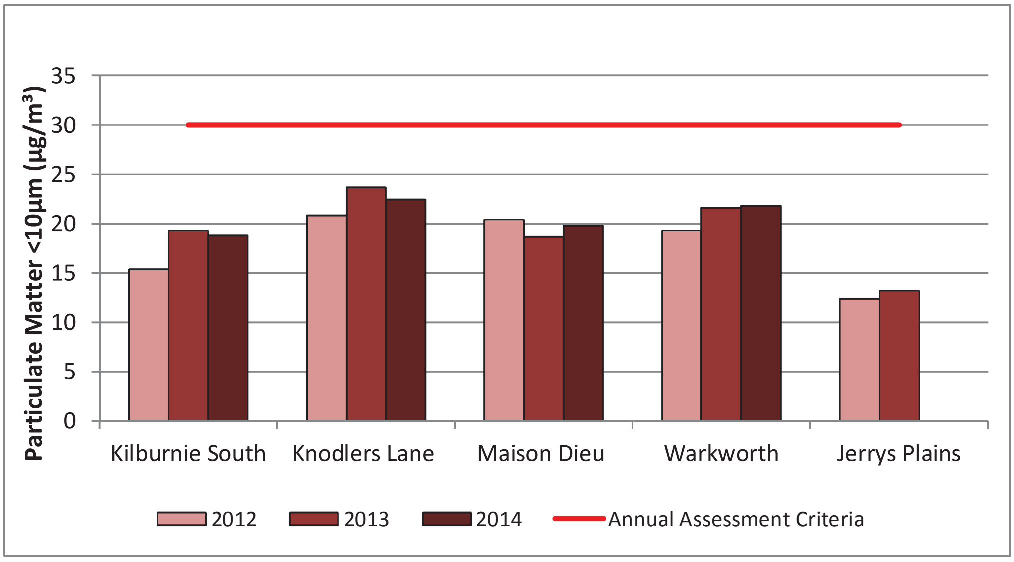


Figure 33: Annual average HVAS PM10 results 2012 to 2014

3.4.7 Comparison of 2014 Air Quality data against EA predictions

Table 28 to Table 30 show a comparison between 2014 air quality data and the predictions made in the HVO South Environmental Assessment 2008 (EA). Comparisons have been made against the predictions listed in the EA for the nearest private residence to each monitoring location.

Annual average PM10 measurements in 2014 are either below or consistent with predicted levels for all monitoring locations with the exception of Kilburnie South. Excluding the bushfire affected measurement of 16th January 2014, the amended annual average (17.6 µg/m3) is within 1 µg/m3 of the predicted value.

Comparison of 2014 maximum 24hr PM10 values against the predicted maximum values returned results either below or consistent with the predicted worst case results for the Maison Dieu and Knodlers Lane and Long Point monitoring locations. It should be noted that the worst case 24hr PM10 predictions refer to maximum concentrations generated by HVO South alone.

The measured results described in the table contain particulate matter contributions from a range of sources including HVO (North and South), neighbouring mines, and other non-mining sources such as agriculture and road traffic. The maximum result presented for the Kilburnie South monitoring location (49µg/m3 on the 24th November 2014) occurred on a day in which strong nor-westerly winds occurred for approximately 37% of the day. As such, it is highly unlikely that HVO South's contribution to this event exceeded the maximum predicted contribution of 40.9 µg/m3. TSP Annual Averages exceeded modelled predictions in 2014 at all monitoring locations with the exception of Warkworth. Section 9.1 of the HVO South Coal Project Air Quality Assessment (Holmes Air Sciences) notes that TSP concentrations are significantly under predicted. This is due to the fact that local dust sources (such as dust from local roads, stock movements and agricultural activity) have not been considered in the model.

Table 31 and Table 32 detail comparisons between 2014 air quality monitoring results and the modelled predictions from the 2010 HVO North Carrington West Wing Air Quality Impact Assessment. Predictions have been sourced from modelled scenarios of Year One of the Carrington West Wing development. It should be noted that while Approval has been granted for the commencement of that project, works have not yet commenced.

Comparison of measured PM10 closely aligns with modelled predictions for all monitoring locations (Table 34), however TSP measurements have exceeded predictions in a similar fashion to the comparison undertaken for HVO South. Given that the TSP fraction settles out of suspension faster than PM10 (and thus much closer to the operation), it is not reasonable to suggest that nearby private residences are being impacted by TSP to a greater degree than by PM10, on the basis of measured data exceeding the predictions. Rather, the data suggests the assumptions in the model relating to extraneous dust sources are under predicting total TSP levels which are experienced at receptors.

Regardless of correlation with the modelled predictions, TSP levels measured remain well below the impact assessment criteria of 90µg/m3 and have been relatively stable in recent years (Figure 27).

Table 28: 2014 PM10 Annual Average results compared against Cumulative Predictions for 2010 and 2014 HVO South Environmental Assessment

Site (EA receptor)	Short Term (24hr) criteria			Long Term (annual average) criteria		
	Predicted maximum 24hr PM_{10} due to HVO South alone (µg/m^3)		2014 maximum 24hr PM_{10} result (µg/m^3)	Predicted PM_{10} annual averages (µg/m^3)		2014 PM_{10} annual average (µg/m^3)
	2014	**2019**		**2014**	**2019**	
Maison Dieu (47)	81.9	49.4	58	19.7	17.2	19.8
Warkworth (43)	50.8	29	75	32.9	24.8	21.8
Kilburnie South (4)	40.9	16.6	49**	16.7	13.7	18.8
Knodlers Lane (32)	138	26.1	67	33.1	23	22.0
Long Point*	50-90	30-50	58	10-30	10-30	19.6

*No receptor identified in EIS (2008). Estimate has been made based on contours presented in the EIS.

** Bushfire influenced maximum result of 86µg/m3 excluded from this analysis

Table 29: HVO South Project Environmental Assessment Cumulative Predictions for 2010 and 2014 against 2014 Annual Averages for TSP Data

Site (EA receptor)	Long Term (annual average) TSP criteria		
	2014 Prediction ($\mu g/m^3$)	2019 Prediction ($\mu g/m^3$)	2014 Annual Average ($\mu g/m^3$)
Maison Dieu (47)	44.0	22.2	62.0
Warkworth (43)	60.1	29.8	54.4
Kilburnie South (4)	40.4	18.7	57.0
Knodlers Lane (32)	61.0	28.0	66.0
Long Point*	30-50	30-50	56.9

*No receptor identified in EIS (2008). Estimate has been made based on contours presented in the EIS.

Table 30: HVO South Environmental Assessment Cumulative Predictions for 2010 and 2014 against 2014 Annual Averages for Dust Deposition Data

Site	Units (Insoluble Solids)	Assessment Criteria	2014 Depositional Dust – EA Predictions Annual Averages	2019 Depositional Dust – EA Predictions Annual Averages	2014 Depositional Dust – Actual Annual Average
D118 (Kilburnie Sth) (4)	g/m2/month	4	0.8	1.1	3.0
D119 (Jerry's Plains School) (13)	g/m2/month	4	0.7	1.1	2.5
DL14 (Maison Dieu) (47)	g/m2/month	4	1.0	1.3	2.0
DL21 (32)	g/m2/month	4	2.0	1.9	2.2
DL22 (16)	g/m2/month	4	2.2	1.9	2.3
Knodlers Lane (24/34)	g/m2/month	4	1.5	1.6	1.4
Warkworth (43)	g/m2/month	4	1.7	1.6	2.8

Table 31: 2014 PM10 Annual Average results compared against Cumulative Predictions for Year One (CWW) - HVO North Environmental Assessment

Site (EA receptor)	Long Term (annual average) criteria	
	Predicted PM_{10} annual average ($\mu g/m^3$)	**2014 PM_{10} annual average ($\mu g/m^3$)**
Maison Dieu (6)	19.1	19.8
Warkworth (39)	20.8	21.8
Kilburnie South (4)	19.7	18.8

*no modelled predictions for the Long Point area

Table 32: 2014 TSP Annual Average results compared against Cumulative Predictions for Year One (CWW) - HVO North Environmental Assessment

Site (EA receptor)	Long Term (annual average) criteria	
	Predicted TSP annual averages ($\mu g/m^3$)	**2014 TSP annual average ($\mu g/m^3$)**
Maison Dieu (6)	44.7	62.0
Warkworth (39)	46.6	54.4
Kilburnie South (4)	45.2	57.0

*no modelled predictions for the Long Point area

3.4.8 Air Quality Non-compliances during the Reporting Period

HVO complied with all air quality criteria during 2014.

3.5 Water Balance

3.5.1 Water Management

HVO manages surface and ground water according to three main objectives:

- Fresh water usage is minimised;
- Impacts on the environment and HVO neighbours are minimised; and
- Interference to mining production is minimal.

This is achieved by:

- Minimising freshwater use from the Hunter River;
- Preferentially using mine water for coal preparation and dust suppression;
- An emphasis on control of water quality and quantity at the source;
- Segregating waters of different quality where practical;
- Recycling on-site water;
- Ongoing maintenance and review of the system; and
- Disposing of water to the environment in accordance with statutes and regulations.

Plans showing the layout of all water management structures and key pipelines are shown in Figure 35 to Figure 37. The HVO Water Management Plan contains further detail on management practices and is available on Rio Tinto Coal Australia's website.

Stage 1 of the Hunter River bridge project was completed in 2014. Stage 1 focused on the north side of the bridge and included augmentation of the existing sediment basins to increase containment capacity and provide automated pump-out control. Figure 34 shows a completed sediment basin. Further detail regarding stage 2 of this project is included in section 6.6 of this report.

Water management improvement works were also completed at the Newdell Coal Receival Pad. This work involved a combination of desilting of basins, improvement to ground cover, re-grading areas and removing or isolating disused infrastructure to ensure that water management infrastructure in the area was functioning correctly.

Figure 34: The completed sediment basin on the north-east side of the Hunter River Bridge

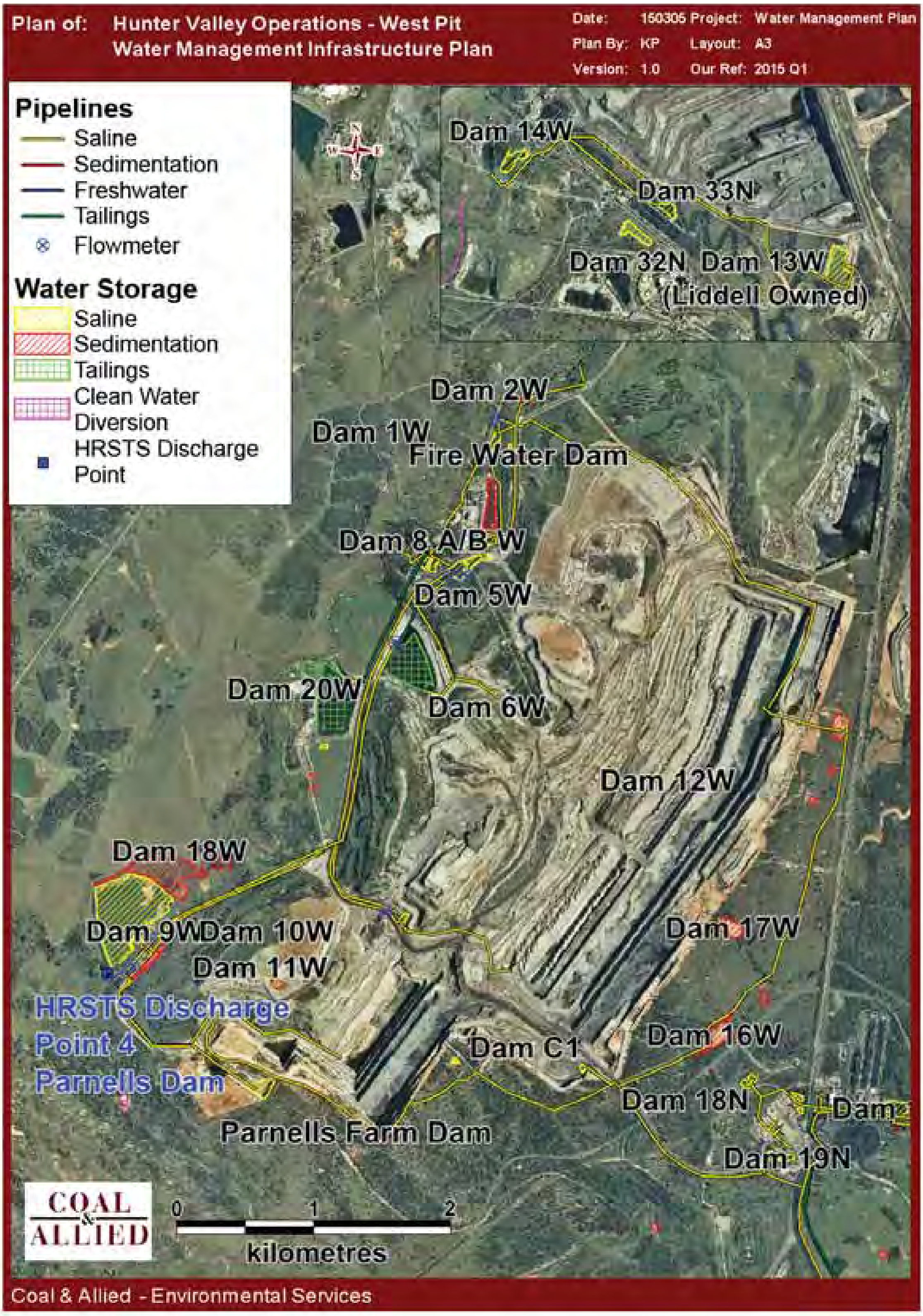


Figure 35: West Pit water management infrastructure

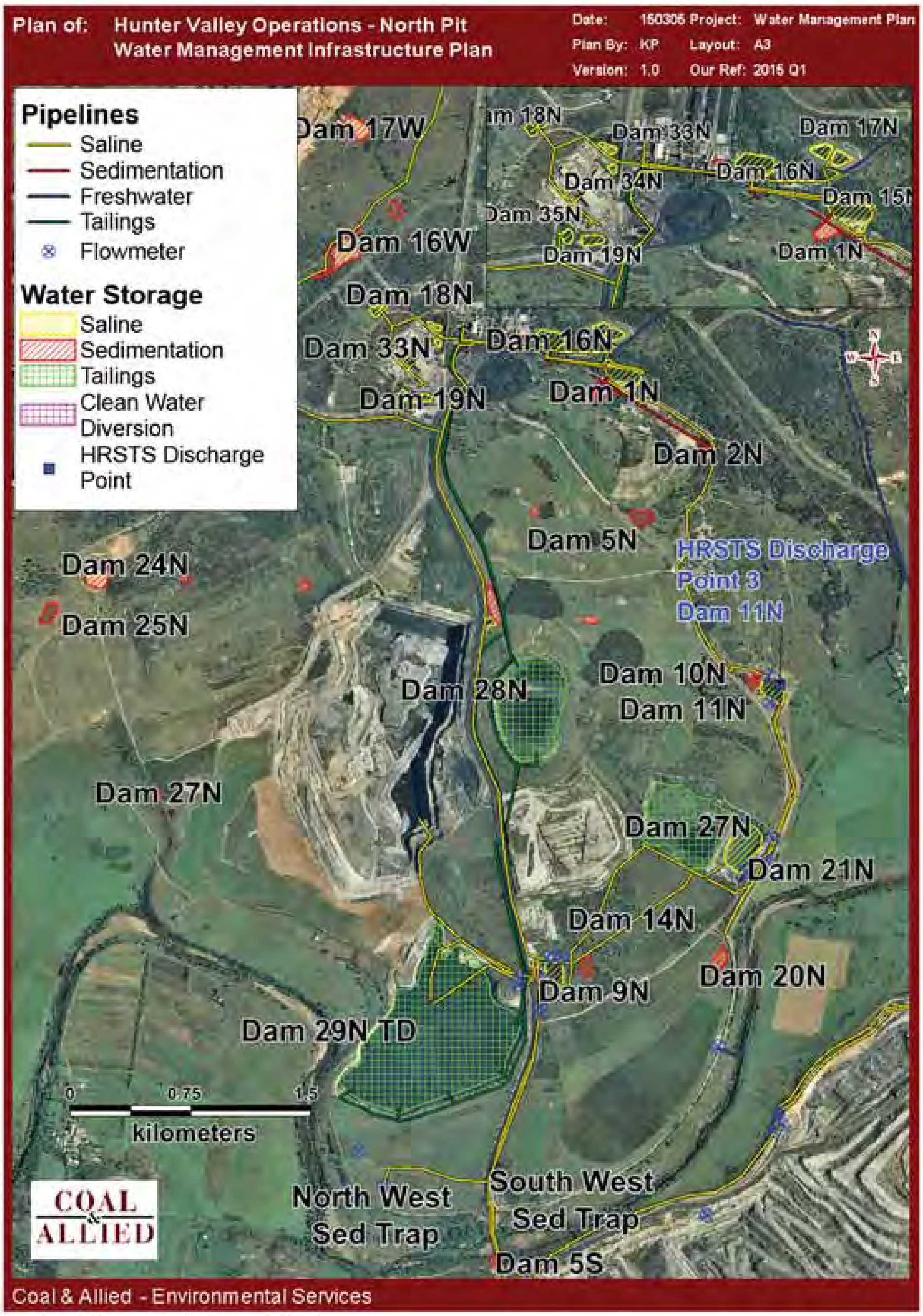


Figure 36: North Pit water management infrastructure

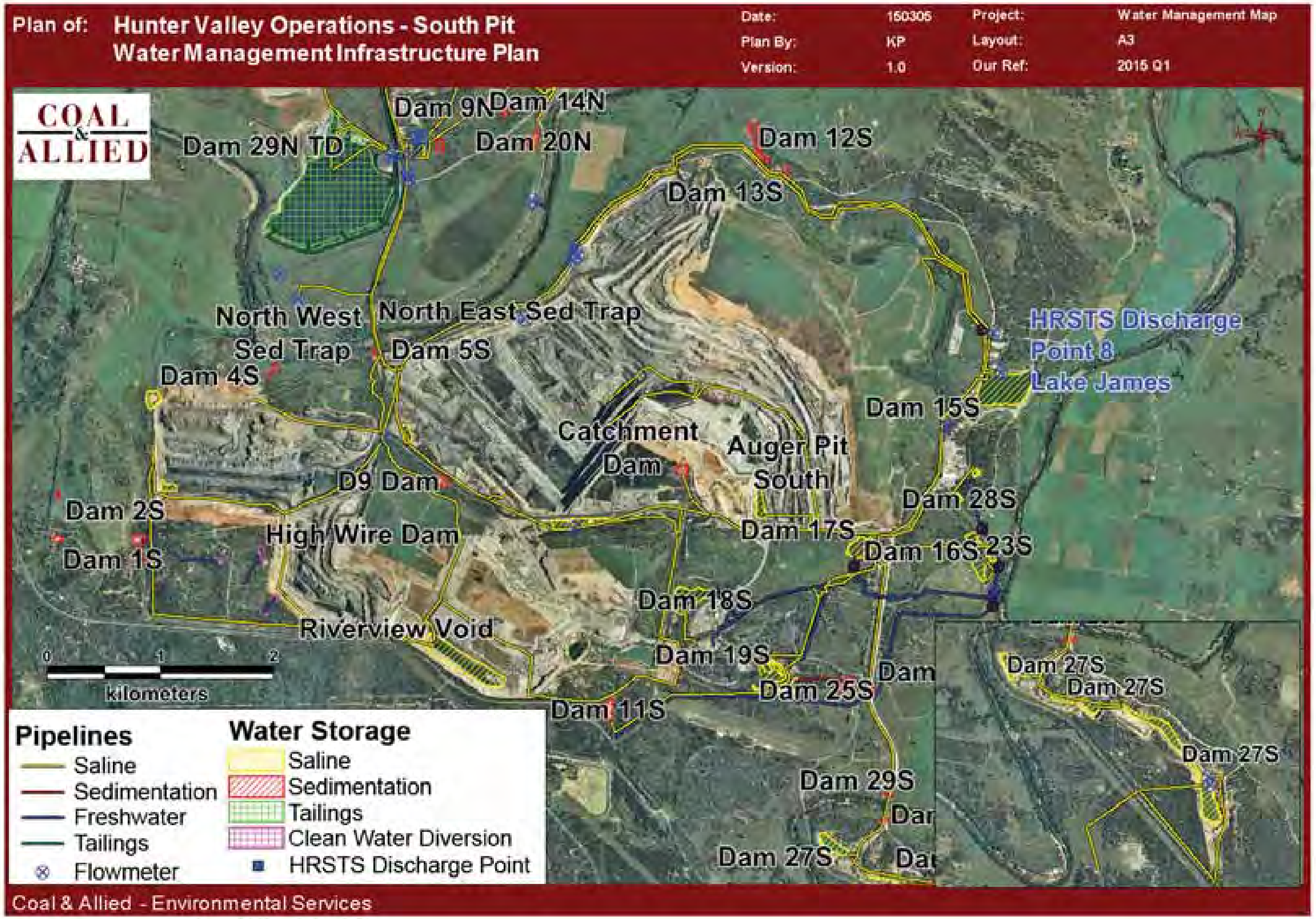


Figure 37: South Pit water management infrastructure

3.5.2 Water Performance

3.5.2.1 Water Balance

The 2014 static water balance for HVO is presented in Table 33 and a simplified schematic of this balance is included as Figure 38. The water balance is for a coal production rate of 18 million tonnes per year ROM and 13.91 million tonnes per year of product. Inputs and outputs (relative to production) were consistent with 2013. A salt flux schematic is shown in Figure 39.

Water balance results for 2014 are generally consistent with 2013; an increase in water use for dust suppression (due to drier weather conditions) and reduction in water lost due to evaporation (refinement of water balance model) are noted.

Table 33: 2014 HVO Water Balance

Water Stream	Volume (ML)
Inputs	
Fresh Water (potable)	23 (<1%)
Groundwater	1,752 (20%)
Rainfall Runoff	4,760 (54%)
Recycled to CHPP from Tails & Storage (not included in total)	2,724
Imported (Liddell)	35 (<1%)
Imported (Wambo)	584 (7%)
Water from ROM Coal	1,596 (18%)
Total Inputs	**8,750**
Outputs	
Dust Suppression	2,620 (31%)
Evaporation - Mine Water & Tailings Dams	811 (10%)
Entrained in Process Waste	1,443 (17%)
Discharged (HRSTS)	0
Sent to 3rd Party (Liddell)	4 (<1%)
Sent to 3rd Party (MTW)	620 (7%)
Vehicle Wash-down	257 (3%)
Miscellaneous Industrial Use	350 (4%)
Water in Coarse Reject	949 (11%)
Water in Product Coal	1,340 (16%)
Total Outputs	**8,394**
Change in Pit Storage (increase)	**356**

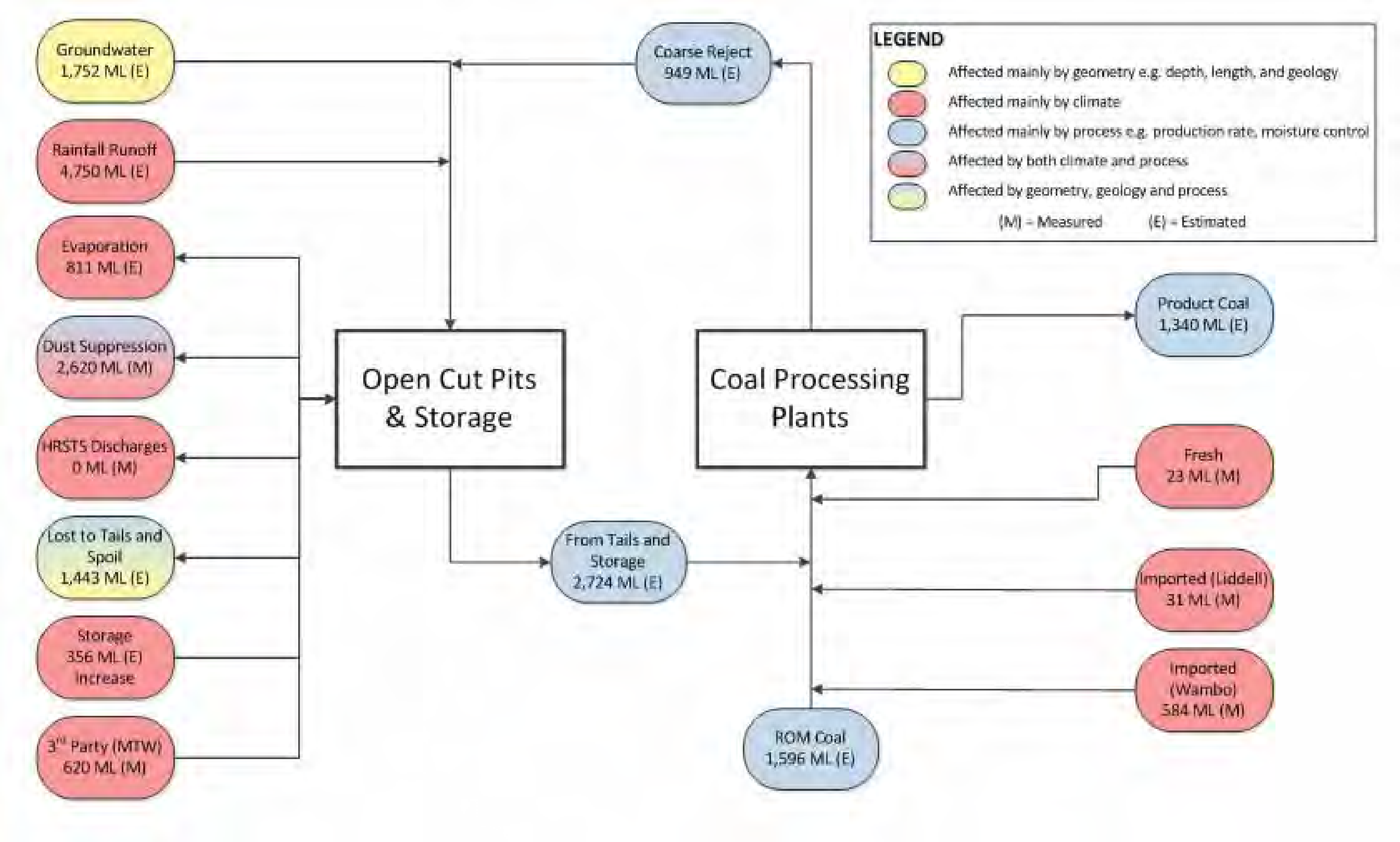


Figure 38: HVO water balance schematic diagram

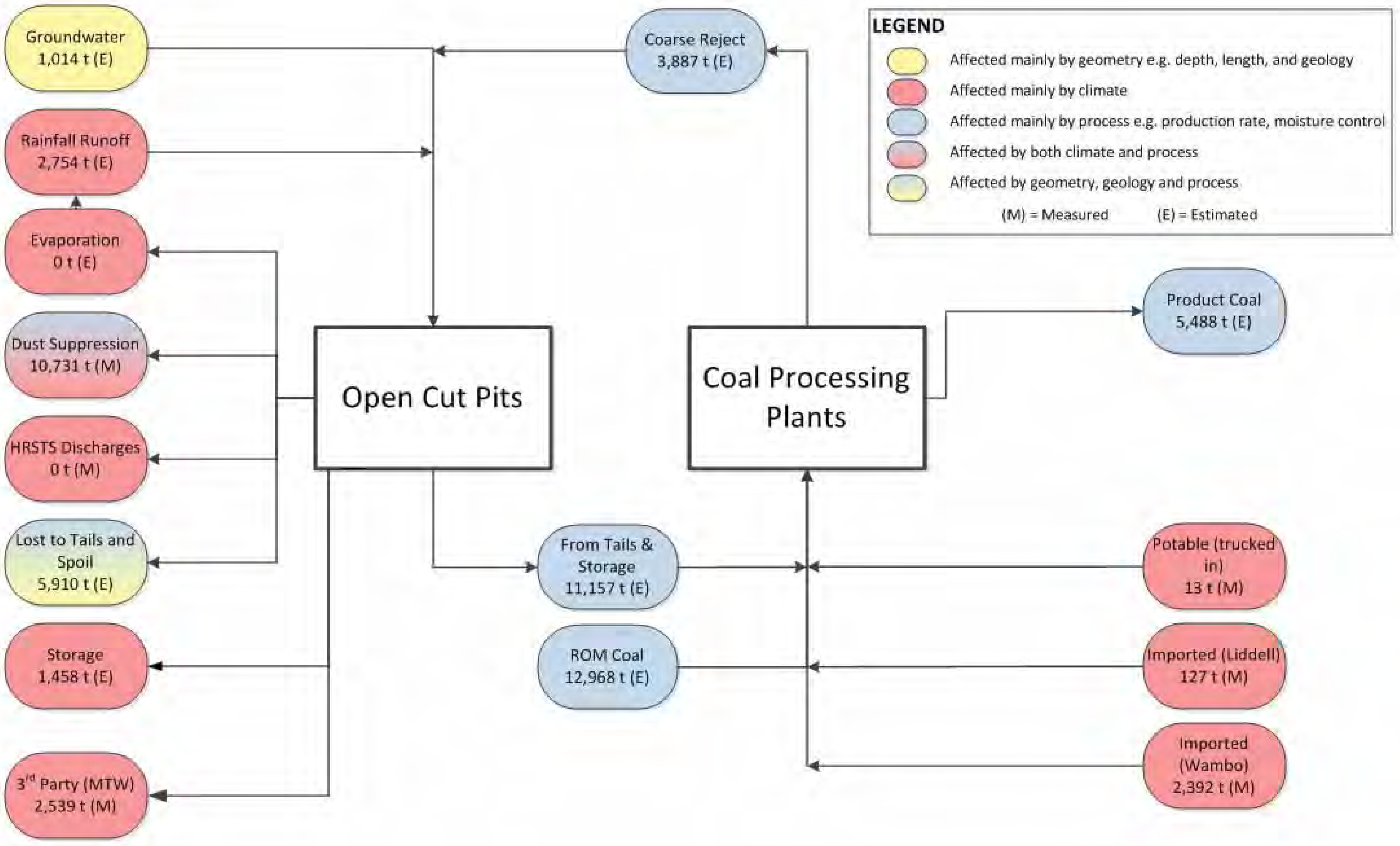


Figure 39: HVO Salt balance schematic diagram

3.5.2.2 Water Inputs

Water was supplied predominantly from three sources in 2014:

- Surplus mine water stored in pit;
- Intercepted runoff water; and
- Groundwater percolation into the open cut.

A total of 602.6 mm of rainfall was recorded at HVO in 2014 producing an estimated 4,760 ML of runoff from approximately 7,094 ha of developed, disturbed and mining catchments. Water falling on undisturbed clean water catchments is diverted off site into natural systems where possible. Rainfall runoff was the largest input to the site mine water balance in 2014.

Groundwater contributed a modelled 1,752ML to the site water supply. Groundwater modelling shows approximately 50% of total groundwater is contributed from the Hunter River and Wollombi Brook alluvium. Table 34 lists the modelled amounts of water entering the pit.

Groundwater intercepted from Hunter River is estimated to have contributed 916.2 ML to the site during the reporting period. HVO has a high security licence entitlement for 3,165ML of water in Zone 1B of the Hunter River. Seepage from the Wollombi Brook into South Lemington is estimated at 3.65 ML/year; a licence application to convert a current licence holding is still to be assessed by NSW Office of Water (NOW).

No fresh water was pumped from the Hunter River during the reporting period. All water extracted from the Hunter River is recorded against Water Access Licences issued by NSW Office of Water. Refer to Table 7 for details of these licences.

Table 34: Modelled or Measures Groundwater Contribution from Connected Hunter River

Pit	Alluvial Groundwater Intercepted (ML/day)	Source	Reference
Cheshunt (Including Barrys)	2.30	Hunter River	AGE 2014
North Pit (Alluvial Lands)	0.10	Hunter River	MER 2005
Carrington	0.11	Hunter River	AGE 2014
South Lemington	0.01	Wollombi Brook	AGE 2014

HVO South and Lemington 2014 Groundwater Impacts Report; Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) (2014).
HVO North – Annual Groundwater Impacts Review Report; Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) (2014).
Geochemical characterisation of coarse rejects and preliminary evaluation of groundwater mixing: alluvial lands pit – Hunter Valley Operations; Mackie Environmental Research (MER) (2005).

3.5.2.3 Water Outputs

Significant water uses at HVO in 2014 were for dust suppression on haul roads, mining areas and coal stockpiles (2,620ML) and water entrained in Process Waste (1,443ML). Evaporation from water storages and tailings facilities was estimated at 811ML.

HVO participates in the Hunter River Salinity Trading Scheme (HRSTS) allowing it to discharge from licensed discharge points during declared discharge events, associated with increased flow in the Hunter River. HVO maintains three licensed discharge monitoring locations:

- Dam 11N, located at HVO North, which discharges to Farrell's Creek
- Lake James, located at HVO South, which discharges to the Hunter River; and
- Parnell's Dam, located at HVO West, which discharges to Parnell's Creek

During 2014 Hunter Valley Operations did not discharge any water under the Hunter River Salinity Trading Scheme and Environment Protection Licence 640.

3.6 Surface Water

3.6.1 Water Management

HVO surface water management is detailed in the HVO Water Management Plan, and includes:

- Detailed plans of mine water infrastructure;
- Erosion and sediment controls;
- Performance criteria for the water management system, surface water quality; and
- Water quality and water flow triggers requiring action.

Surface water monitoring activities continued in 2014 in accordance with the HVO Water Management Plan and HVO Surface Water Monitoring Programme. HVO maintains a network of surface water monitoring sites located on mine site dams, discharge points and surrounding natural watercourses (Figure 40). Water quality monitoring is undertaken to verify the effectiveness of the water management system onsite, and to identify the emergence of potentially adverse effects on surrounding watercourses. Mine site dams are monitored routinely to verify the quality of mine water, used in coal processing, dust suppression, and other day to day activities around the mine.

Surface water monitoring data is reviewed on a quarterly basis. The review involves a comparison of measured pH, Electrical Conductivity (EC) and Total Suspended Solids (TSS) results against internal trigger values which have been derived from the historical data set. A two-stage trigger system is in place for assessing variances in water quality data, utilising both 5th and 95th percentile values to highlight data points which are not consistent with historical norms. The response to measured excursions outside the trigger limits is detailed in the HVO Water Management Plan.

Figure 40: Surface Monitoring Locations

3.6.2 Surface Water Monitoring

Routine surface water monitoring was undertaken from 38 sites at the frequencies described the Surface Water Monitoring Programme. Data recovery for 2014 was 100 per cent from 29 monitoring sites, however nine sites had less than 100 per cent data recovery and are further explained in Table 35. All sampling of surface waters was carried out in accordance with AS/NZS 5667.6 (1998). All analysis of surface water was carried out in accordance with approved methods by a NATA accredited laboratory.

Water quality is evaluated through the parameters of pH, EC and TSS. Pertinent surface water sites were also sampled for comprehensive analysis annually. Long term water quality trends for the Hunter River, Wollombi Brook, other surrounding tributaries and site dams are presented in this section. Where review of monitoring data has identified results outside of the internal statistical triggers, these are discussed in this section. ANZECC criteria are shown in the figures for comparative purposes.

Table 35: HVO Water Monitoring Data Recovery for 2014 (by exception)

Location	Data Recovery (%)	Comments
Other Surface Water Tributaries		
Bayswater Creek Downstream	25%	Site recorded as dry during June, September and December monitoring events.
Carrington Billabong	0%	Site recorded as dry during all 2014 monitoring events.
NSW3 Davis Ck	0%	Site recorded as dry during all 2014 monitoring events.
Pikes Creek Downstream	50%	Site recorded as dry during June and September monitoring events.
Pikes Creek Upstream	50%	Site recorded as dry during June and December monitoring events.
W5 Farrells Ck downstream	25%	Site recorded as dry during June, September and December monitoring events.
W5 Farrells Ck upstream	25%	Site recorded as dry during June, September and December monitoring events.
Site Dams		
Bob's Dump Tailings Dam (20W)	75%	Unable to safely access water during December monitoring event.
Dam 5S	75%	Site recorded as dry during December monitoring event.

Hunter River

The Hunter River was sampled on 28 occasions from seven monitoring locations during 2014. Long term trends for pH, EC and TSS are shown in Figure 41 to Figure 43.

Results for water quality were consistent with historical trends and acceptable ranges, indicating no adverse impacts on the Hunter River during 2014.

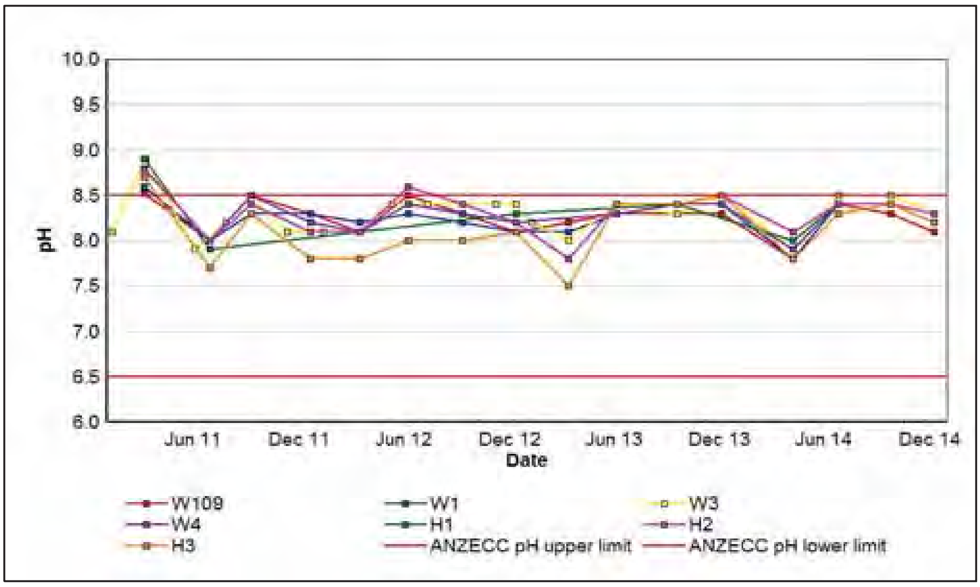


Figure 41: Hunter River pH Trends 2011-2014

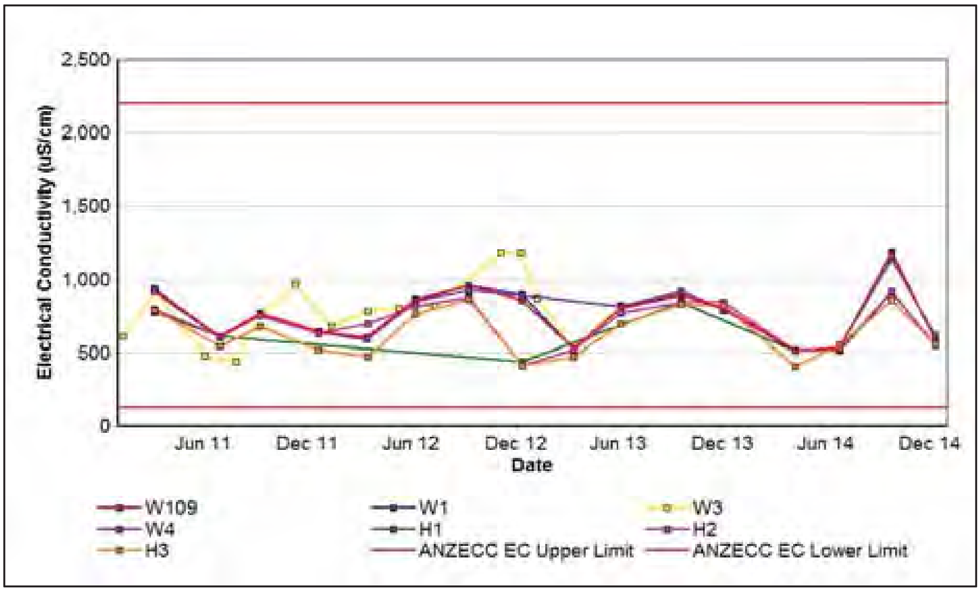


Figure 42: Hunter River EC Trends 2011– 2014

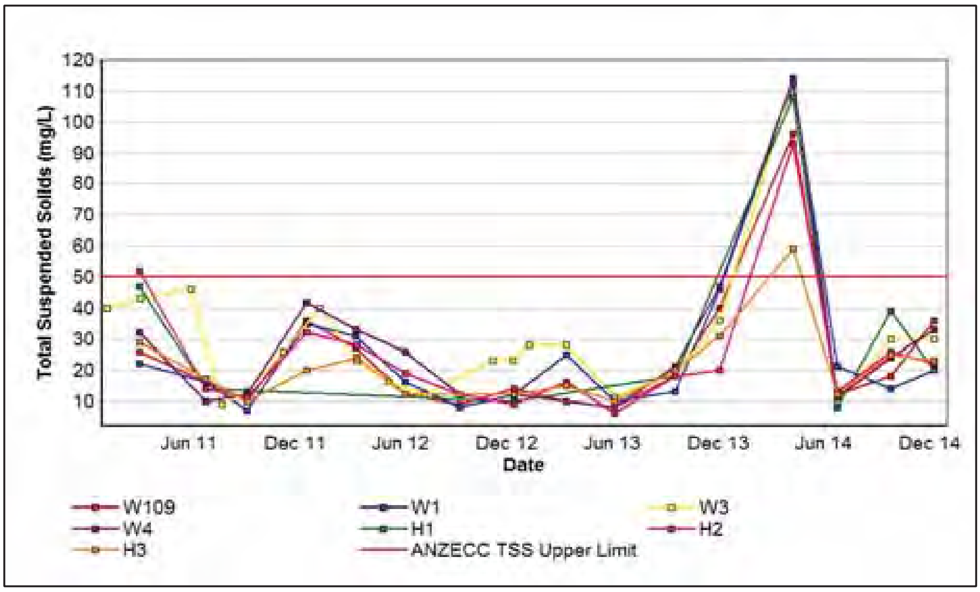


Figure 43: Hunter River TSS Trends 2011 – 2014

Wollombi Brook

Wollombi Brook was sampled on 12 occasions from three monitoring locations during 2014. Long term trends for pH, EC and TSS from Wollombi Brook are shown in Figure 44 to Figure 46. Results were consistent with historical trends and acceptable ranges, indicating no adverse impacts on Wollombi Brook during 2014.

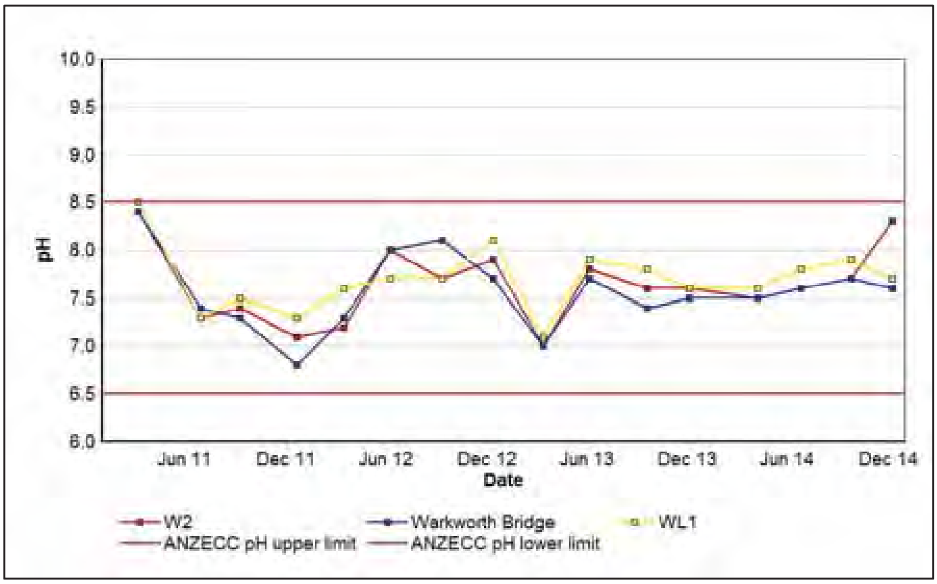


Figure 44: Wollombi Brook pH Trends 2011 – 2014

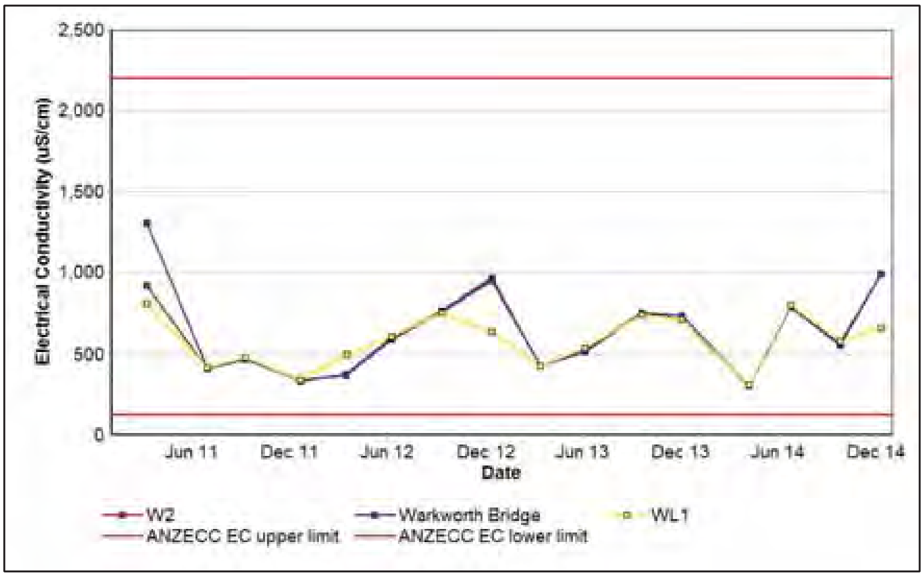


Figure 45: Wollombi Brook EC Trends 2011 – 2014

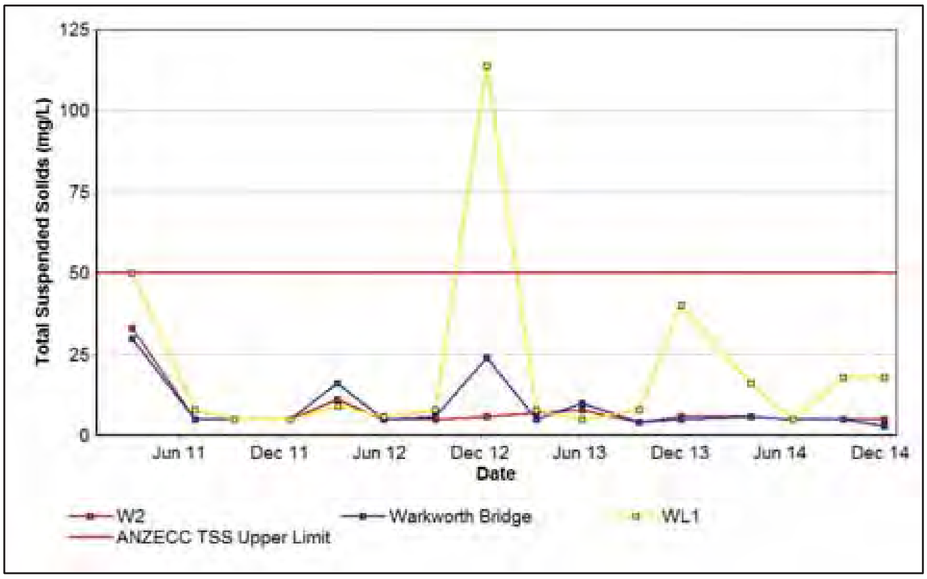


Figure 46: Wollombi Brook TSS Trends 2011 – 2014

Other Surrounding Tributaries

35 samples were collected across 13 watercourses during 2014. Routine monitoring of natural tributaries surrounding HVO continued during 2014, from monitoring locations on the following water courses:

- Comleroi Creek
- Emu Creek
- Farrells Creek
- Pikes Creek
- Davis Creek
- Bayswater Creek
- Parnells Creek

A number of these sites are ephemeral in nature, and are often dry on the scheduled day of sampling. Two sites were reported as dry during 2014; Carrington Billabong and NSW3 Davis Creek and consequently not sampled.

Long term trends for pH, EC and TSS are shown Figure 47 to Figure 49. Results for water quality remained generally within historical trends and acceptable ranges, indicating no adverse impacts on the other tributaries during 2014. The ephemeral nature of these monitoring locations is the primary reason for the considerable variation physical water quality.

Trigger tracking results are detailed in Table 36.

Table 36: Other Tributaries Internal Trigger Tracking Results

Location	Date	Trigger limit	Action taken in response
Bayswater Creek Midstream	8/04/2014	**EC - 1st Stage 95th Percentile**	Watching Brief *
	26/06/2014	**EC - 1st Stage 95th percentile**	Watching Brief *
	24/09/2014	**EC - 1st Stage 95th percentile**	3rd consecutive measure above trigger limit. A review of the data/trend indicates that increasing electrical conductivity at both sites may be caused by lack of rainfall. Furthermore as the trend is exhibited by both the upstream and midstream locations it is unlikely that HVO Operations has contributed to this result.
	9/12/2014	**EC - 1st Stage 95th percentile**	No action taken, following review at 3rd consecutive reading trigger limits will be revised in 2015.
Bayswater Creek Upstream	8/04/2014	**EC - 1st Stage 95th Percentile**	Watching Brief *
	26/06/2014	**EC - 1st Stage 95th percentile**	Watching Brief *
	24/09/2014	**EC - 1st Stage 95th percentile**	3rd consecutive measure above trigger limit.A review of the data/trend indicates that increasing electrical conductivity at both sites may be caused by lack of rainfall. Furthermore as the trend is exhibited by both the upstream and midstream locations it is unlikely that HVO Operations has contributed to this result.
	9/12/2014	**EC - 1st Stage 95th percentile**	No action taken, following review at 3rd consecutive reading trigger limits will be revised in 2015.

* = 1st/2nd trigger. Watching Brief established pending outcomes of subsequent monitoring events. No specific actions required

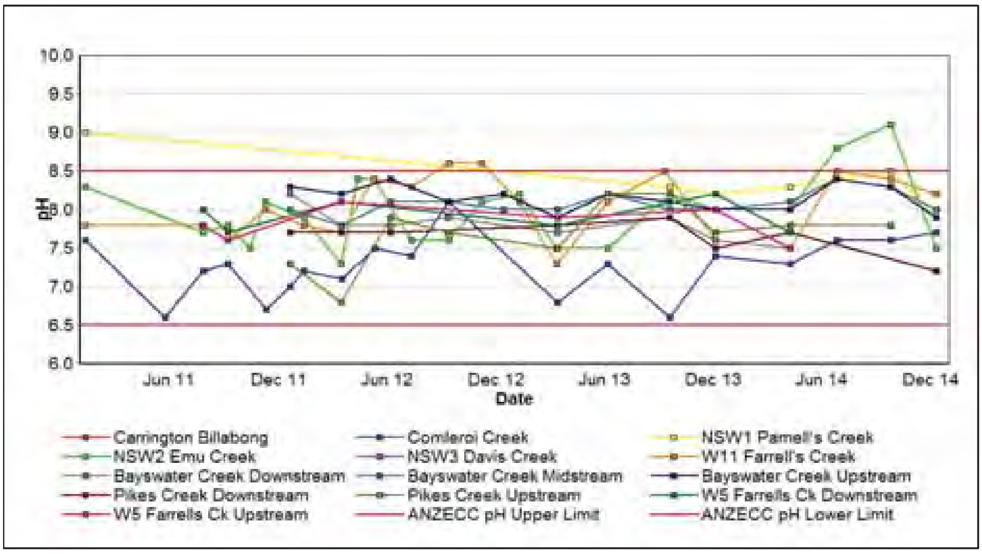


Figure 47: Other Tributaries pH Trends 2011 – 2014

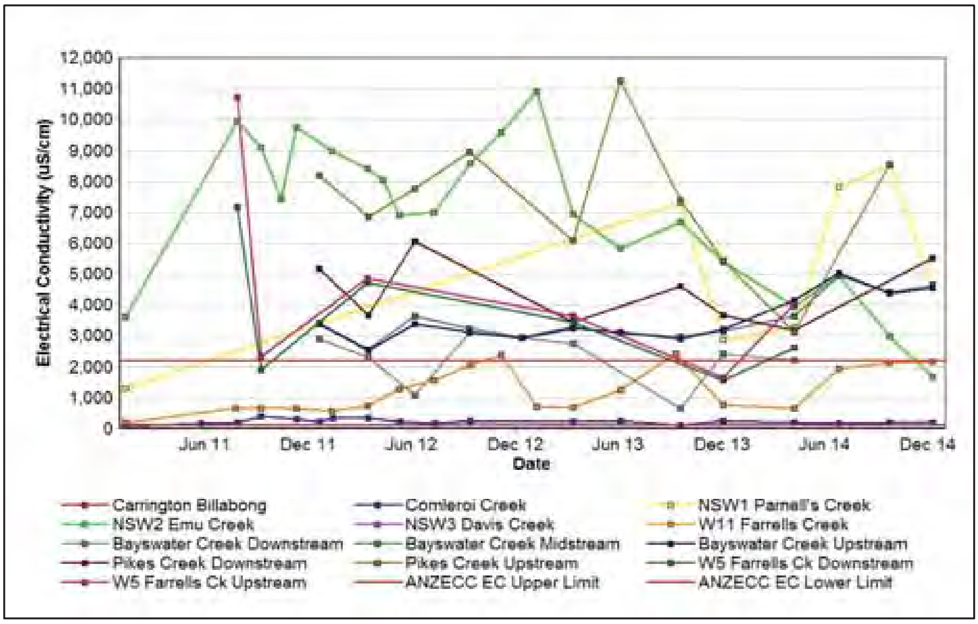


Figure 48: Other Tributaries EC Trends 2011 - 2014

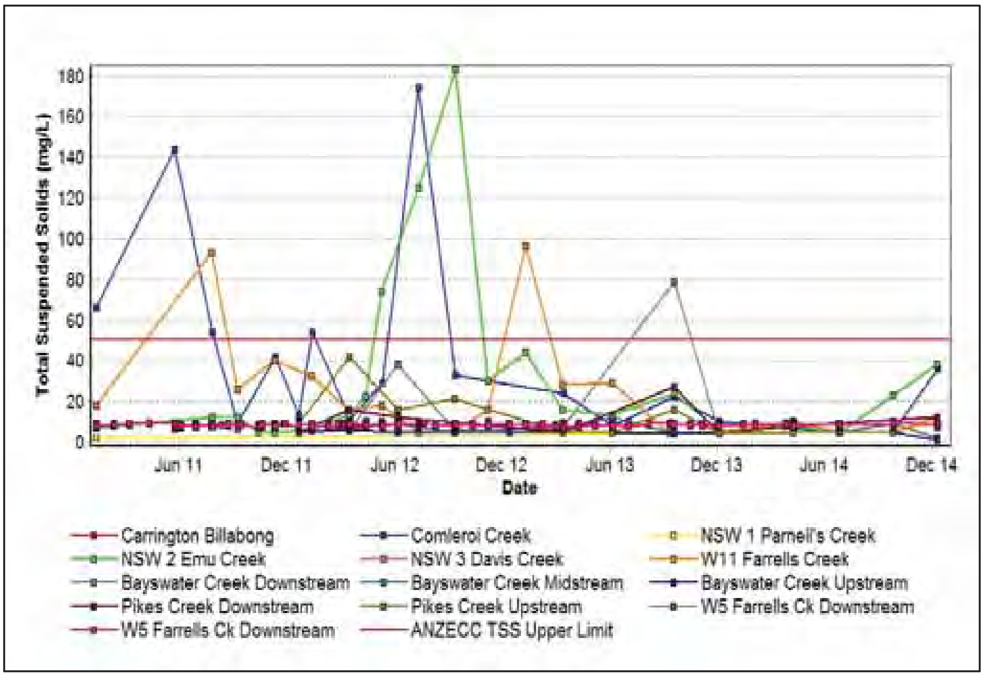


Figure 49: Other Tributaries TSS Trends 2011 – 2014

HVO Site Dams

75 samples were collected across 15 key dams during 2014. Long term trends for pH, EC and TSS are shown in Figure 50 to Figure 52. Results for water quality were consistent with historical trends.

No licenced discharge events were undertaken during the review period.

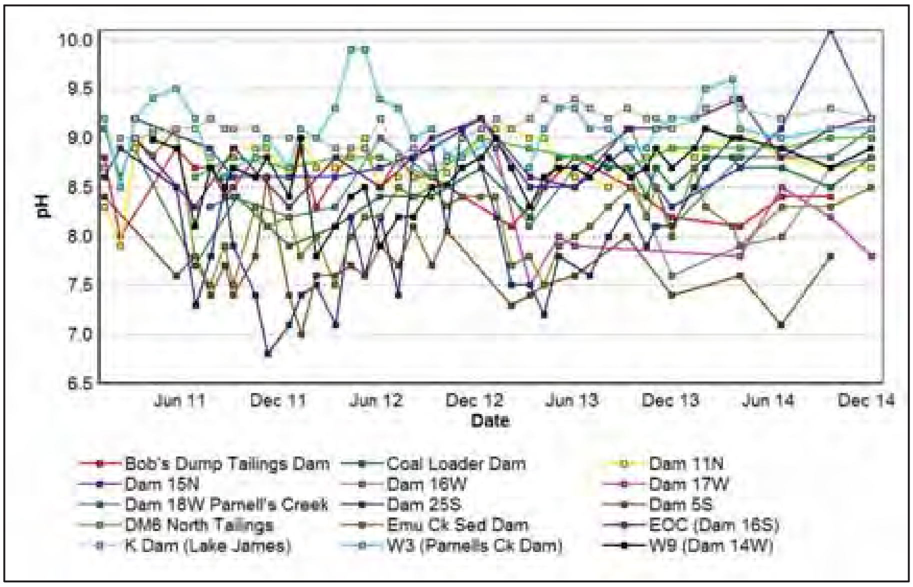


Figure 50: HVO Site Dams pH Trends 2011 – 2014

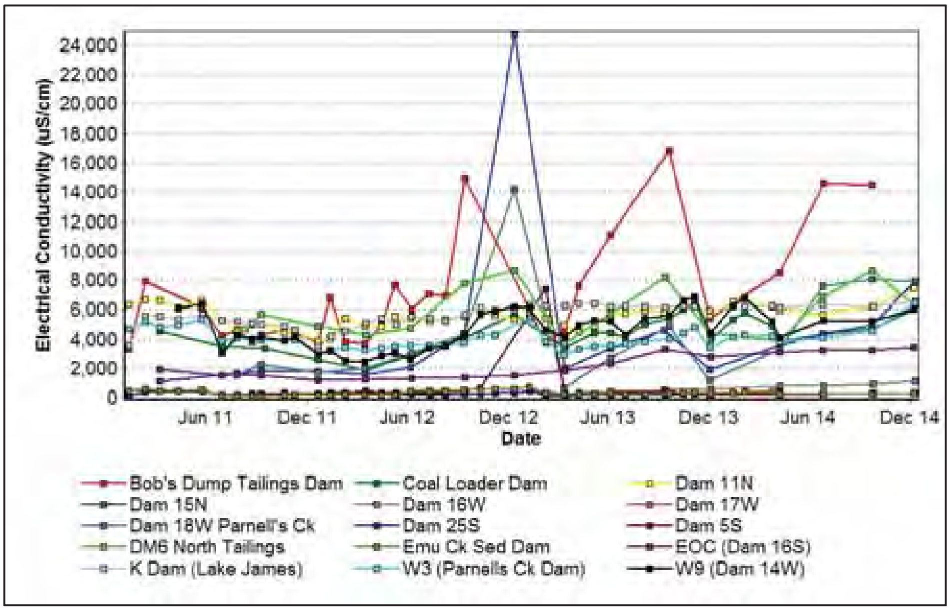


Figure 51: HVO Site Dams EC Trends 2011– 2014

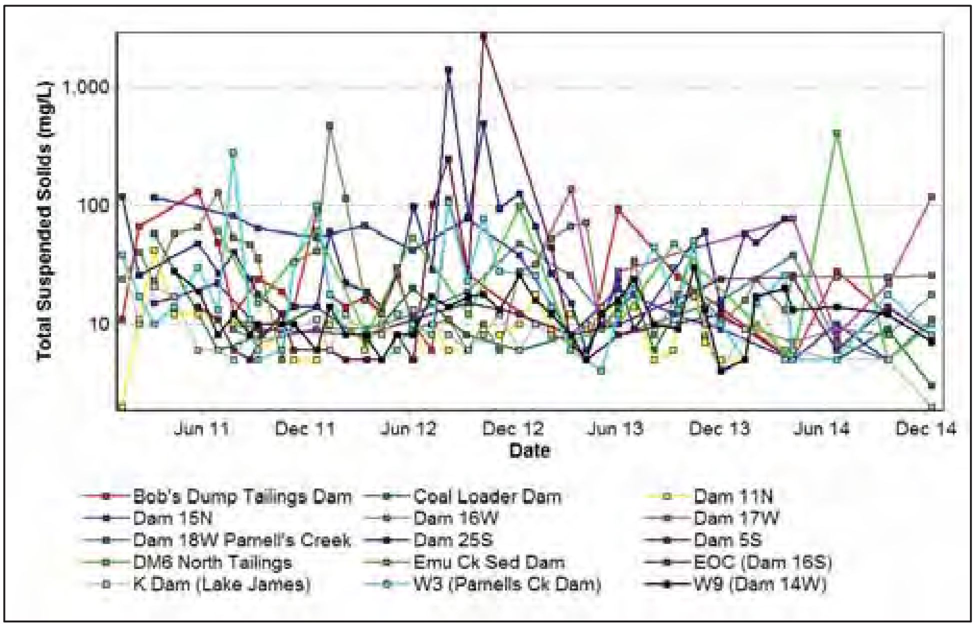


Figure 52: HVO Site Dams TSS Trends 2011 – 2014

3.6.3 Comparison of 2014 Water Quality Data with EIS Predictions

3.6.3.1 South Pit EIS Predictions

The South Pit EIS estimated an 'instantaneous' water quality for Electrical Conductivity of 5,700 µS/cm as an upper limit. Instantaneous water quality is a simple estimate obtained by dividing the total salt available by the maximum amount of possible void water. Electrical Conductivity measurements at Lake James averaged 6,301µS/cm, slightly above the predicted 'instantaneous' measure. One possible explanation for this is the concentration of salt in Lakes James from evaporation, given no discharge from the dam for more than a year.

The South Pit EIS estimated average runoff water quality from undisturbed catchments to be 400 mg/L for TSS and 615µS/cm for EC. Comleroi Creek, South of Cheshunt Pit had an average TSS of 13mg/L and EC of 200µS/cm during the review period, demonstrating that runoff water from undisturbed catchments in the HVO South area to be of better quality than that which was predicted in the EIS.

3.6.3.2 Carrington Pit EIS Predictions

The long term mine water quality for Carrington is discussed in the Carrington Mine Environmental Impact Statement (ERM 1999). The EIS estimated an "instantaneous" water quality for Electrical Conductivity of 7,050µS/cm.

Dewatering from Carrington is a mixture of surface runoff from overburden emplacements, coal mining areas and seepage from the coal seams and alluvium. Water is directed to Dam 9N and into Dam 11N. The average EC and TSS in Dam 11N during 2014 was 6,404µS/cm and 5mg/L respectively, and is considered broadly representative of mine water quality for Carrington.

The Carrington EIS states that runoff from undisturbed catchments within the Carrington Pit will be directed around the mine via contour banks or surface drains to discharge where possible into natural creeks. The salinity of the runoff water was predicted to be approximately 615 µS/cm. Runoff from rehabilitated lands was initially predicted to have higher TSS, with levels approaching pre-mining conditions after several years. Carrington Billabong (where such water quality would be measured for this comparison) was reported as dry during all scheduled monitoring events in 2014 with no samples collected.

3.6.3.3 West Pit EIS Predictions

The West Pit EIS included the data below as representative of water quality (Table 37).

The pH at Emu Creek (NSW2) averaged 8.4 during the review period, demonstrating good correlation with the EIS predictions. EC values at Emu Creek were variable, ranging between 1,666µS/cm and 4,960µS/cm. Emu Creek is an ephemeral creek with samples often taken from stagnant pools of water when no-flow is occurring. This would result in elevated EC results due to evapo-concentration of salt. In addition to this, due to the advance of mining over time, the sampling location is now located at the head of the catchment and is unlikely to receive significant flushing. Farrell's Creek exhibited average water quality of pH 8.2, and EC of 1,720µS/cm, within the predicted range. Parnell's Dam (W3) measured an average EC of 4,546µS/cm in 2014, within the predicted range.

Table 37: Representative Water Quality for West Pit:

Watercourse	pH (pH Units)	EC (µS/cm)
Davis Creek	7.7 to 8.4	767 to +8,000
Emu Creek	7.5 to 8.8	365 to +1,000
Farrells Creek	7.0 to 9.2	195 to +12,000
Mine Water (Parnell's Dam)	-	2,400 to 6,300

Davis Creek was reported as dry throughout 2014 thus no comparison can be made against the predicted water quality.

3.6.4 Performance relating to HRSTS Discharges

HVO participates in the Hunter River Salinity Trading Scheme (HRSTS), allowing it to discharge to the Hunter River via three licensed discharge points, including Dam 11N, Dam 15S (Lake James) and Dam 9W (Parnells Dam). Discharges can only take place subject to the schemes regulations.

As required by the EPL, HVO submitted a discharge report for the 2013/14 financial year. No HRSTS discharges occurred during the 2013/14 reporting year or in the second half of 2014.

3.6.6 Non-compliances and Complaints during Reporting Period

9 October 2014

During a routine water infrastructure inspection at approximately 10:25am on 9 October 2014 it was identified that the water pipeline adjacent to the Lemington Underground (LUG) Bore had ruptured. The LUG Bore is an operating production bore that abstracts water from the disused Lemington Underground mine workings, to supply water to the neighbouring MTW and Hunter Valley Operations (HVO) mines. The pipe rupture appears to have resulted in a discharge of water from the pipe. Water has continued via overland flow to the north through a grassed paddock for approximately 400 m, resulting in some discharge into the Wollombi Brook.

The duration of discharge from the ruptured pipe is unknown, however, on a worst case scenario, was no greater than 19 hours. This is known because a routine inspection was completed at approximately 15:30 on 8 October 2014, with no pipeline rupture noted. So far as we have been able to determine, the most likely cause of the rupture was that the water pressure in the pipeline exceeded the maximum rated pressure of the pipe at this location.

The actions taken, or that will be taken, in respect of the incident included:

i. The LUG Bore was immediately shut down following identification of the ruptured pipeline. Once the bore was shut down the flow of water ceased. The bore is currently isolated and unable to be restarted.
ii. A review of immediate containment options for the leaked water were undertaken, however was not considered feasible due to the topography.
iii. Follow up actions included the suspension of all intra-site water transfers, pending a review of the infrastructure, to confirm all infrastructure is adequately rated. Correspondingly, a review of all procedures, maintenance and inspection protocols are underway.
iv. Implementing engineering controls to match pump water pressure with pipeline capacity
v. Implementing a leak detection system

Both Planning & Environment and the Environment Protection Authority were notified of the event on 9 October 2014, with a follow up incident report prepared and sent to both regulators on 17 October 2014. The Environment Protection Authority is continuing their investigation in relation to the event.

9 November 2014

On Sunday 9 November 2014 at approximately 18:30 pooling water was observed along the road verge adjacent to Comleroi Road, near the HVO South workshop entrance road. Staff inspected the area in question, identifying that the water pipeline connecting Dam 19S to Dam 17S had ruptured. Following identification of the rupture the pipeline was isolated and the flow of water from the pipe ceased shortly thereafter. The pipeline is used to transfer water between Dam 19S and Dam 17S as required and is connected to the water reticulation network for HVO South Workshop Facilities.

The exact duration of discharge from the ruptured pipe is not known, we estimate that flow commenced on that day. Based on the investigation, the rupture was either caused by fatigue of the pipe weld or pressure in the pipeline exceeding the maximum rated pressure of the pipe weld at this location.

The actions taken in respect of the incident included:

i. The Dam 19S to Dam 17S pipeline was immediately isolated following identification of the ruptured pipeline. Once the pipeline was isolated the flow of water ceased.

ii. A review of containment options was undertaken, resulting in the pumping of water out of the unnamed tributary between Tuesday 11 November and Wednesday 12 November 2014. A total of 247 kL was abstracted from the dam. The tributary and flow path leading to the tributary contained existing runoff water from the catchment (farm land).

iii. Follow up actions included a review of water management procedures in the former Lemington CHPP area, and relocation or provision of secondary containment for sections of the pipeline exposed to offsite flow.

Both Planning & Environment and the Environment Protection Authority were notified of the event on 10 November 2014, with a follow up incident report prepared and sent to both regulators on 17 November 2014. Investigations indicated no actual harm or potential for harm to the environment.

3.6.7 Complaints

No complaints were received in regards to water during 2014.

3.7 Groundwater

3.7.1 Groundwater Management

Groundwater monitoring activities were undertaken in 2014 in accordance with the HVO Water Management Plan and Groundwater Monitoring Programme. The monitoring results are used to establish and monitor trends in physical and geochemical parameters of surrounding groundwater potentially influenced by mining.

The groundwater monitoring programme at HVO measures the quality of groundwater against background data, EIS predictions and historical trends. Ground water quality is evaluated through the parameters of pH, EC, and Standing Water Level (SWL) (measured as elevation in metres with respect to the Australian Height Datum, mAHD). On a periodic basis (nominally once per annum) a comprehensive suite of analytes are measured, including major anions, cations and metals. Prior to sampling for comprehensive analysis, bore purging is undertaken to ensure a representative sample is collected.

Groundwater monitoring data is reviewed on a quarterly basis. The review involves a comparison of measured pH and EC results against internal trigger values which have been derived from the historical data set. Trigger limits are calculated as the 95th percentile maximum value and the 5th percentile minimum value from data collected over the last three years (2011 onwards). Trigger levels have been set on the basis of geographical proximity and target stratigraphy. Bores that record as dry and bores of unknown seam have not been included in calculation of the trigger limits. The response to measured excursions outside the trigger limits is detailed in the HVO Water Management Plan. Where investigations and subsequent actions have been undertaken following review of monitoring data, these are detailed in this section. Monitoring locations are shown in Figure 53.

The alluvial lands area of North Pit was mined and subsequently backfilled between the late-1990's and mid-2000's, following initial approval in 1995. The original groundwater modelling predicted the backfilled void would recharge via rainfall runoff and equilibrate to a water quality that would ultimately allow mixing with the Hunter River. To ensure management commitments relating to the water quality objectives for Hunter River mixing could be achieved at some time in the future investigations determined dewatering of the void should be undertaken to reduce the salt load.

In 2014, the drilling and construction of five monitoring bores was undertaken, to confirm the target site for a deep dewatering bore and augment the existing monitoring network. Further work for this project is described in section 6.6 of this report.

3.7.2 Groundwater Performance

Sampling of ground waters was carried out from 112 monitoring bores across Hunter Valley Operations in accordance with AS/NZS 5667.6 (1998). Where laboratory analysis was undertaken, this was performed by a NATA accredited laboratory. Sites with a data capture rate of less than 100 per cent are outlined in Table 38.

Table 38: HVO Groundwater Monitoring Data Recovery for 2014

Location	Data Recovery (%)	Comments
Carrington Interburden Seam		
CGW47	0%	Site recorded as dry during all monitoring events.
Carrington West Wing Alluvium Seam		
CGW46a	0%	Site recorded as dry during all monitoring events.
Cheshunt Mt Arthur Seam		
BZ4A(2)	50%	Site recorded as dry during March and May monitoring events.
Lemington South Alluvium Seam		
D317(ALL)	0%	Site recorded as dry during all monitoring events.

Figure 53: Groundwater Monitoring Network at HVO in 2014

3.7.2.1 Groundwater Monitoring Summary

The following section presents groundwater monitoring data in relation to the geographic locations and target stratigraphy for groundwater monitoring bores. Results are given for the following locations:

- Carrington Broonie
- Carrington Alluvium
- Carrington Interburden
- Carrington West Wing Alluvium
- Cheshunt / North Pit Alluvium
- Cheshunt Interburden
- Cheshunt Mt Arthur
- Cheshunt Piercefield
- Lemington South Alluvium
- Lemington South Arrowfield
- Lemington South Bowfield
- Lemington South Woodlands Hill
- North Pit Spoil
- South Facilities Piercefield
- West Pit Alluvium
- West Pit Sandstone / Siltstone

Each location is discussed below, and a summary of monitoring data presented. Where monitoring results required further investigation following the recording of three consecutive measurements outside the internal statistical limits, these results are summarised in tables for each location.

3.7.2.2 Carrington Broonie

Carrington Groundwater was sampled on 10 occasions during 2014 from two monitoring locations. The EC, pH and SWL trends for 2011 to 2014 for Carrington Broonie Seam groundwater bores are shown in Figure 54, Figure 55 and Figure 56 respectively.

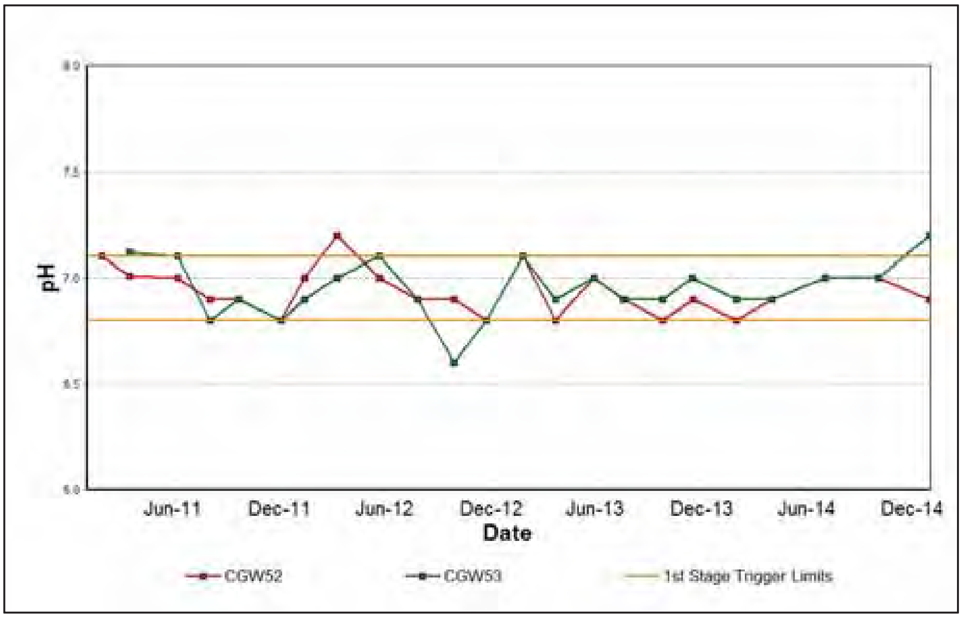


Figure 54: Carrington Broonie Groundwater pH Trends 2011-2014

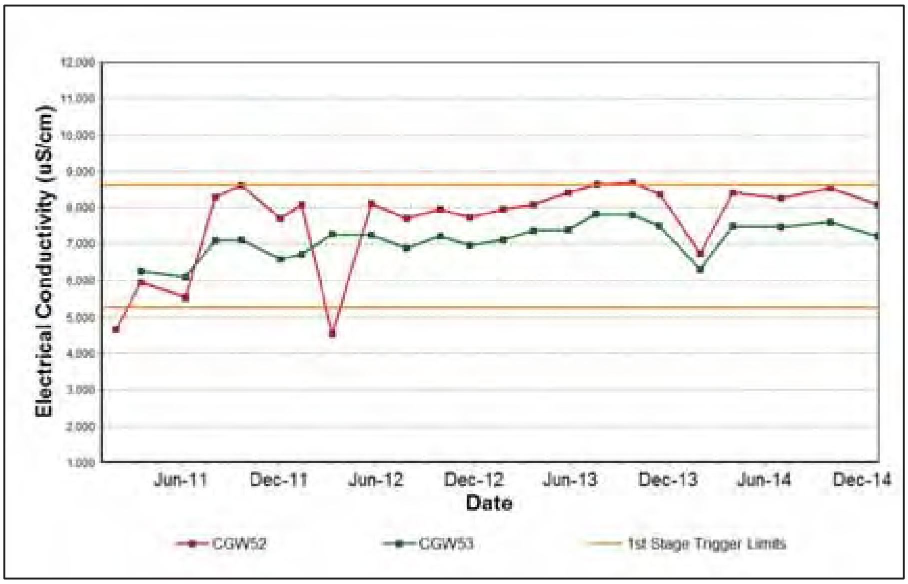


Figure 55: Carrington Broonie Groundwater EC Trends 2011-2014

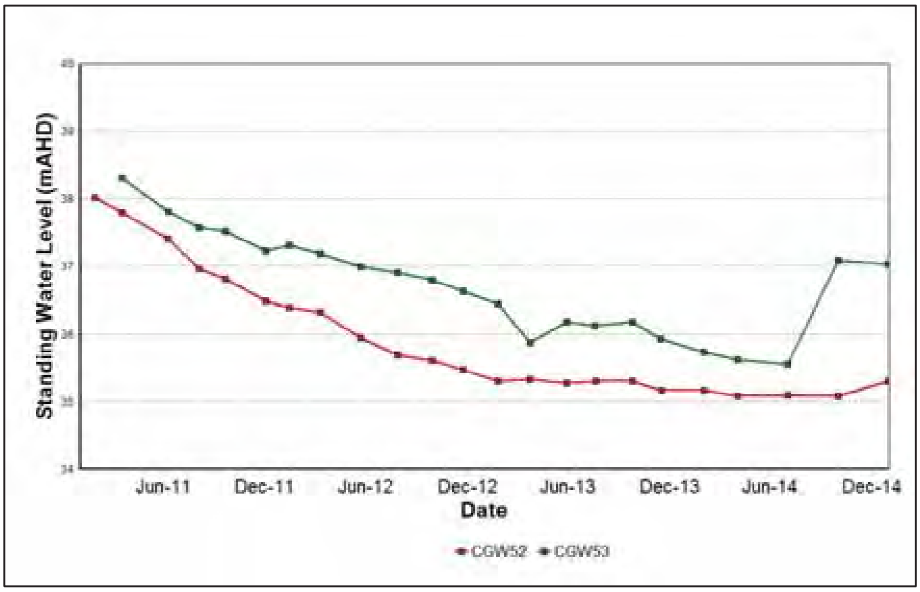


Figure 56: Carrington Broonie Groundwater SWL Trends 2011-2014

3.7.2.3 Carrington Alluvium

Groundwater monitoring in the Carrington Alluvium area was undertaken at six sites during 2014, with 24 samples collected during the reporting period. The EC, pH and SWL trends for 2011 to 2014 for Carrington Alluvium groundwater bores are shown in Figure 57, Figure 58 and Figure 59 respectively. Trigger tracking results are listed in Table 39.

Table 39: HVO Carrington Alluvium Groundwater 2014 Monitoring Internal Trigger Tracking

Location	Date	Trigger limit	Action taken in response
CFW55R	01/04/2014	**pH - 1st Stage 5th percentile**	Watching Brief*
	01/07/2014		Watching Brief *
	01/10/2014		Trend generally consistent with historical trend. No adverse impact due to mining identified.
CGW51a	01/04/2014	**pH - 1st Stage 5th percentile**	Watching Brief *
	01/07/2014		Watching Brief *
	01/10/2014		Investigation has determined that CGW51a has been incorrectly identified as an Alluvium seam bore. The 2015 trigger limit revision will place this bore in the Carrington Interburden seam group. As such results outside the trigger range are viewed as erroneous.
	30/12/2014		4th consecutive reading below pH trigger limit. See above
CGW52a	01/04/2014	**EC - 1st Stage 5th percentile**	Watching Brief *
	01/07/2014		Watching Brief *
	1/10/2014		EC results are consistent with a historical freshening trend. No impact due to mining identified.
	30/12/2014		4th consecutive reading below EC trigger limit. See above
CGW55a	01/04/2014	**EC - 1st Stage 5th percentile**	Watching Brief *
	01/07/2014		Watching Brief *
	01/10/2014		EC results are consistent with a historical freshening trend. No impact due to mining identified.
	30/12/2014		4th consecutive reading below EC trigger limit. See above

* = 1st/2nd trigger. Watching Brief established pending outcomes of subsequent monitoring events. No specific actions required

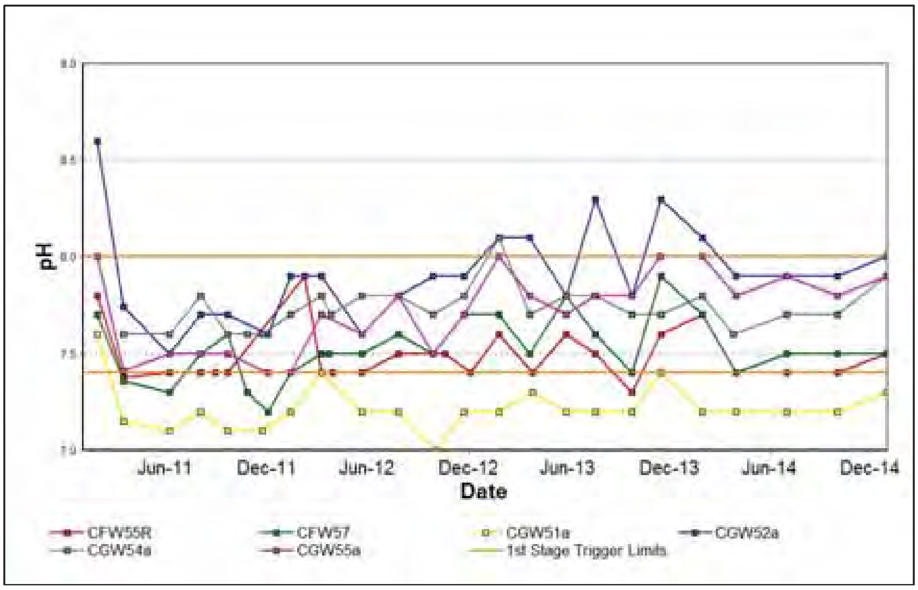


Figure 57: Carrington Alluvium Groundwater pH Trends 2011-2014

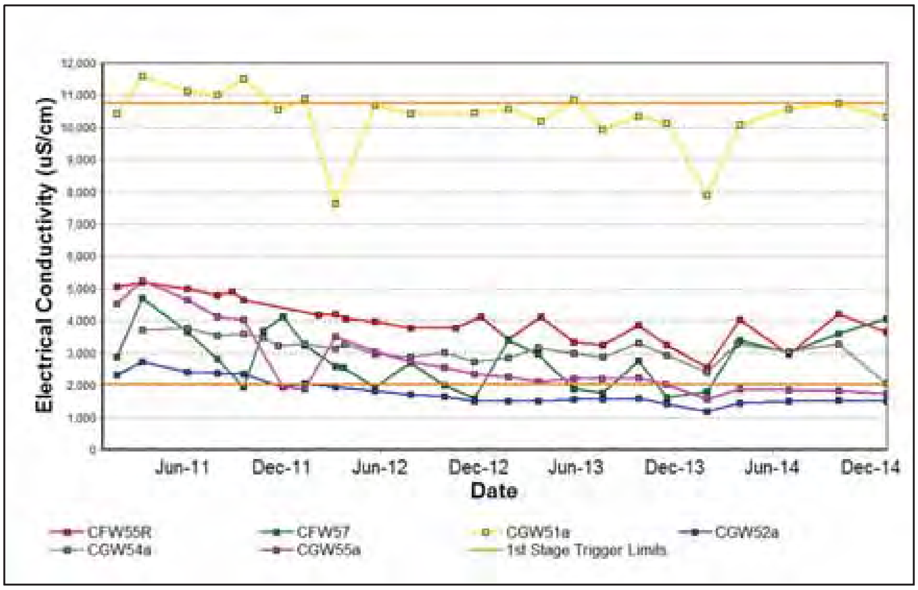


Figure 58: Carrington Alluvium Groundwater EC Trends 2011-2014

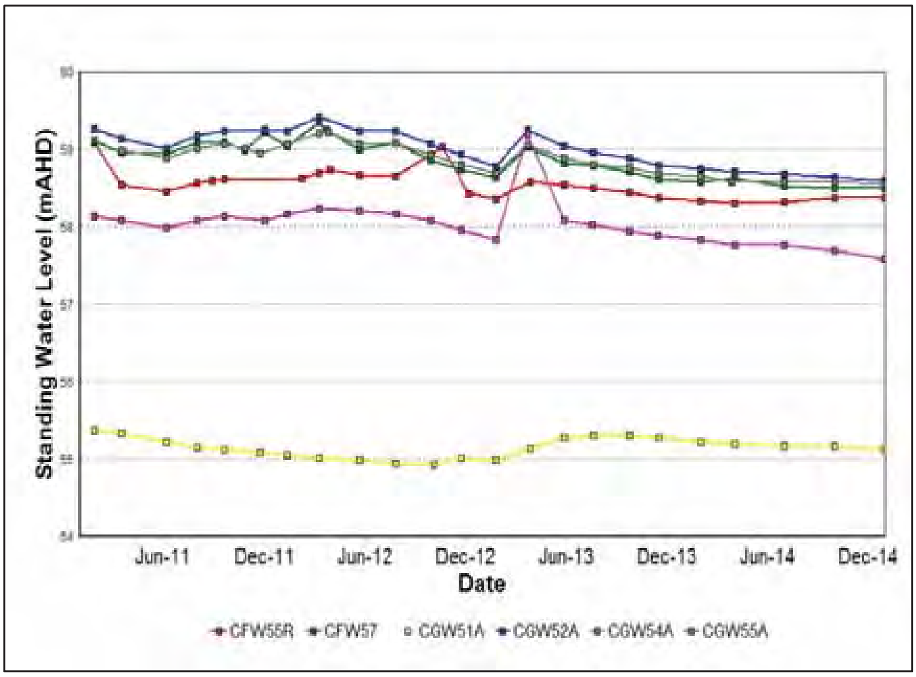


Figure 59: Carrington Alluvium Groundwater SWL trends 2011– 2014

3.7.2.4 Carrington Interburden Groundwater

Groundwater monitoring in the Carrington Interburden was undertaken four sites during 2014, with 17 samples collected for field analysis during the reporting period. CGW47 was dry during all monitoring events for the reporting period. The EC, pH and SWL trends for 2011 to 2014 for groundwater bores in the Carrington Interburden are shown in Figure 60, Figure 61 and Figure 62 respectively.

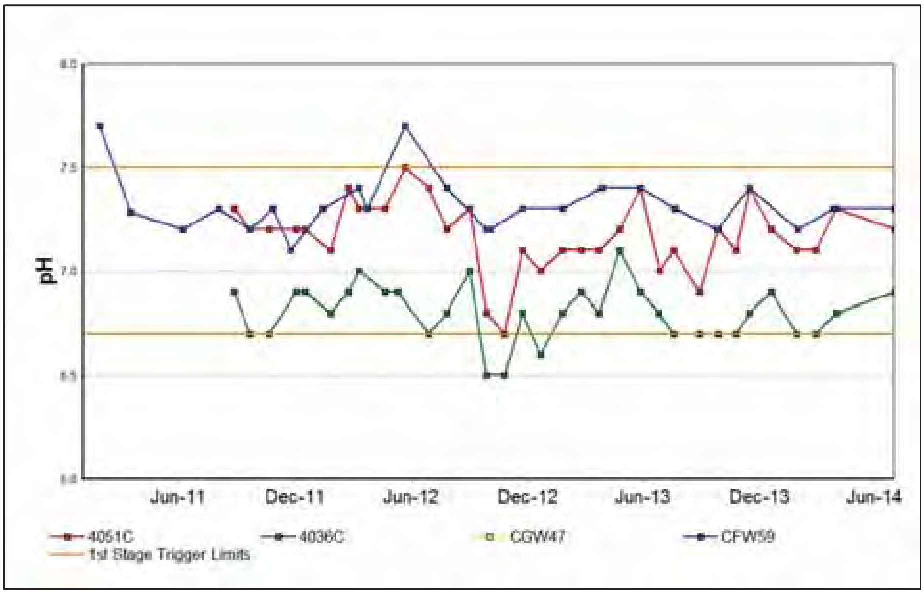


Figure 60: Carrington Interburden Groundwater pH Trends 2011-2014

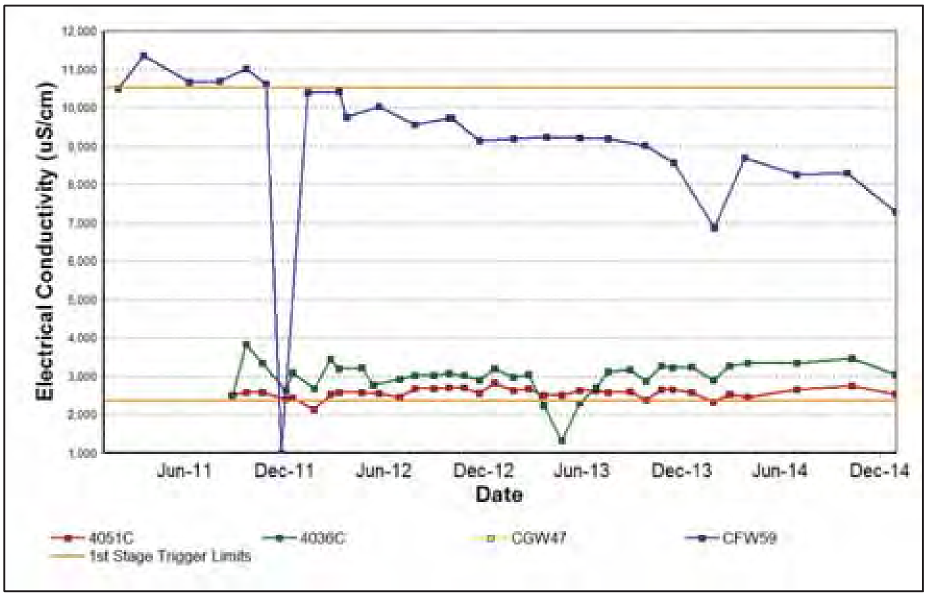


Figure 61: Carrington Interburden Groundwater EC Trends 2011 – 2014

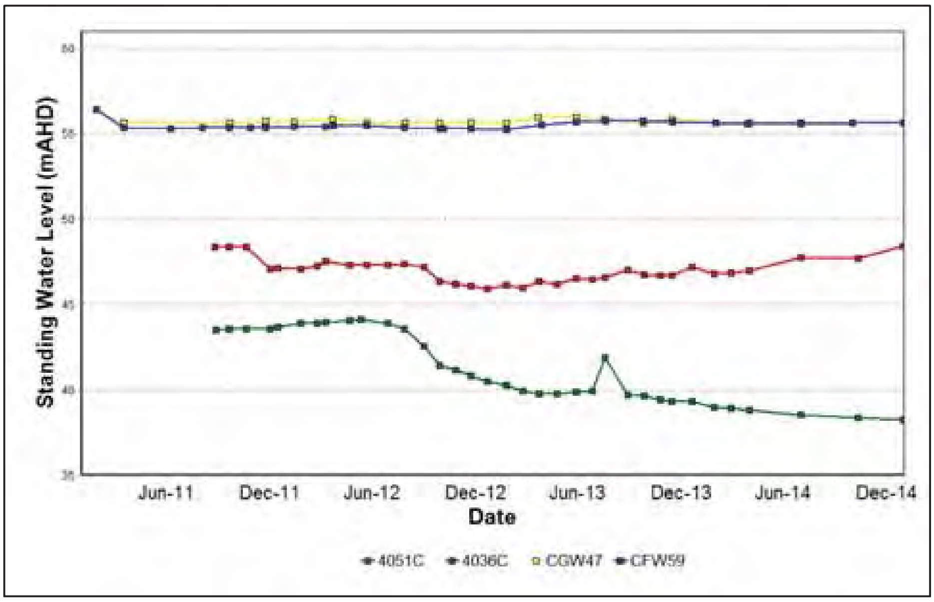


Figure 62: Carrington Interburden Groundwater SWL Trends 2011-2014

3.7.2.5 Carrington West Wing Alluvium

Groundwater monitoring in the Carrington West Wing Area, was undertaken at14 sites in 2014 with 64 samples collected for field analysis during the reporting period. CGW46a was dry during all monitoring events for the reporting period. Results are shown in Figure 63, Figure 64 and Figure 65, with trigger tracking results given in Table 40.

Table 40: Carrington West Wing 2014 Internal Trigger Tracking

Location	Date	Trigger limit	Action taken in response
GW_106	11/04/2014	**pH - 1st Stage 5th percentile**	Watching Brief*
	01/07/2014		
	09/09/2014		Trend is not considered to be concerning. Trend is consistent with historical values (limited dataset available). No adverse impact identified due to mining. Bore construction and monitoring data to be reviewed to determine if correctly classified as an alluvial bore.
	30/12/2014		4th consecutive reading below pH trigger limit. See above
CGW32	01/04/2014	**EC - 1st Stage 95th percentile**	Watching Brief *
	01/07/2014		
	09/09/2014		Trend is not considered to be concerning. Trend is consistent with historical values. No adverse impact identified due to mining. Bore construction and monitoring data to be reviewed to determine if correctly classified as an alluvial bore.
	30/12/2014		4th consecutive reading above EC trigger limit. See above
GW_106	11/04/2014	**EC - 1st Stage 95th percentile**	Watching Brief *
	01/07/2014		
	09/09/2014		Trend is not considered to be concerning. Trend is consistent with historical values (limited dataset available). No adverse impact identified due to mining. Bore construction and monitoring data to be reviewed to determine if correctly classified as an alluvial bore.
	30/12/2014		4th consecutive reading above EC trigger limit. See above

*= 1st/2nd trigger. Watching Brief established pending outcomes of subsequent monitoring events. No specific actions required

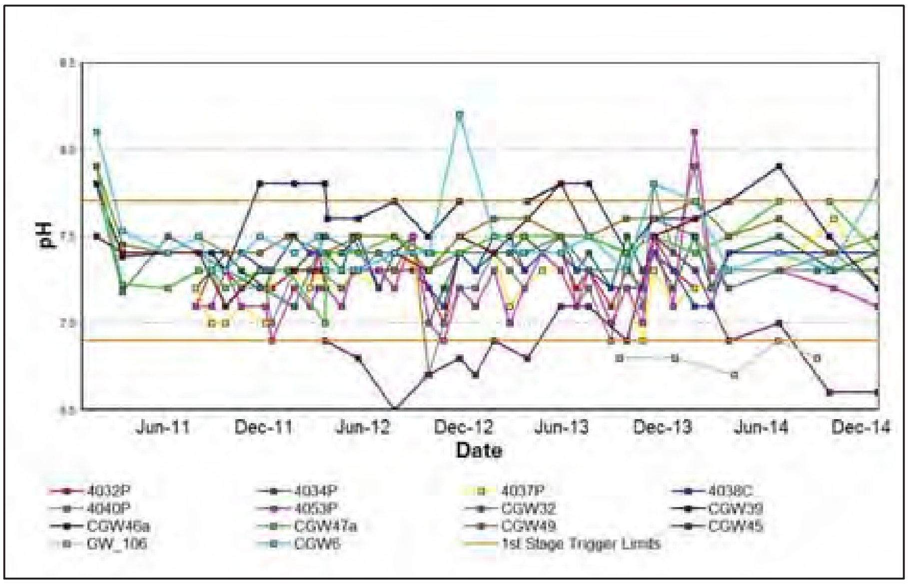


Figure 63: Carrington West Wing Groundwater pH Trends 2011-2014

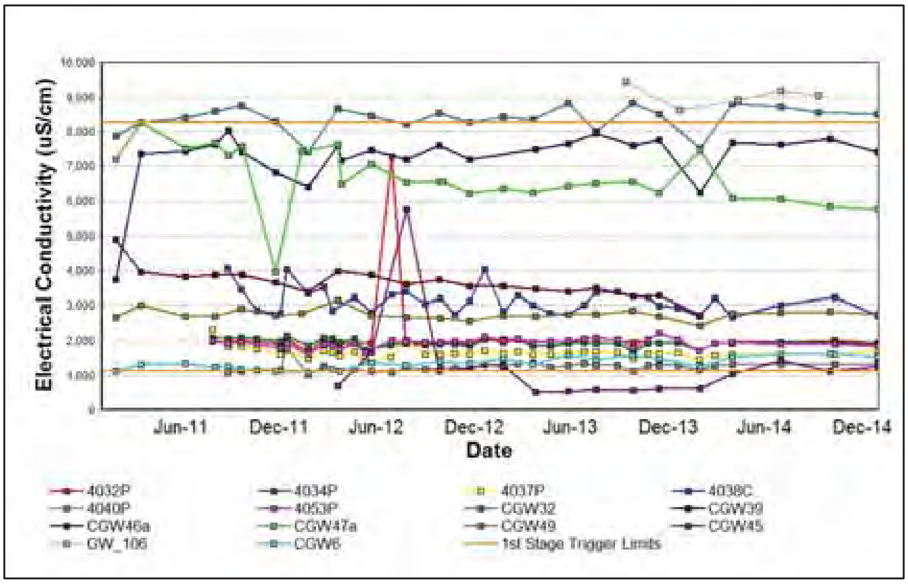


Figure 64: Carrington West Wing Groundwater EC Trends 2011 – 2014

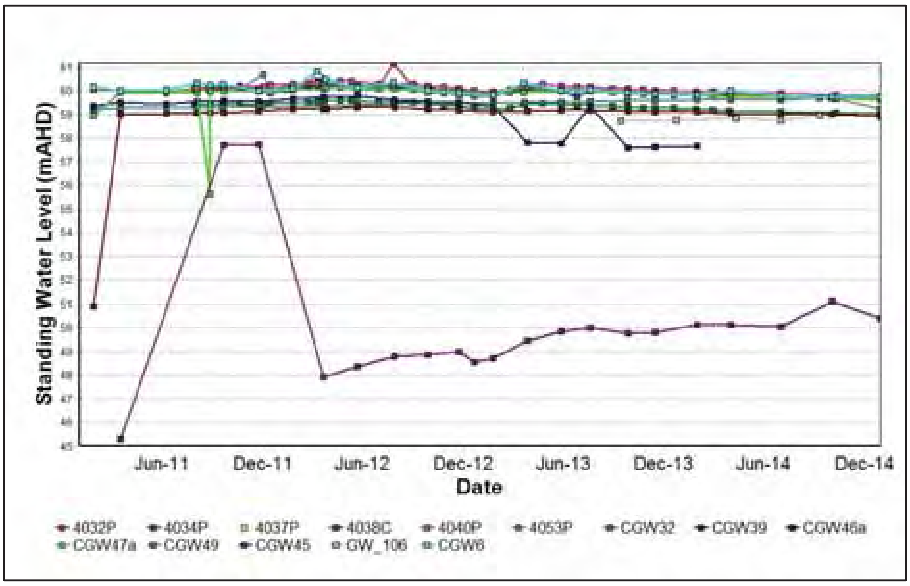


Figure 65: Carrington West Wing Groundwater SWL Trends 2011-2014

3.7.2.6 Cheshunt / North Pit Alluvium

Groundwater monitoring in the Cheshunt / North Pit area was undertaken at20 sites during 2014, with 80 samples collected during routine monitoring. Electrical Conductivity, pH and SWL trends for 2011 to 2014 for groundwater bores in the Cheshunt / North Pit are shown in Figure 66 to Figure 68. Trigger tracking results are given in Table 41.

Table 41: HVO Cheshunt/ North Pit Alluvium Internal Trigger Tracking

Location	Date	Trigger limit	Action taken in response
Hobdens Well	05/03/2014	**pH - 1st Stage 95th percentile**	Watching Brief*
	09/05/2014		
	03/09/2014		Third consecutive result above trigger limit. Data consistent with historical water quality recorded at this location. Watching brief maintained.
	05/11/2014		4th consecutive reading above pH trigger limit. See above
BZ1-1	06/03/2014	**EC - 1st Stage 95th percentile**	Watching Brief *
	09/05/2014		
	08/09/2014		Investigation has determined that BZ1-1 has been incorrectly identified as an Alluvium seam bore. The 2015 trigger limit revision will place this bore in the Cheshunt Interburden seam group. As such results outside the trigger range are viewed as erroneous.
	05/11/2014		4th consecutive reading above EC trigger limit. See above

*= 1st/2nd trigger. Watching Brief established pending outcomes of subsequent monitoring events. No specific actions required

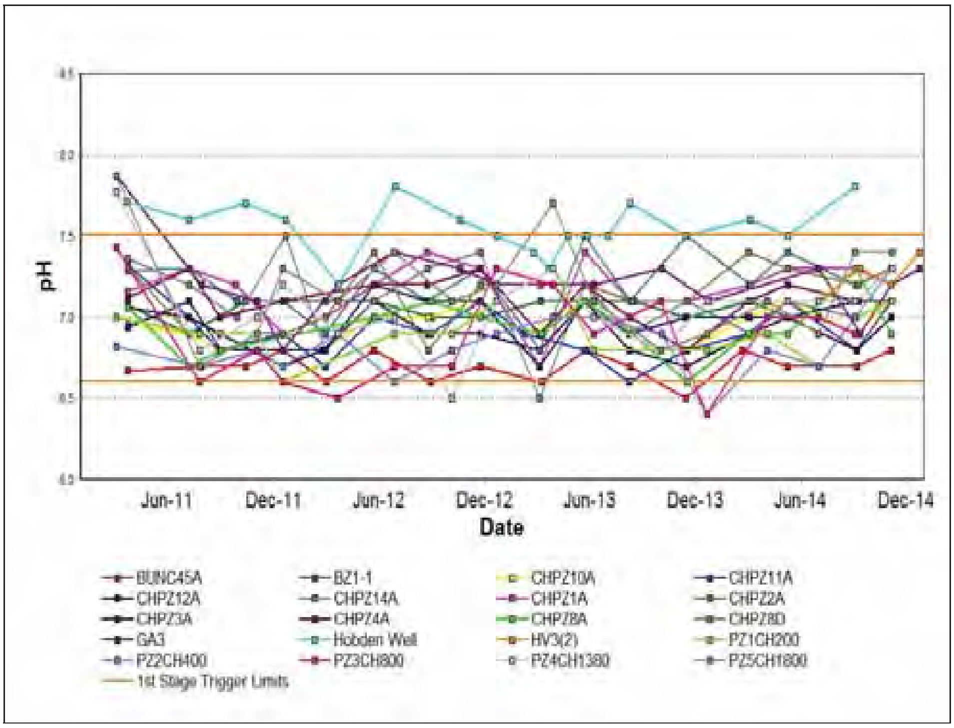


Figure 66: Cheshunt/North Pit Alluvium Groundwater pH trends 2011– 2014

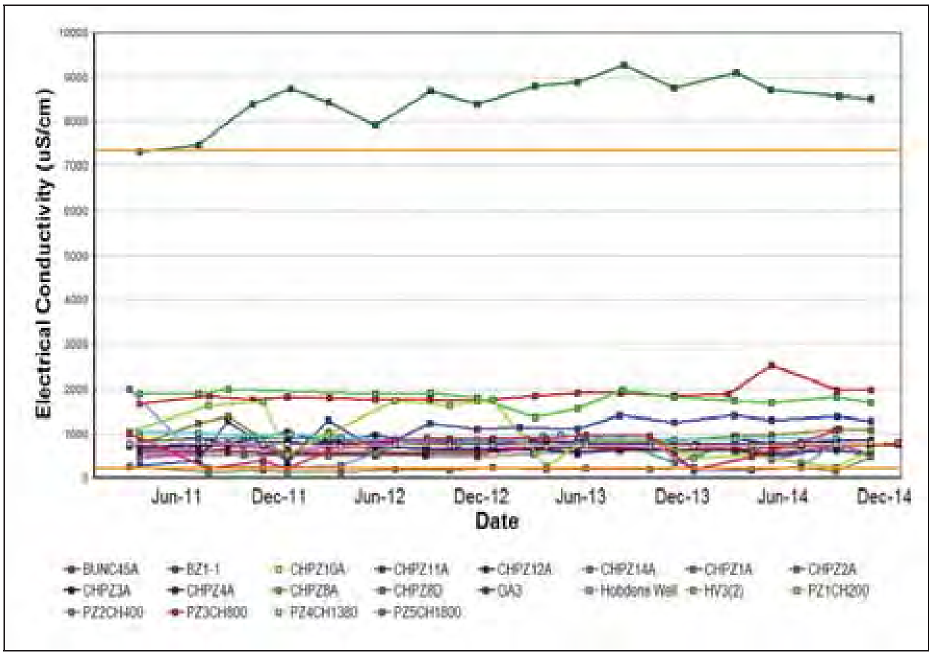


Figure 67: Cheshunt/North Pit Alluvium Groundwater EC Trends 2011 - 2014

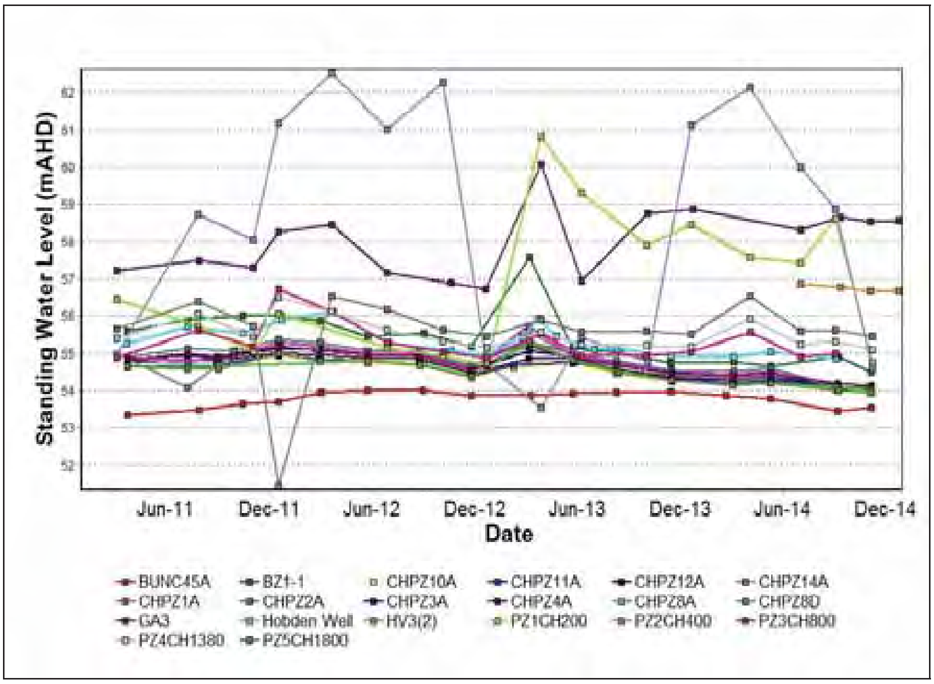


Figure 68: Cheshunt/North Pit Alluvium Groundwater SWL trends 2011- 2014

3.7.2.7 Cheshunt Interburden

Groundwater monitoring in the Cheshunt Interburden area was undertaken at3 sites during 2014, with 12 samples collected during the reporting period. The EC, pH and SWL trends for 2011 to 2014 for Cheshunt Interburden bores is shown in **Figure 69** to Figure 71. Trigger tracking results are listed in Table 42.

Table 42: Cheshunt East Interburden area Ground Water Internal Trigger Tracking

Location	Date	Trigger limit	Action taken in response
BZ3-1	06/03/2014 09/05/2014	**pH - 1st Stage 95th percentile**	Watching Brief*
	08/09/2014		Third consecutive trigger. Additional sampling and comprehensive laboratory analysis undertaken following successive trigger breaches. Results of review indicate water chemistry is consistent with historical data and does not show evidence of mixing due to leakage from other aquifers.
	05/11/2014		4th consecutive reading above pH trigger limit. See above. Triggers to be reviewed in 2015.
BZ8-2	06/03/2014 09/05/2014	**EC - 1st Stage 5th percentile**	Watching Brief *
	08/09/2014		Third consecutive trigger. Review of comprehensive laboratory analysis undertaken following successive trigger breaches. Results of review indicate water chemistry is consistent with historical data and does not show evidence of mixing due to leakage from other aquifers.
	5/11/2014		4th consecutive reading below EC trigger limit. See above. Triggers to be reviewed in 2015.
HG2	05/03/2014 09/05/2014	**EC - 1st Stage 95th percentile**	Watching Brief *
	08/09/2014		Third consecutive trigger. Additional sampling and comprehensive laboratory analysis undertaken following successive trigger breaches. Results of review indicate water chemistry is consistent with historical data and does not show evidence of mixing due to leakage from other aquifers.
	05/11/2014		4th consecutive reading above EC trigger limit. See above. Triggers to be reviewed in 2015.

*= 1st/2nd trigger. Watching Brief established pending outcomes of subsequent monitoring events. No specific actions required

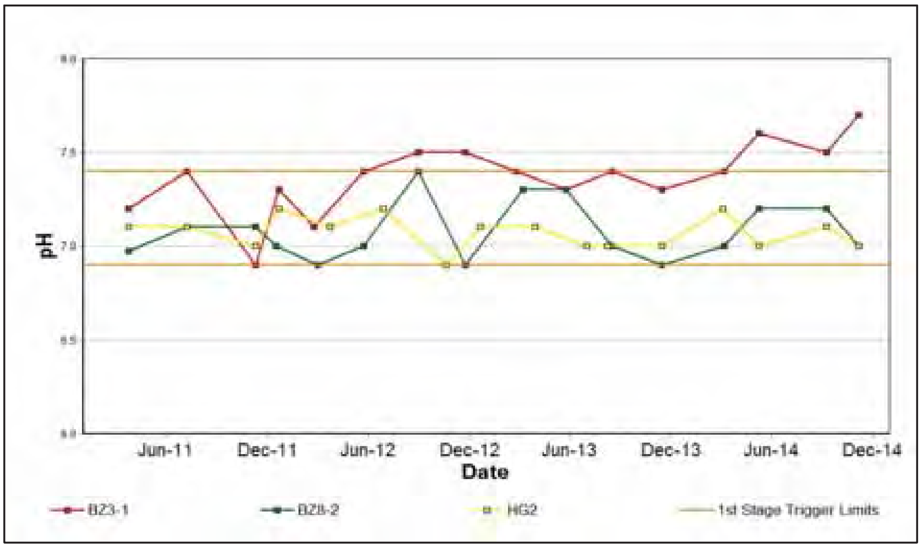


Figure 69: Cheshunt Interburden Groundwater pH Trends 2011 – 2014

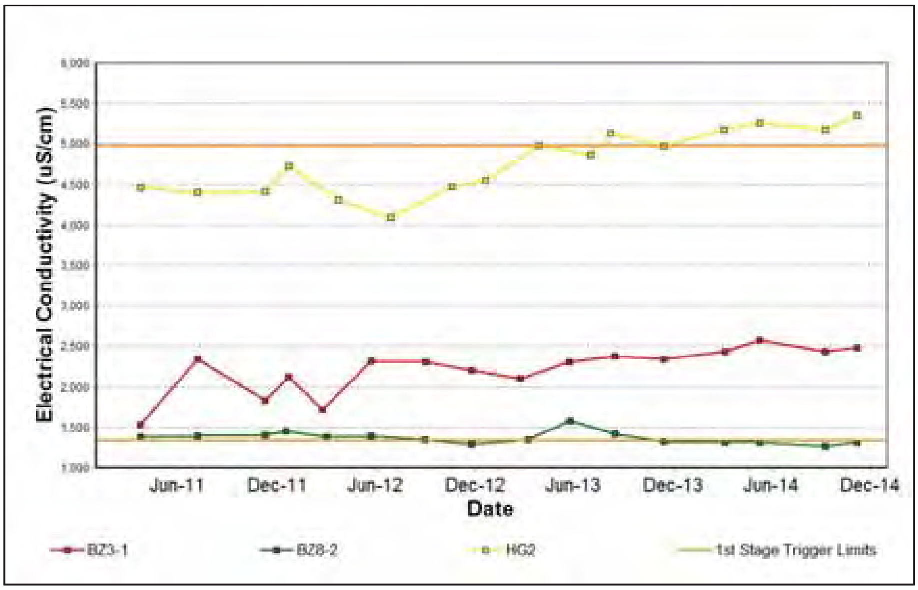


Figure 70: Cheshunt Interburden Groundwater EC Trends 2011 – 2014

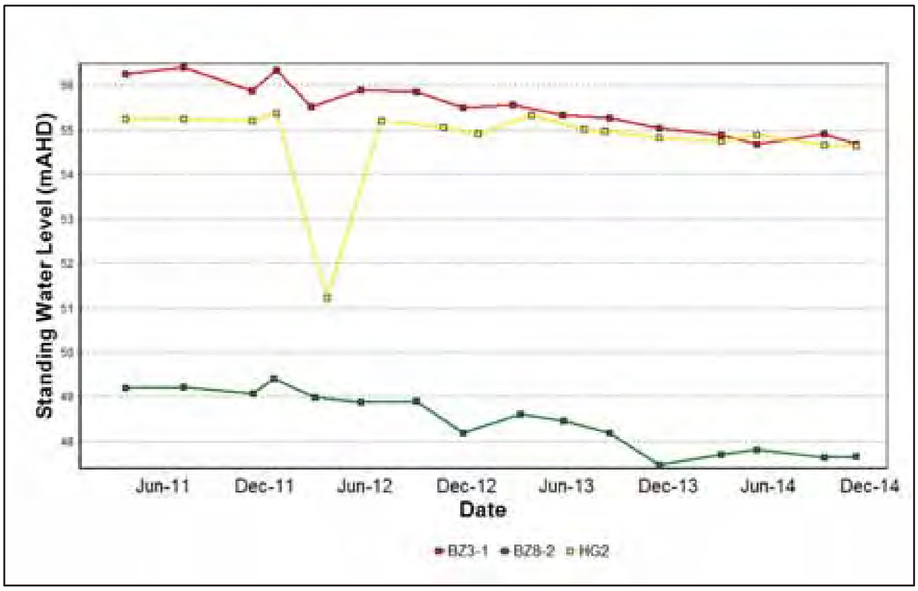


Figure 71: Cheshunt Interburden Groundwater SWL Trends 2011- 2014

3.7.2.8 Cheshunt Mt Arthur

Groundwater monitoring in the Cheshunt Mt Arthur area was undertaken at nine sites during 2014. A total of 34 samples were collected during the reporting period. The pH, EC and SWL trends for 2011 to 2014 for Cheshunt Mt Arthur groundwater bores are shown in Figure 72 to Figure 74. BZ4A(2) was recorded as dry on both March and April monitoring events. Trigger tracking results are detailed in Table 43.

Table 43: Cheshunt Mt Authur Ground Water Internal Trigger Tracking 2014

Location	Date	Trigger limit	Action taken in response
BZ1-3	06/03/2014 09/05/2014	**EC – 2nd Stage 95th percentile**	The elevated EC results exhibited by BZ1-3 are typically associated with depressurisation of the Mt Arthur seam due to close proximity of the active mining area in 2013-14. This is further evidenced by reduction in standing water level, which is also occurring at a lesser magnitude in nearby bores.
	08/09/2014	**EC - 1st Stage 95th percentile**	
	05/11/2014	**EC – 2nd Stage 95th percentile**	

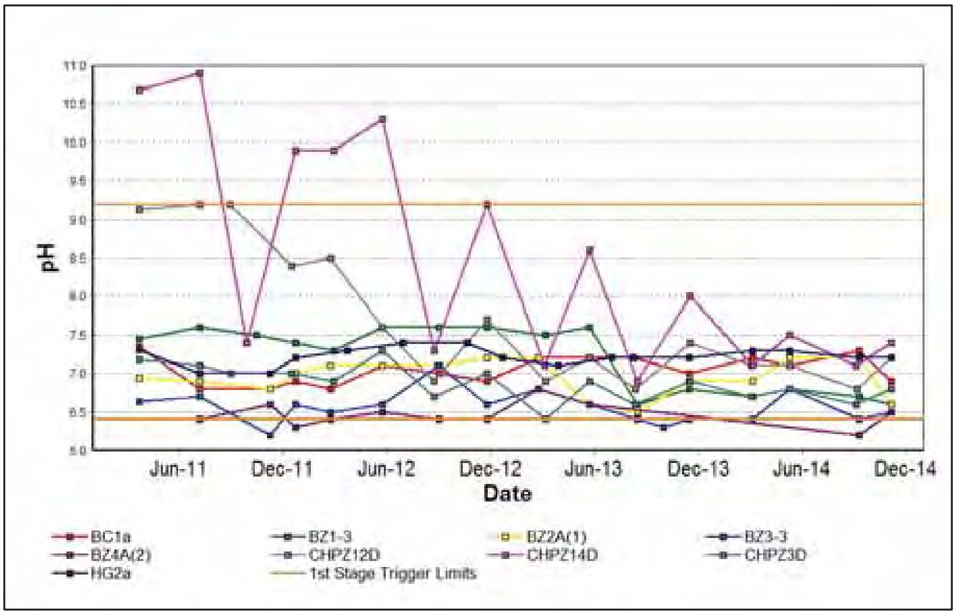


Figure 72: Cheshunt Mt Arthur Groundwater pH Trends 2011 - 2014

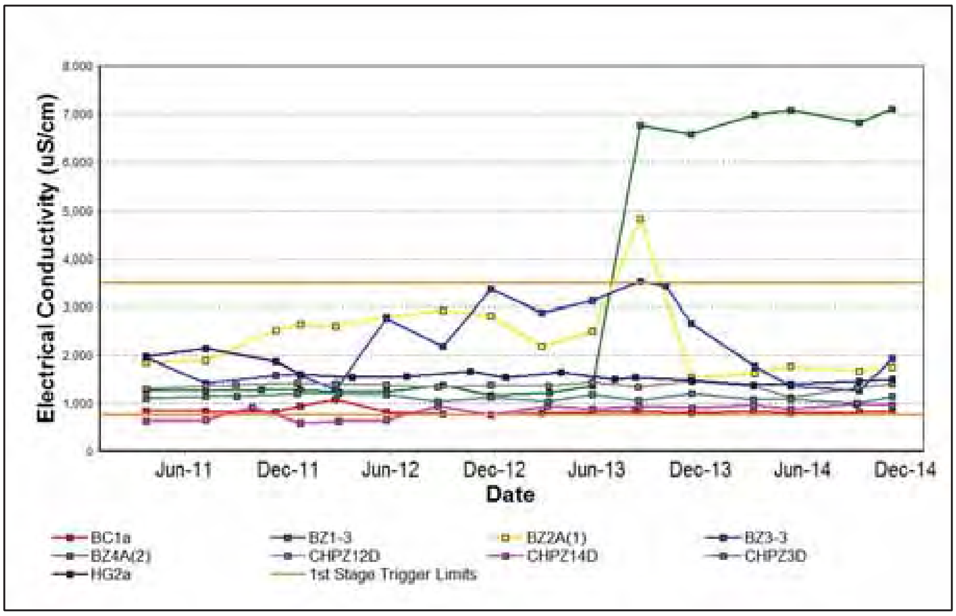


Figure 73: Cheshunt Mt Arthur Groundwater EC Trends 2011 – 2014

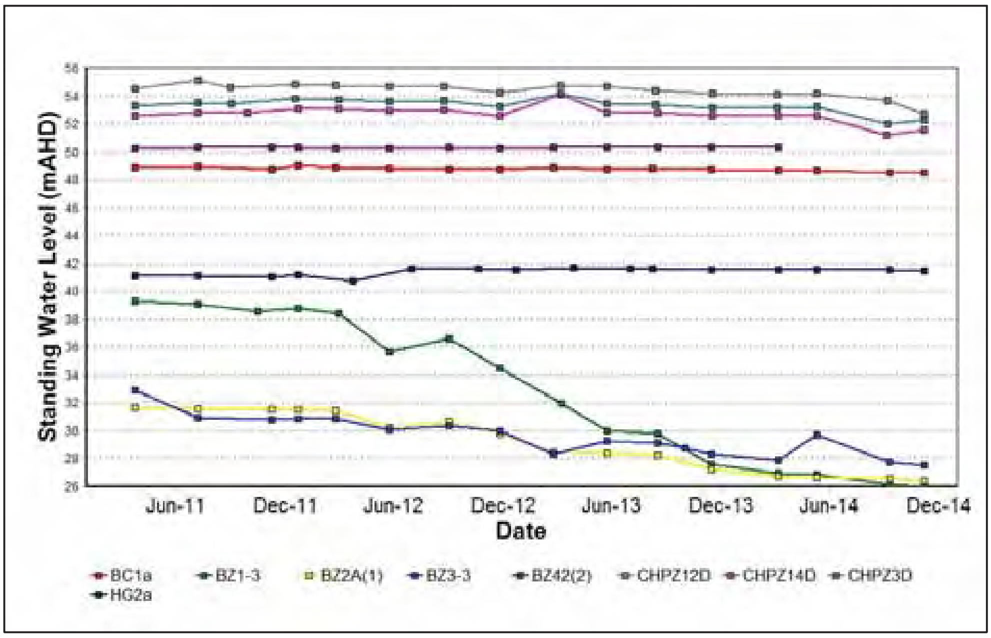


Figure 74: Cheshunt Mt Arthur Groundwater SWL Trends 2011 - 2014

3.7.2.9 Cheshunt Piercefield

Groundwater monitoring in the Cheshunt Piercefield area was undertaken from one site during 2014. A total of 4 samples were collected during the reporting period. The pH, EC and SWL trends for 2011 to 2014 for Cheshunt Piercefield groundwater bore are shown in Figure 75 to Figure 77.

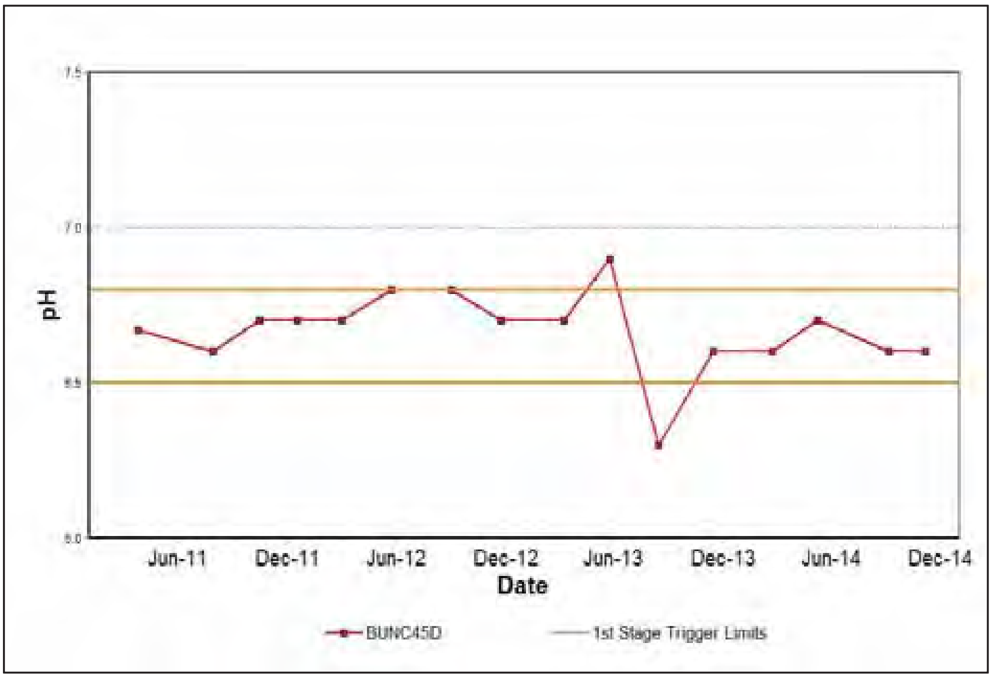


Figure 75: Cheshunt Piercefield Groundwater pH Trends 2011 - 2014

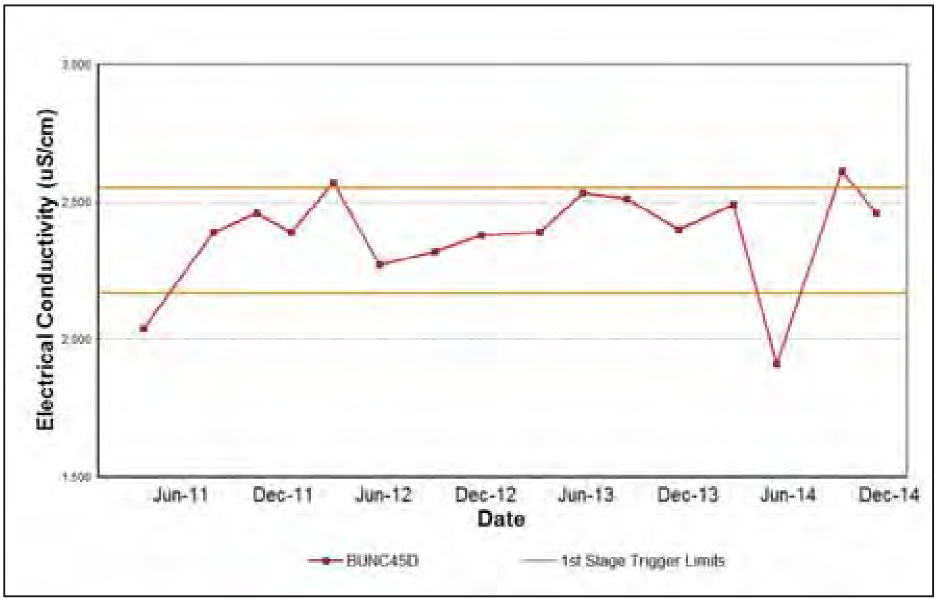


Figure 76: Cheshunt Piercefield Groundwater EC Trends 2011 – 2014

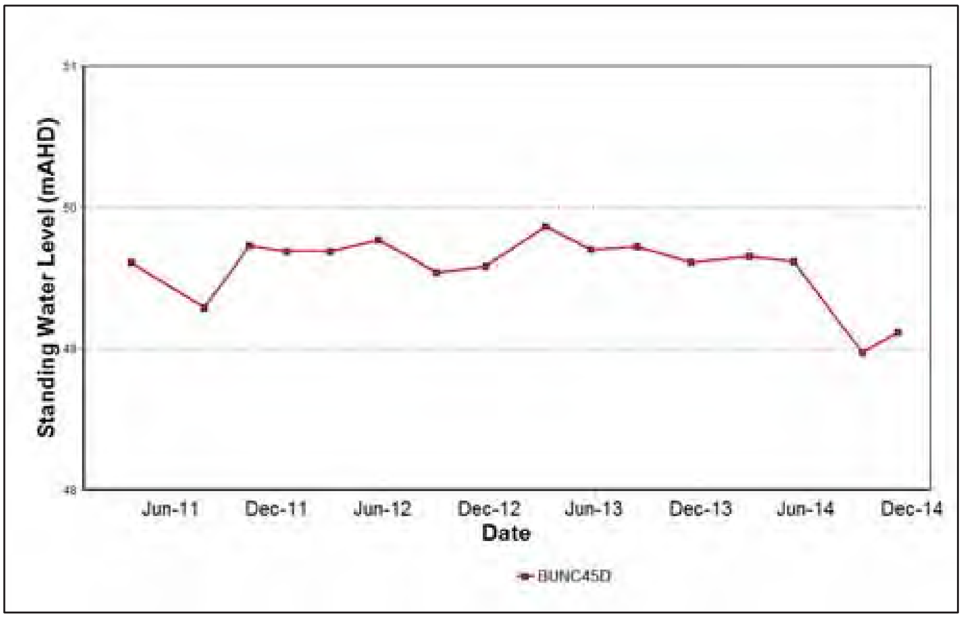


Figure 77: Cheshunt Piercefield Groundwater SWL Trends 2011 - 2014

3.7.2.10 Lemington South Alluvium

Groundwater monitoring in the Lemington South Alluvium area was undertaken at five sites during 2014. A total of 16 samples were collected during the reporting period. The pH, EC and SWL trends for 2011 to 2014 for Lemington South Alluvium groundwater bores are shown in Figure 78 to Figure 80 respectively. D317(ALL) was recorded as dry during all monitoring events in 2014. Trigger tracking results are detailed in Table 44.

Table 44: Lemington South Alluvium Groundwater 2014 Internal Trigger Tracking

Location	Date	Trigger limit	Action taken in response
Appleyard Farm	31/03/2014	**EC - 1st Stage 5th percentile**	Watching Brief*
	28/05/2014		
	29/08/2014		Consistent with historical records, paucity of data available to set trigger limits. Generally, trend not viewed as concerning Alluvium expected to be fresh, bore is very close to the wollombi brook. Triggers will be revised in 2015.
	11/11/2014		4th consecutive reading below EC trigger limit. See above.
C130(ALL)	28/05/2014	**EC - 1st Stage 95th percentile**	Watching Brief *
	31/03/2014		
	29/08/2014		Investigation has determined that C130(ALL) has been incorrectly identified as an Alluvium seam bore. As such results outside the trigger range are viewed as erroneous.
	11/11/2014		4th consecutive reading above EC trigger limit. See above.

*= 1st/2nd trigger. Watching Brief established pending outcomes of subsequent monitoring events. No specific actions required

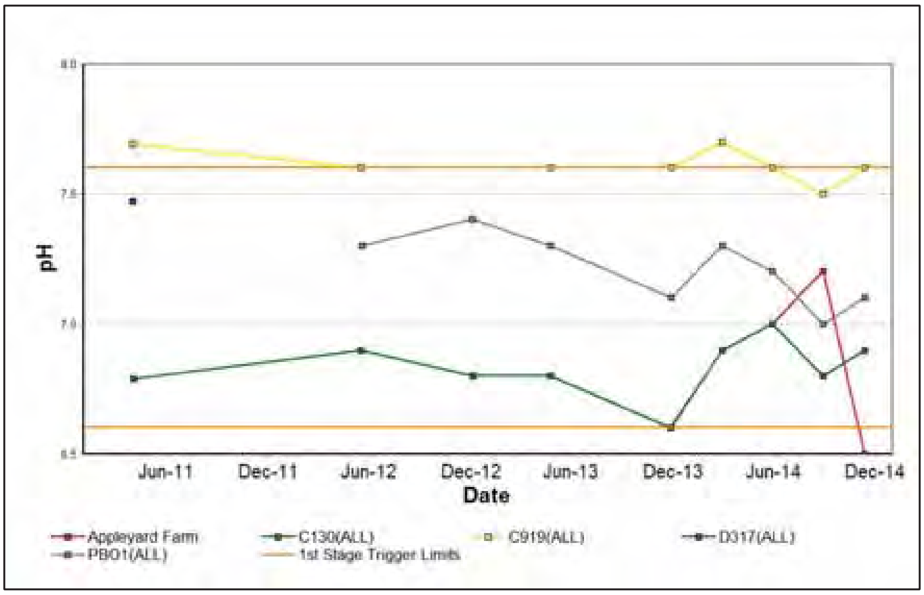


Figure 78: Lemington South Alluvium Groundwater pH Trends 2011 – 2014

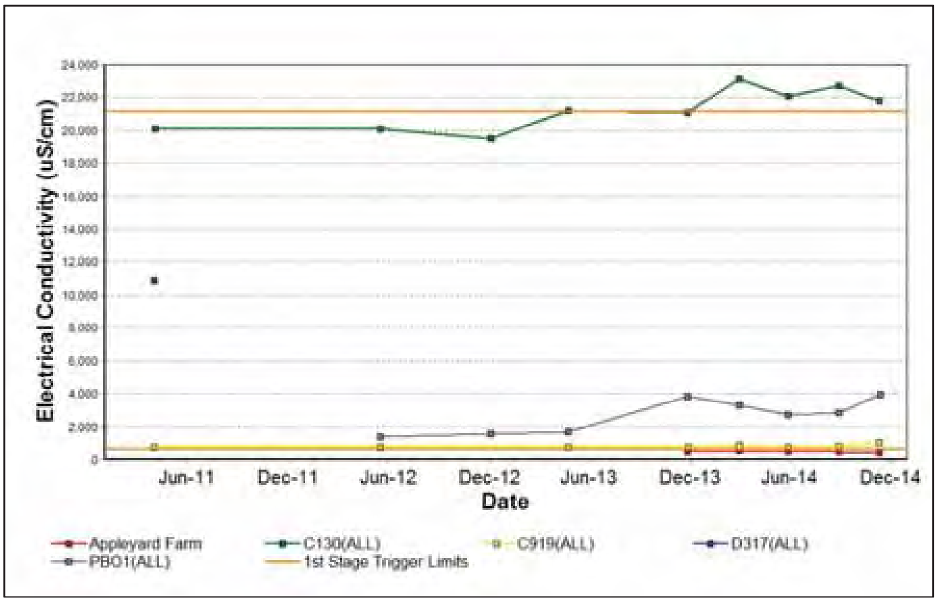


Figure 79: Lemington South Alluvium Groundwater EC Trends 2011- 2014

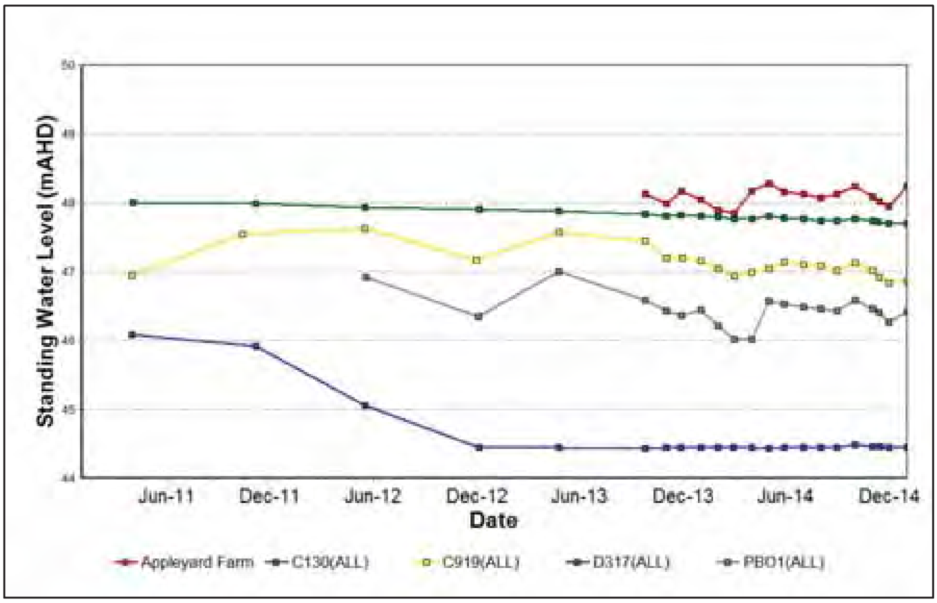


Figure 80: Lemington South Alluvium Groundwater SWL Trends 2011-2014

3.7.2.11 Lemington South Arrowfield

Groundwater monitoring in the Lemington South Arrowfield area was undertaken at four sites during 2014. A total of 8 samples were collected during the reporting period. The pH, EC and SWL trends for 2011 to 2014 for Lemington South Arrowfield groundwater bores are shown in Figure 81 to Figure 83.

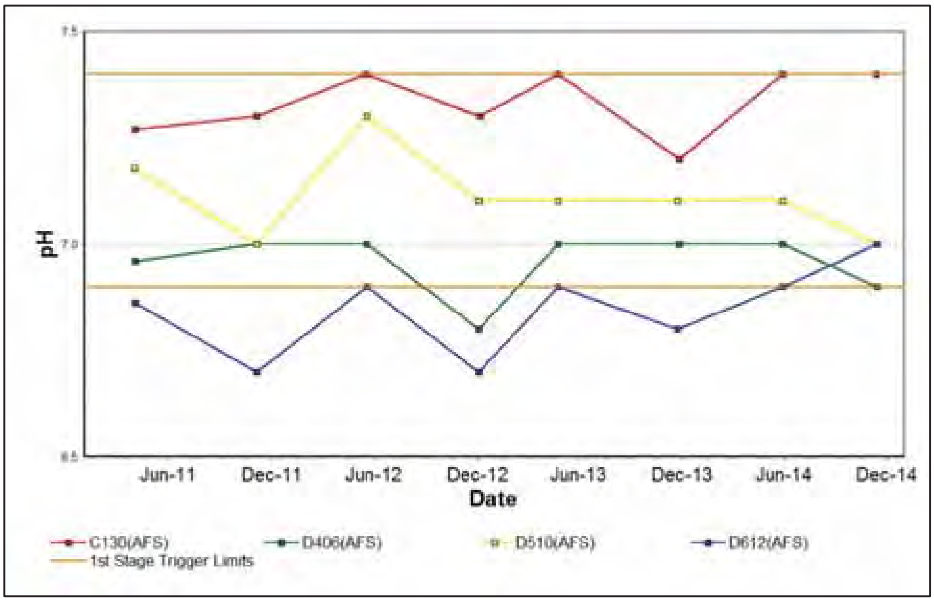


Figure 81: Lemington South Arrowfield Groundwater pH Trends 2011 – 2014

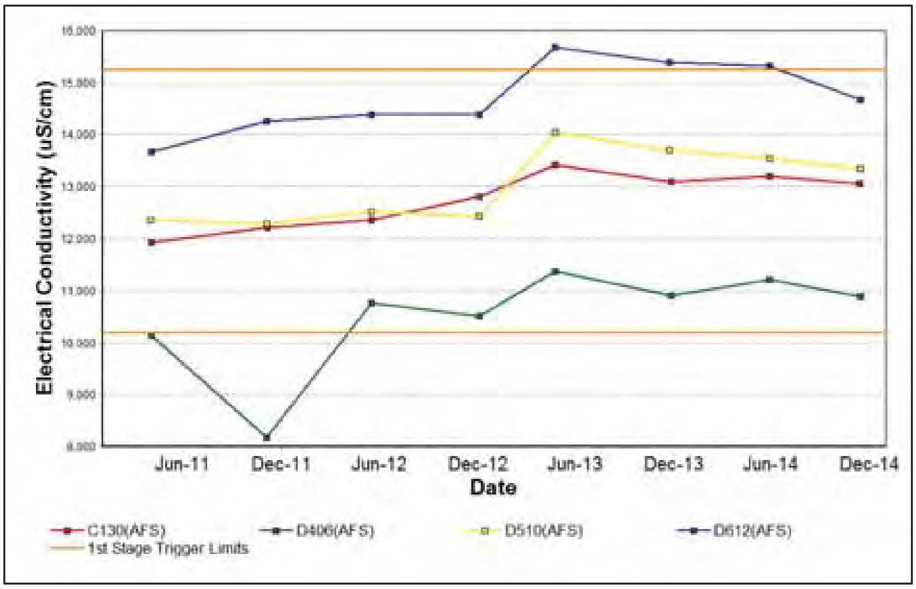


Figure 82: Lemington South Arrowfield Groundwater EC Trends 2011 – 2014

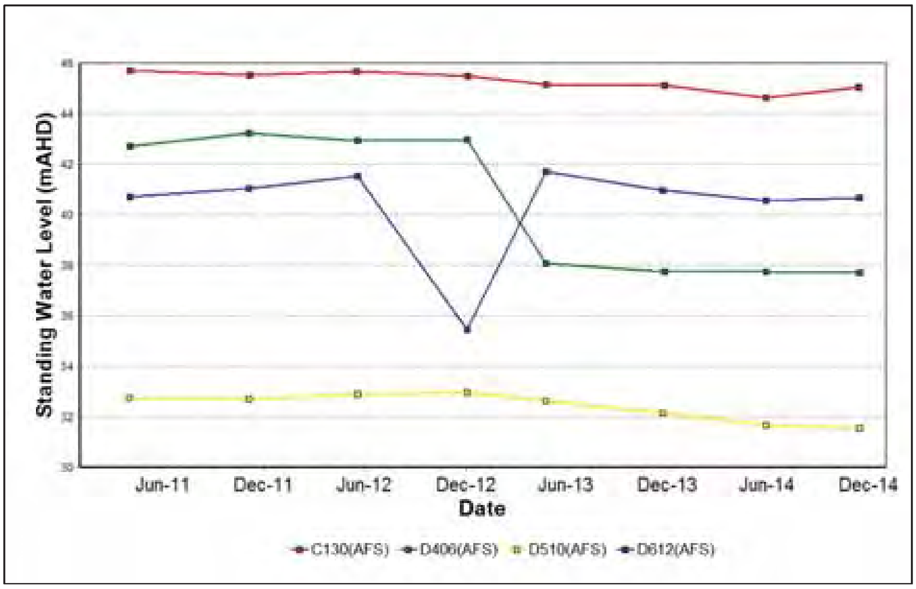


Figure 83: Lemington South Arrowfield Groundwater SWL Trends 2011 - 2014

3.7.2.12 Lemington South Bowfield

Groundwater monitoring in the Lemington South Bowfield area was undertaken at15 sites during 2014. A total of 30 samples were collected during the reporting period. The pH, EC and SWL trends for 2011 to 2014 for Lemington South Bowfield groundwater bores are shown in Figure 84 to Figure 86 respectively.

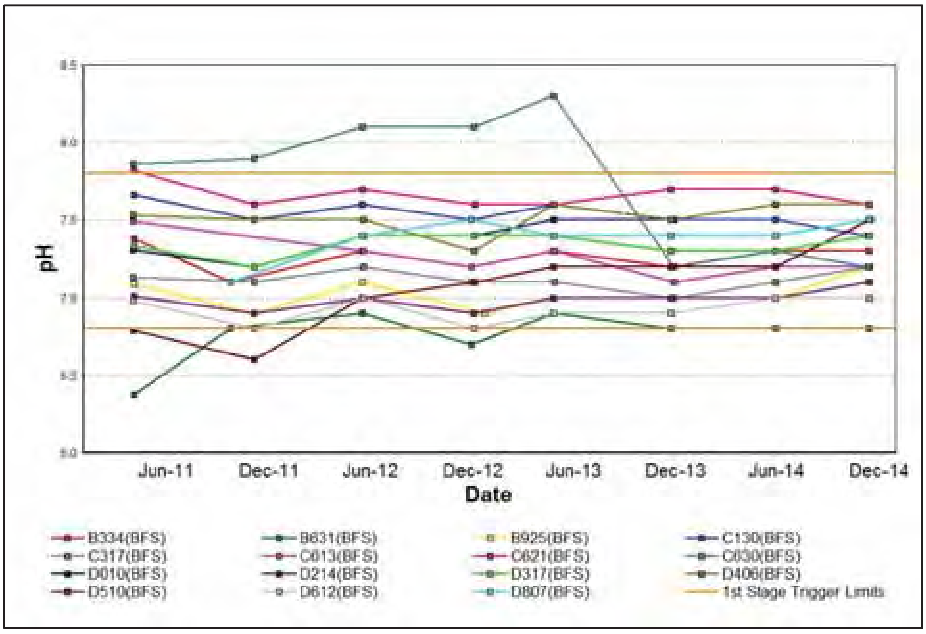


Figure 84: Lemington South Bowfield Groundwater pH Trends 2011 – 2014

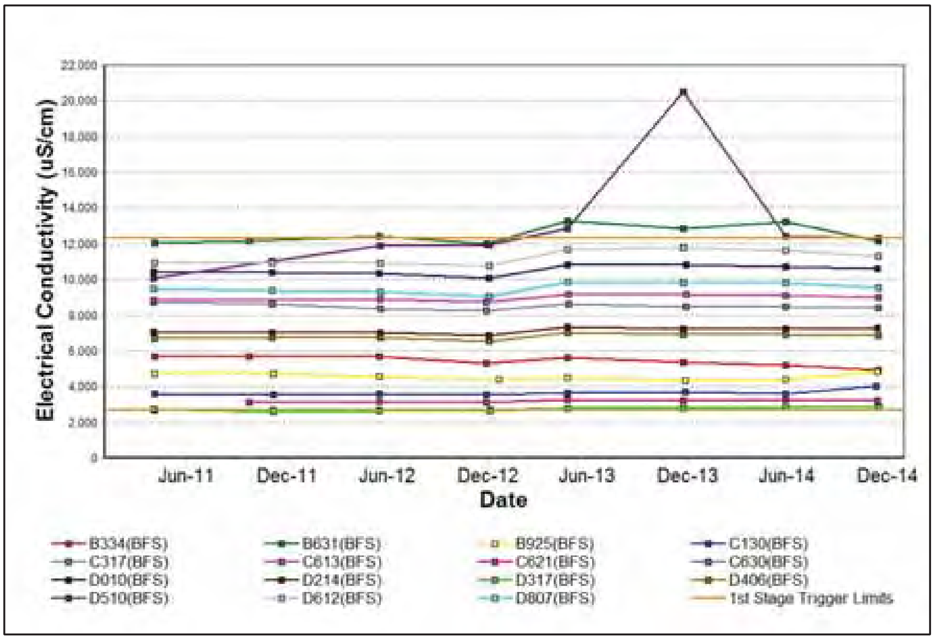


Figure 85: Lemington South Bowfield Groundwater EC Trends 2011 – 2014

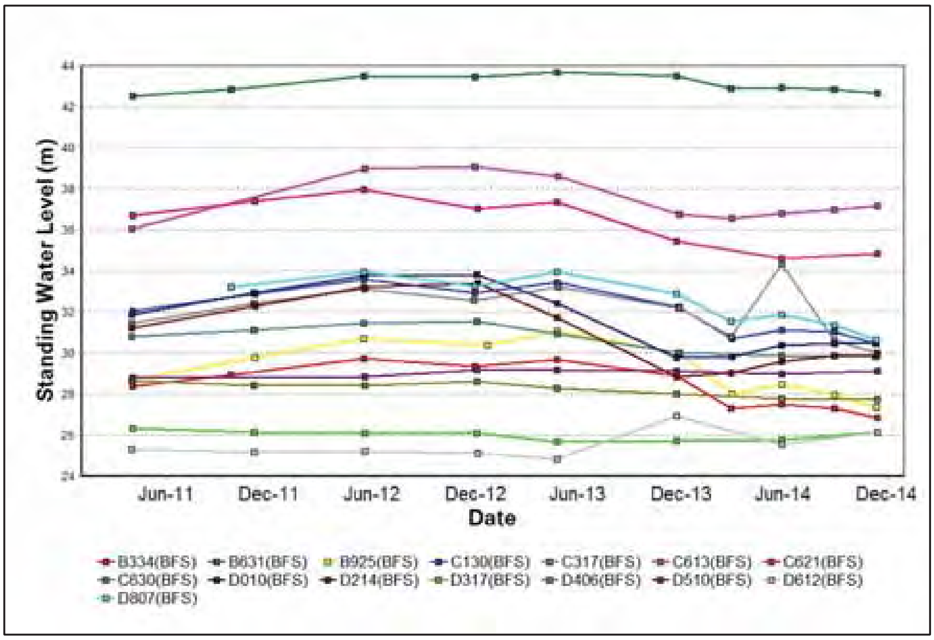


Figure 86: Lemington South Bowfield Groundwater SWL Trends 2011 - 2014

3.7.2.13 Lemington South Woodlands Hill

Groundwater monitoring in the Lemington South Woodlands Hill seam was undertaken at seven sites during 2014. A total of 14 samples were collected during the reporting period. The pH, EC and SWL trends for 2011 to 2014 for Lemington South Woodlands Hill groundwater bores are shown in Figure 87 to Figure 89.

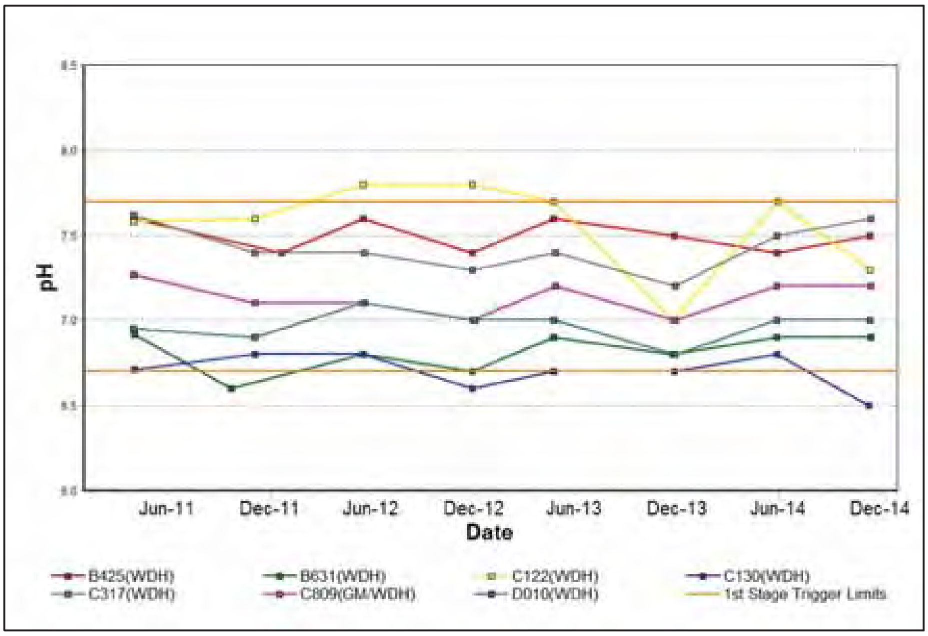


Figure 87: Lemington South Woodlands Hill Groundwater pH Trends 2011 – 2014

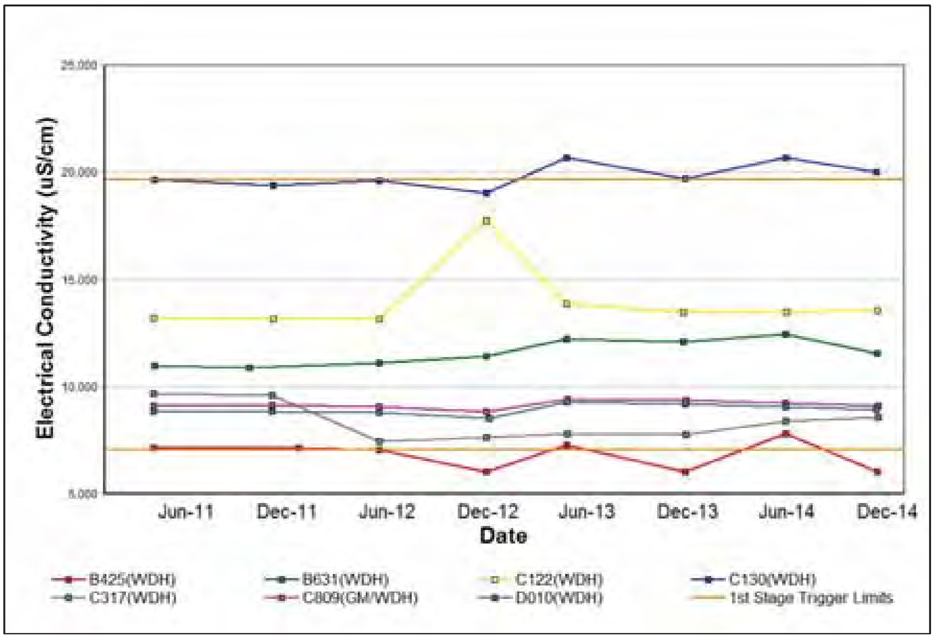


Figure 88: Lemington South Woodlands Hill Groundwater EC Trends 2011 – 2014

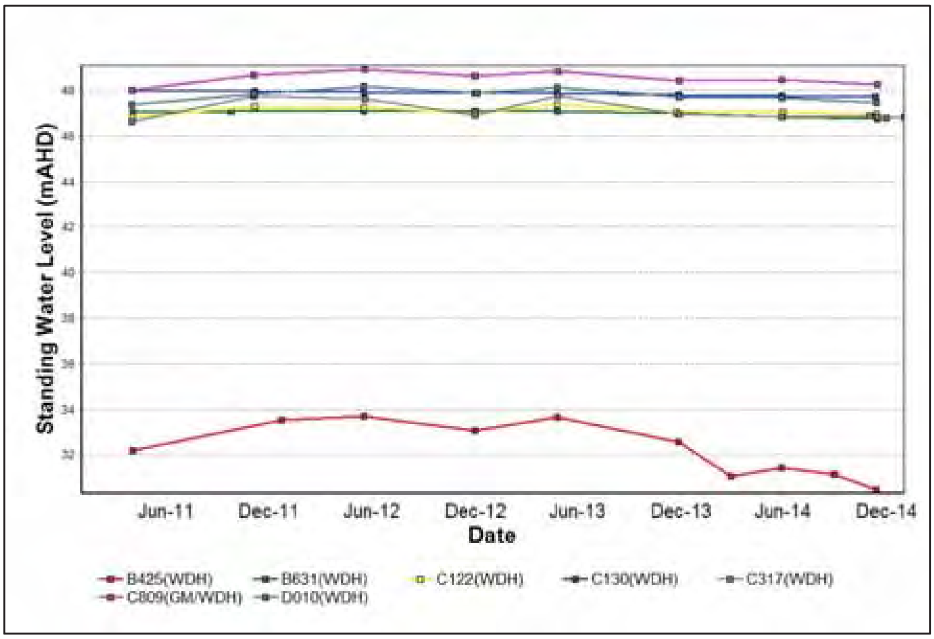


Figure 89: Lemington South Woodlands Hill Groundwater SWL Trends 2011 - 2014

3.7.2.14 North pit Spoil

Groundwater monitoring in the North Pit Spoil area was undertaken at ten sites during 2014. A total of 40 samples were collected during the reporting period. The pH, EC and SWL trends for 2011 to 2014 for North Pit Spoil groundwater bores are shown in Figure 90 to Figure 92. Trigger tracking results are detailed in Table 45.

Table 45: North Pit Spoil Groundwater 2014 Internal Trigger Tracking

Location	Date	Trigger limit	Action taken in response
4116P	02/04/2014	**EC - 1st Stage 95th percentile**	Watching Brief*
	02/07/2014		
	03/10/2014		Results within the historical range for this bore. The recent trend is consistent with nearby bore 4117p targeting the same aquifer.
	23/12/2014		4th consecutive reading above EC trigger limit. See above.

*= 1st/2nd trigger. Watching Brief established pending outcomes of subsequent monitoring events. No specific actions required

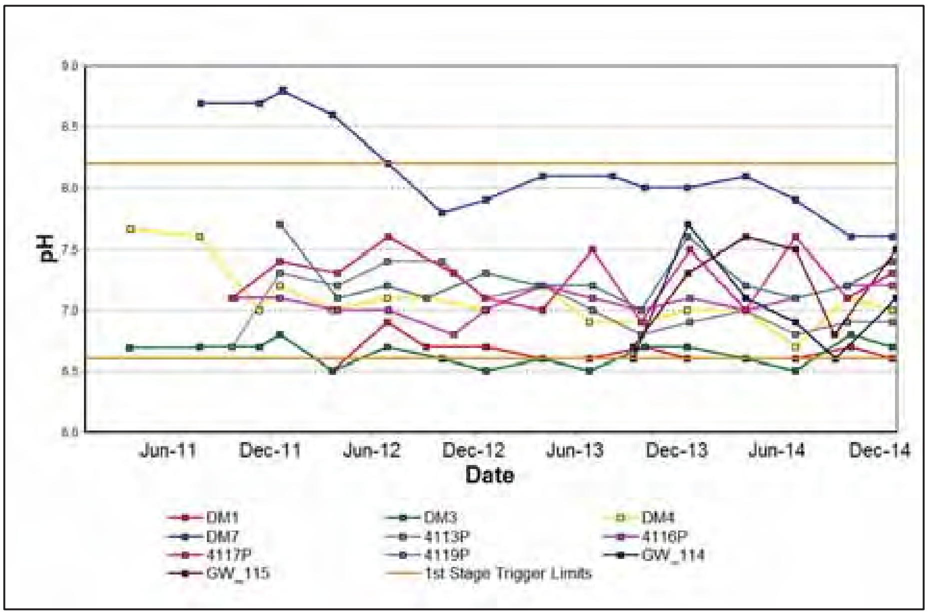


Figure 90: North Pit Spoil Groundwater pH Trends 2011 – 2014

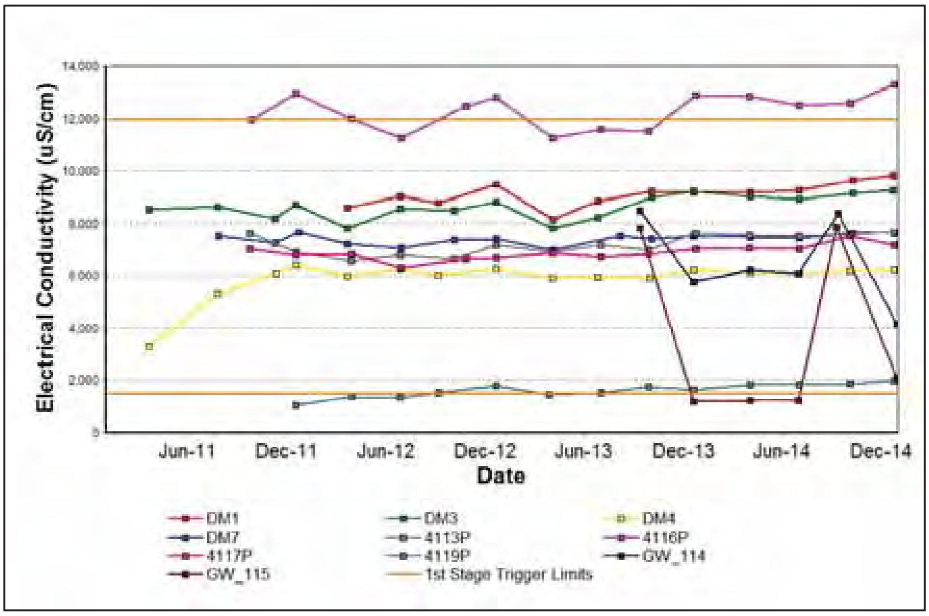


Figure 91: North Pit Spoil Groundwater EC Trends 2011 – 2014

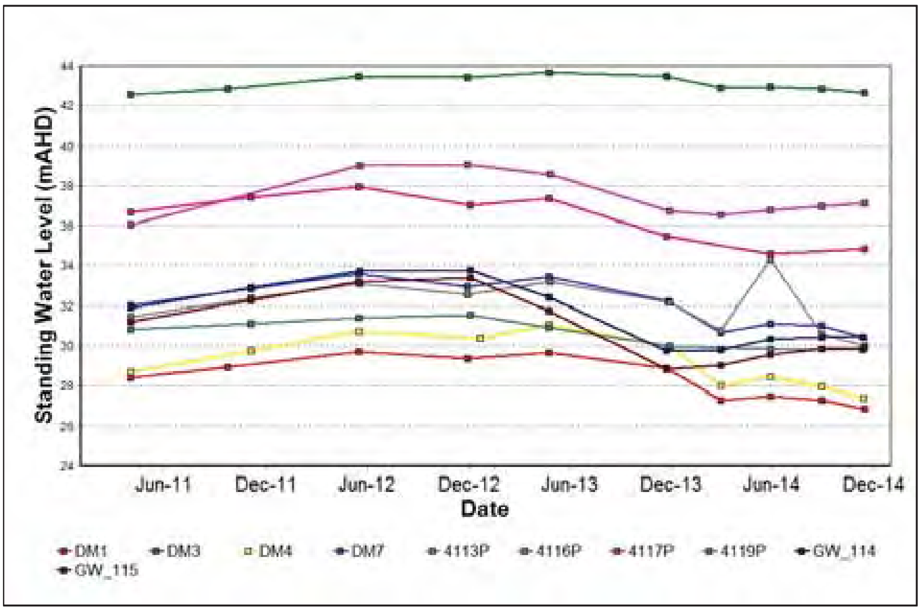


Figure 92: North Pit Spoil Groundwater SWL Trends 2011 - 2014

3.7.2.15 South Facilities Piercefield

Groundwater monitoring in the South Facilities Piercefield area was undertaken at four sites during 2014. A total of 10 samples were collected during the reporting period. The pH, EC and SWL trends for 2011 to 2014 for South Facilities Piercefield groundwater bores are shown in Figure 93 to Figure 95.

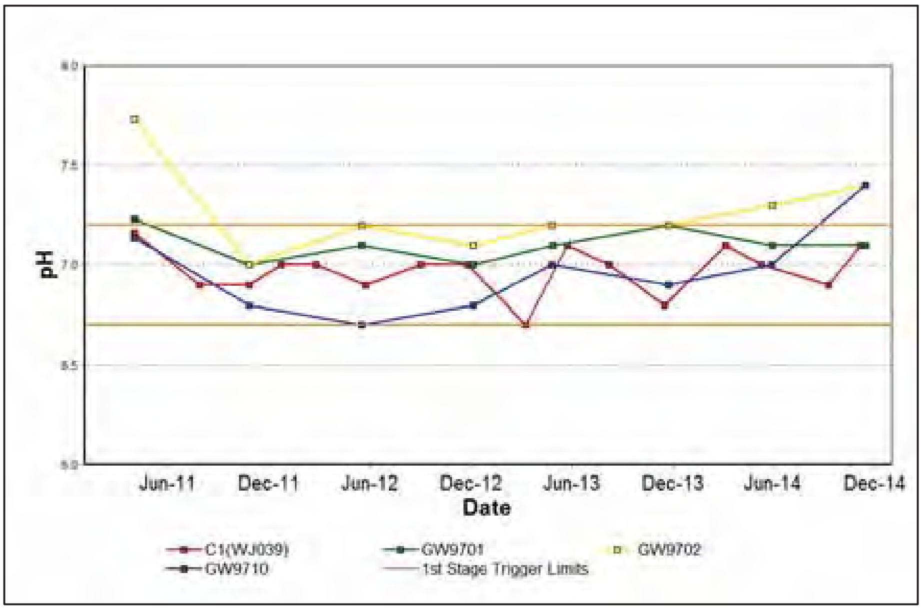


Figure 93: South Facilities Piercefield Groundwater pH Trends 2011 – 2014

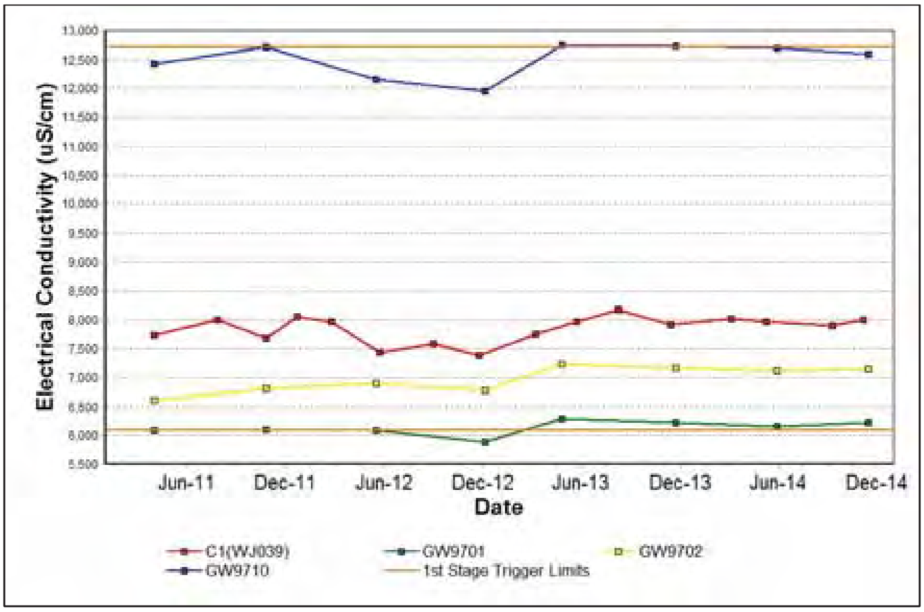


Figure 94: South Facilities Piercefield Groundwater EC Trends 2011 – 2014

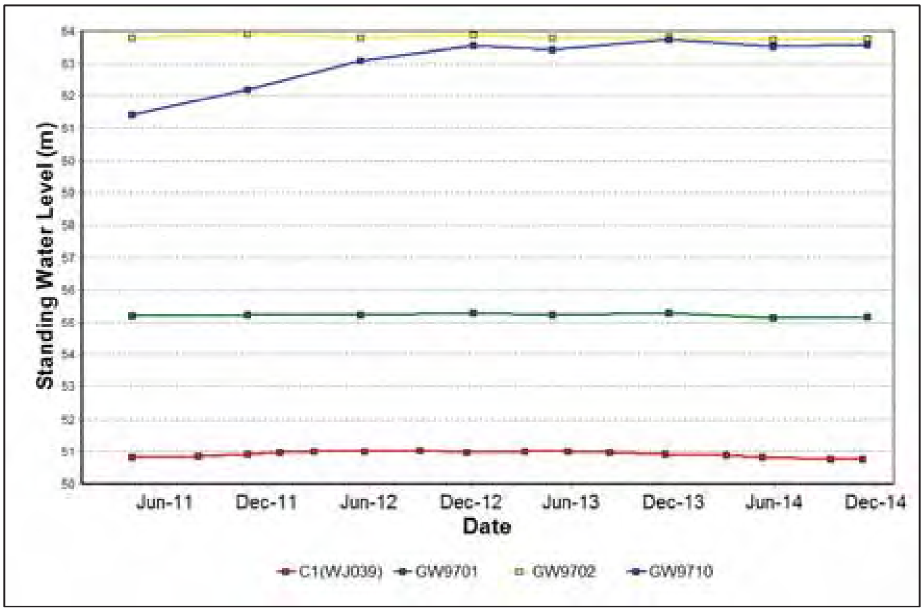


Figure 95: South Facilities Piercefield Groundwater SWL Trends 2011 – 2014

3.7.2.16 West Pit Alluvium

Groundwater monitoring in the West Pit Alluvium area was undertaken at three sites during 2014. A total of 12 samples were collected during the reporting period. The pH, EC and SWL trends for 2011 to 2014 for West Pit Alluvium groundwater bores are shown in Figure 96 to Figure 98. Trigger tracking results are detailed in Table 46.

Table 46: West Pit Alluvium Groundwater 2014 Internal Trigger Tracking:

Location	Date	Trigger limit	Action taken in response
G1	01/07/2014	**EC - 1st Stage 95th percentile**	Watching Brief*
	11/09/2014		
	04/11/2014		Desktop review completed. Review of comprehensive laboratory analysis results undertaken following successive trigger breaches. Results of review indicate water chemistry is consistent with historical data and nearby bores; does not show evidence of mixing due to leakage from other aquifers. Watching brief continued.
	23/12/2014		4th consecutive reading above EC trigger limit. See above.

*= 1st/2nd trigger. Watching Brief established pending outcomes of subsequent monitoring events. No specific actions required

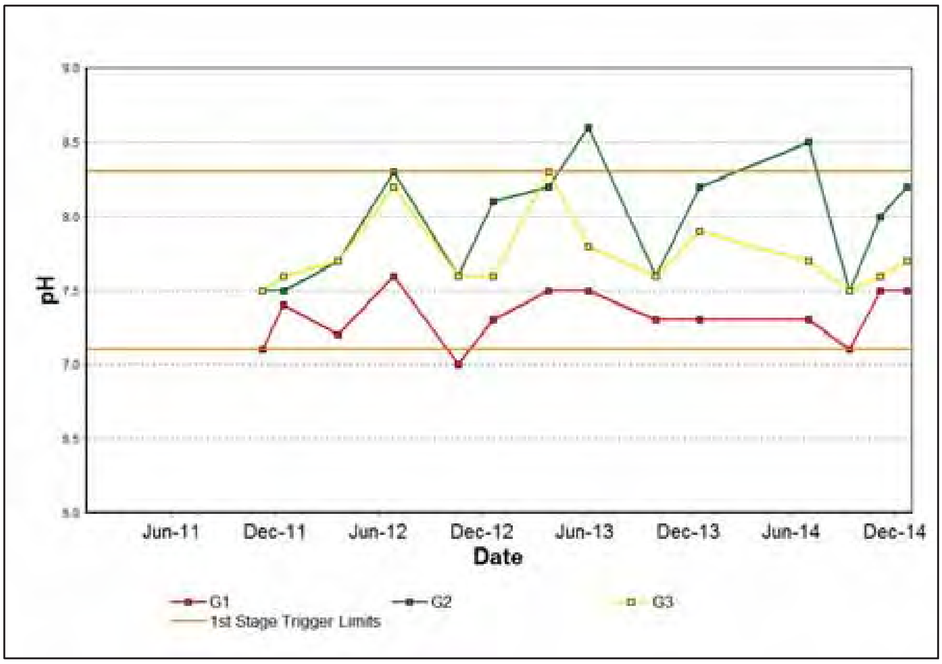


Figure 96: West Pit Alluvium Groundwater pH Trends 2011 – 2014

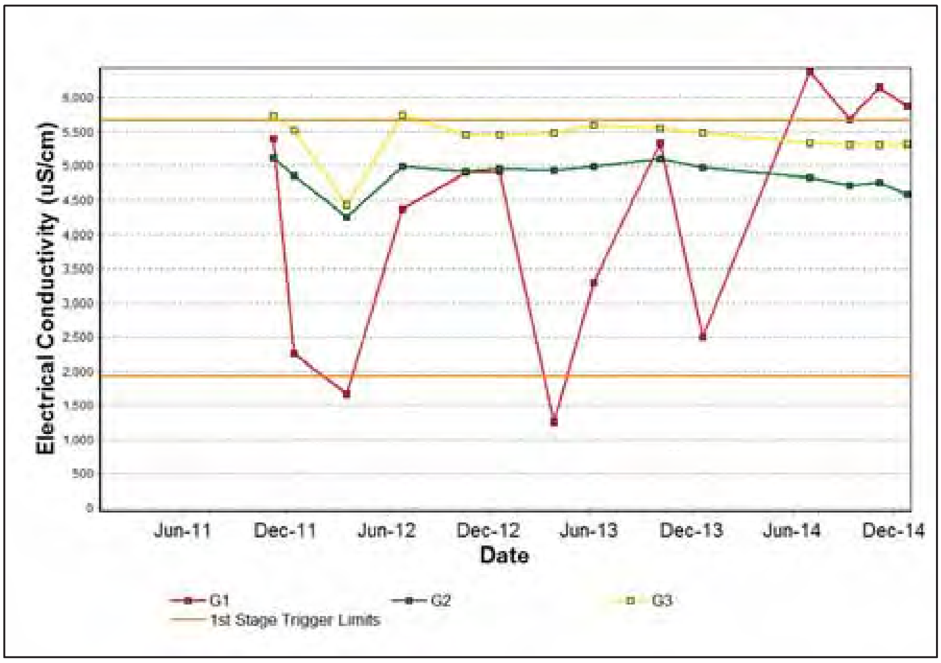


Figure 97: West Pit Alluvium Groundwater EC Trends 2011 – 2014

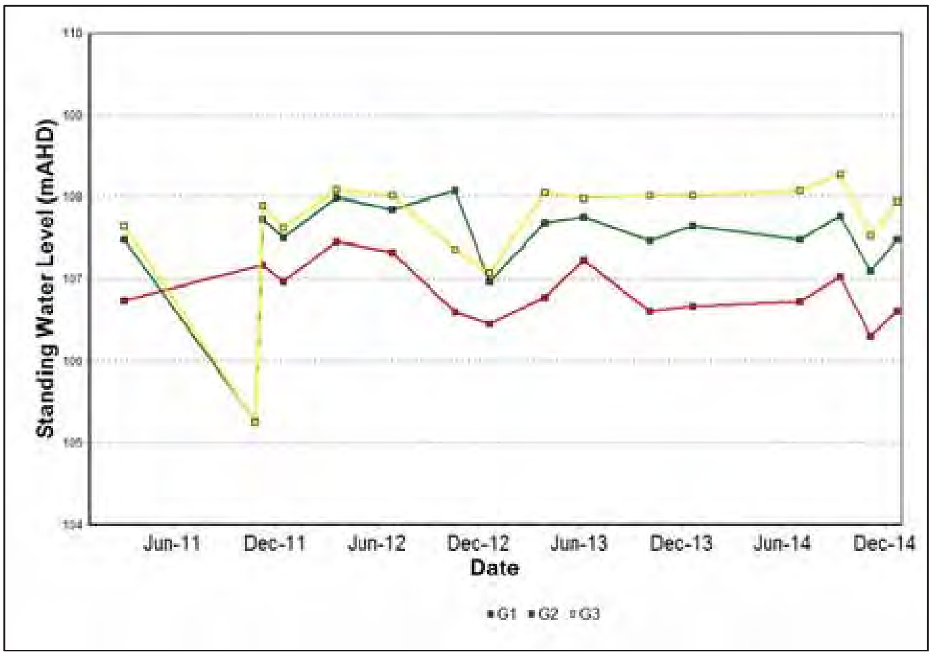


Figure 98: West Pit Alluvium Groundwater SWL Trends 2011 – 2014

3.6.2.17 West Pit Sandstone/ Siltstone

Groundwater monitoring in the West Pit Sandstone/ Siltstone area was undertaken at five sites during 2014. A total of 20 samples were collected during the reporting period. The pH, EC and SWL trends for 2011 to 2014 for West Pit Sandstone/ Siltstone groundwater bores are shown in Figure 99 to Figure 101.

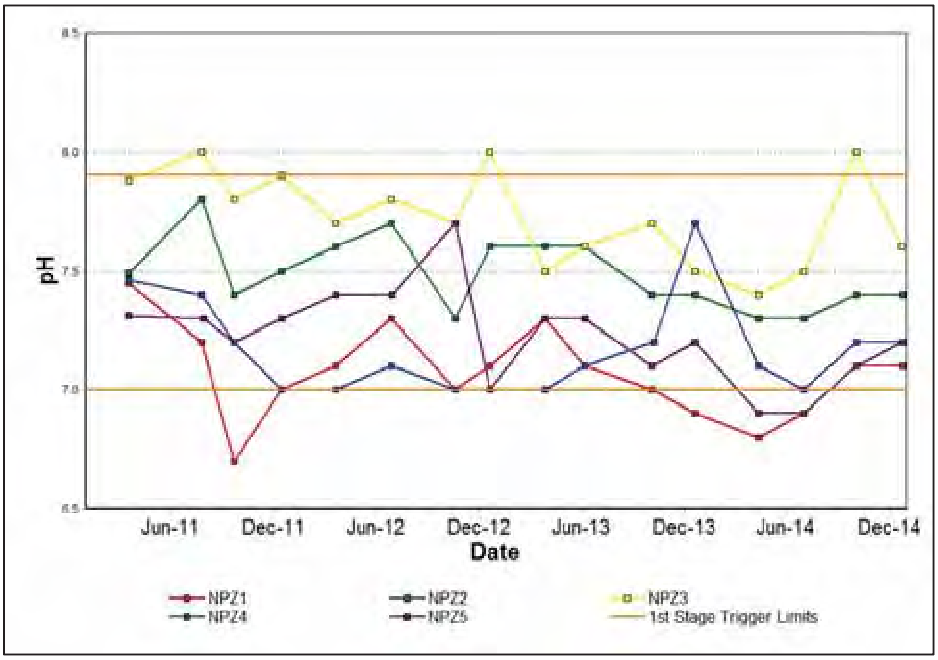


Figure 99: West Pit Sandstone/ Siltstone Groundwater pH Trends 2011 – 2014

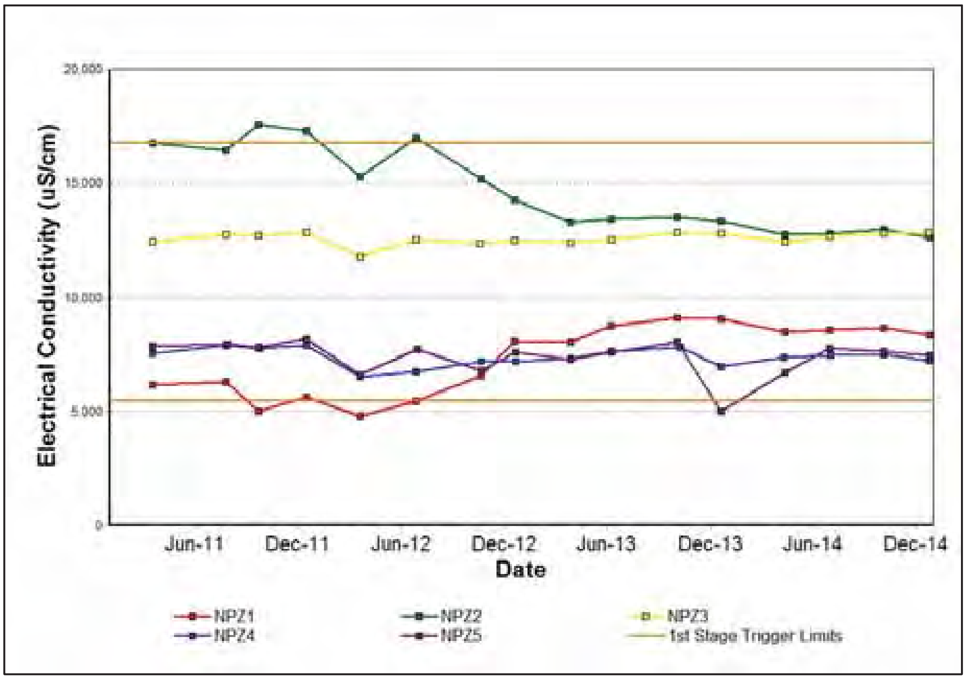


Figure 100: West Pit Sandstone/ Siltstone Groundwater EC Trends 2011 – 2014

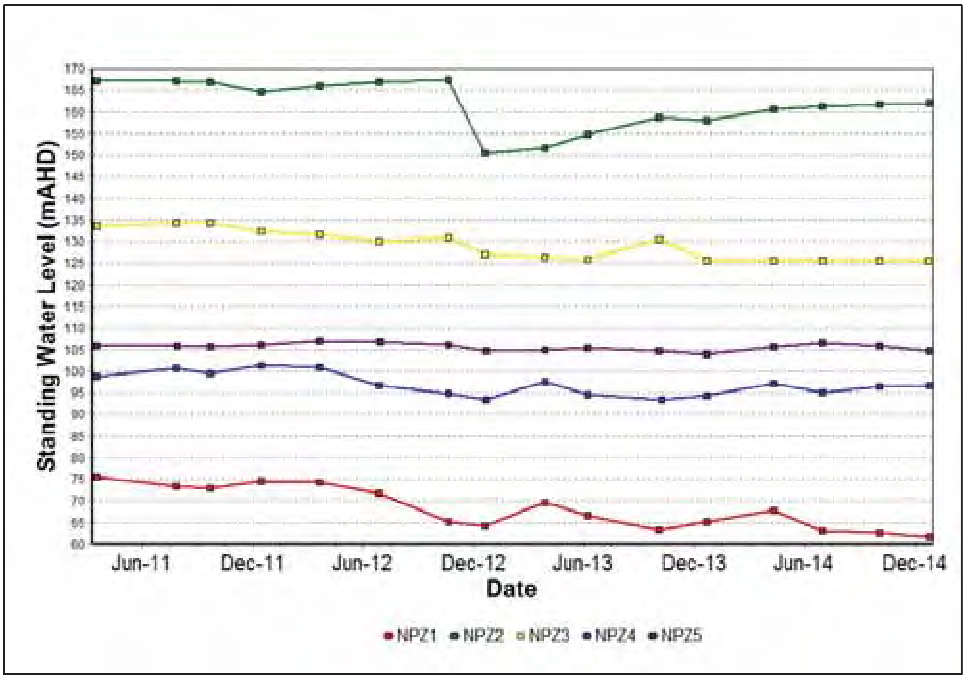


Figure 101: West Pit Sandstone/ Siltstone Groundwater SWL Trends 2011 – 2014

3.7.3 Groundwater Contours

Groundwater contour maps showing the alluvial and coal seam aquifers for HVO North and South are given in Appendix 4. The data is consistent with historical trends.

3.7.4 Ground Water Non-compliances during reporting period

There were no reportable incidents/non-compliances of consent or other approval conditions and no complaints relating to groundwater.

3.8 Greenhouse Gas and Energy Management

3.8.1 Climate Change

During 2014, HVO continued to comply with Australian Government legislation for Greenhouse reporting. Under NGER, Rio Tinto is required to report its annual greenhouse gas emissions, energy use and energy production.

RTCA continues to invest in research and development initiatives (Table 47), to find ways to reduce greenhouse gas emissions throughout the coal chain, with focus on;

- Research to identify new technologies;
- Technology upgrades to improve the way coal is burned; and
- Supporting a policy environment to enable the deployment of low emissions coal technologies.

Table 47: Product Stewardship Programmes

Programme	Outcomes
COAL21	Australian black coal producers contribute a voluntary levy to the Coal21 Fund to support the development of low emission coal technology in Australia. Rio Tinto Coal Australia has committed $52 million to this fund since 2007.
Australian Coal Association Research Programme (ACARP)	Australian black coal producers contribute five cents per tonne of product coal to fund research and the development of technologies that lead to the safe, sustainable production and utilisation of coal. During 2014 this contribution was around $2 million. ACARP is currently coordinating work to develop improved methods for estimating fugitive emissions from underground coal mining. There is also considerable research activity on the reduction of dust emissions from coal during transport to and storage at the major export terminals in Australia and to understand opportunities to reduce fugitive greenhouse gas emissions from mines.
The Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC)	The CO2CRC conducts research and development into carbon capture and storage technologies. It operates the Otway Project in Victoria, Australia's first demonstration of the deep geological storage, or geosequestration, of carbon dioxide. The project has successfully demonstrated the injection and storage of 65,000 tonnes of carbon dioxide. In addition to its $250,000 annual membership contribution, Rio Tinto Coal Australia is providing the CO2CRC with $6 million in funding over 3 years. The funding supports operations at the Otway Project and the Peter Cook Centre for CCS Research at the University of Melbourne.
Global Carbon Capture and Storage Institute (GCCSI)	The mission of the GCCSI is to accelerate the global adoption of CCS. Rio Tinto is a foundation member of the GCCSI.
Leadership Roundtable for the Development of Low Emissions Technologies for Fossil Fuels (the Roundtable)	Rio Tinto is a member of the Roundtable which was established in 2014 in recognition of the importance of actions by industry and governments to curb greenhouse gas emissions. The objective of the Roundtable is to share information on low emissions technologies for fossil fuels and may undertake fact based robust analyses of these technologies to support strategy development.
Coal Industry Advisory Board (CIAB) to the International Energy Agency (IEA)	The CIAB advises the IEA on issues related to coal including opportunities to reduce emissions from the use of coal. The CEO of Rio Tinto Energy is a member of the CIAB and Rio Tinto Energy actively contributes to the work of the CIAB.
Energy Exchange Series	Rio Tinto Energy, the University of Queensland and the Energy Policy Institute of Australia ran a series of three breakfasts (the Energy Exchange Series) during 2014. Each Breakfast featured an internationally recognised speaker on an issue relevant to energy and was attended by up to 300 people. The purpose of the series is to make the highest quality information on the global energy issues available to the Australian debate.

3.8.2 Greenhouse Performance

During 2014, HVO obtained energy from two main sources: (1) electricity supplied through the state electricity grid, and (2) diesel and other fuels. The total energy use for HVO is displayed in Table 49 and the total GHG emissions for HVO including fugitive coal seam gas emissions, and land management emissions are displayed in Table 48.

Table 48: Total Greenhouse Gas Emissions

Hunter Valley Operations Greenhouse Gas Emissions	2011	2012	2013	2014
Electricity (tCO_2-e)	126,340	126,404	126,642	125,541
Diesel and other fuels (tCO_2-e)	287,077	345,165	321,782	322,792
Coal Seam Gas (tCO_2-e)	751,861	369,512	90,041	142,001
Land Management (tCO_2-e)	3,651	5,582	4,194	2,384
Total Site (tCO_2-e)	1,168,971	846,662	542,660	592,717

Table 49: Total Energy Use 2014

Hunter Valley Operations Energy Use	2011	2012	2013	2014
Electricity (GJ)	508,115	514,260	521,091	522,506
Diesel and other fuels (GJ)	4,220,629	5,029,773	4,650,723	4,665,025
Total Site (GJ)	4,728,744	5,544,032	5,171,814	5,187,530

3.8.3 Greenhouse Non-compliance

There were no non-compliances or complaints relating to greenhouse gas or energy usage in 2014.

3.8.4 Related Further Improvements

The Dhanna Yurubaya (means "Stand Strong" in the language of the Wiri people) project was tested and implemented on 63 of the Komatsu 830E AC trucks at HVO. This was a co-operative project between RTCA , Komatsu and Cummins and has reduced fuel consumption by optimising the control system of the electrical drive system on these trucks. It is expected that this project will reduce HVO fuel usage by over 3.0 million litres per year through consumption avoidance. Other HVO fuel reduction projects included the application of Carbon Optimised Engine Software (COES) onto Cummins powered excavators, with one machine being converted with an estimated fuel saving of 150,000 litres per year.

3.9 Visual amenity and Lighting

3.9.1 Visual Amenity and Lighting Management

Coal & Allied aims to provide sufficient lighting for work to be undertaken safely, whilst minimising disturbance to public roads and neighbouring residents. Coal & Allied Visual Management Environmental Work Instruction outlines how lighting is managed to minimise light spillage and glow during both construction and operation at HVO.

Mine lighting is reviewed frequently to ensure light is directed below the horizontal within the pit, while out of pit lighting is shielded to prevent stray light pursuant to the DP&I request. This is to minimise a cumulative disturbance to the 'Dark Skies' region relied upon by the Siding Springs Observatory and neighbouring properties.

3.9.2 Visual Amenity and Lighting Performance

No complaints were received in relation to lighting during the reporting period. Training programmes, signage on the lighting plants and angle exclusion zones are in place to reduce the potential of light impacting on neighbouring residents.

3.9.3 Visual Amenity and Lighting Non-compliances

No Visual amenity or lighting non-compliances were reported during the reporting period.

3.10 Contaminated Land

3.10.1 Contaminated Land Management

Control strategies are in place at HVO to mitigate risk to the environment from contaminated land. Controls include infrastructure such as bunding and segregation systems as well as procedures for waste management, site contamination, prevention, control and remediation. A Contaminated Sites Register is used to record and ensure follow up of any contamination that occurs on site.

3.10.2 Contaminated Land Performance

During the reporting period, bioremediation areas have continued to operate at HVO and are maintained by regular maintenance and monitoring.

Potentially contaminated sites are tested and, if necessary, decontaminated as mining areas advance or areas are no longer used. In this way, HVO can actively reduce the number of potentially contaminated sites within the mining footprint. During 2014 a new technology was employed at HVO's in-pit heavy vehicle refuelling areas. A synthetic clay liner was installed when a new in-pit fuelling facility was constructed, which prevents any potential contamination from fuelling activities from penetrating deeply into the ground. This method was appropriated from the Mount Thorley Warkworth operation, and has become the standard for all new fuelling facilities to be constructed at HVO.

3.10.3 Contaminated Land Non-compliances during reporting period

There were no reportable incidents or complaints relating to land contamination in 2014.

3.11 Waste and Hazard Management

3.11.1 Management

Current licenses exist for the storage of dangerous goods and explosive materials at HVO. These are listed in Table 5.

Inventories of hazardous materials and Safety Data Sheets (SDS) are available through the Occupational Health and Safety department and the ChemAlert system. HVO manages hazardous materials through the ChemAlert system whereby all chemicals used on site are registered in a central database. This database contains all information contained in the SDS and can be accessed at any computer terminal within the operation to provide guidance on storage, use and disposal.

In addition to the ChemAlert system, HVO aims to reduce the number of hazardous chemicals used on site, which restricts the materials to those essential to the operation. A chemical approvals system is utilised at HVO to assess all new chemicals being used on site. This is to ensure proper disposal and environmental management of hazardous materials, while also improving health and safety on site.

Oil water seperators on site are managed with existing infrastructure, plus additional management as required. This can include removal of product using a sucking pump, or deployment of absorbent booms to collect any product. The wash bay at the South workshop and truck wash was managed in this manner in 2014 to supplement the oil water separator.

3.11.2 Waste and Hazard Management Performance

3.11.2.1 Non-Hazardous Wastes

The management of waste generated on the site is undertaken in accordance with Coal & Allied's Total Waste Management System, local ordinances and within existing regulatory guidelines. Waste rubbish not suitable for recycling is disposed of at the Singleton Council's landfill. HVO only uses waste management firms licensed by the NSW EPA.

All wastes leaving the site are tracked and recorded. Regulated wastes are tracked and reported in accordance with regulatory requirements. Figure 102 and Figure 103 depict the waste statistics at HVO. This information is used by HVO personnel to identify areas of improvements and track performance against targets.

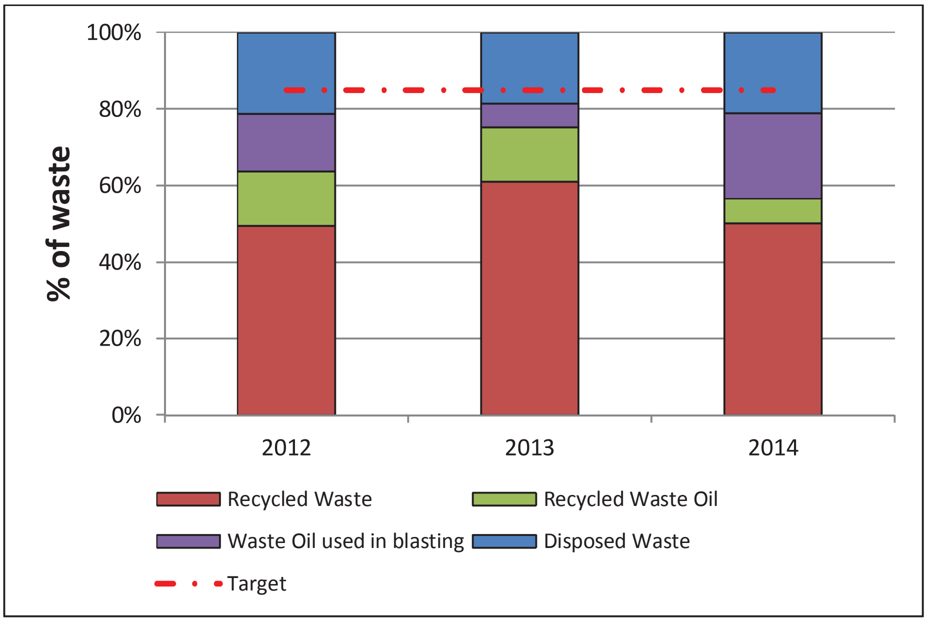


Figure 102: HVO waste streams trend 2012- 2014

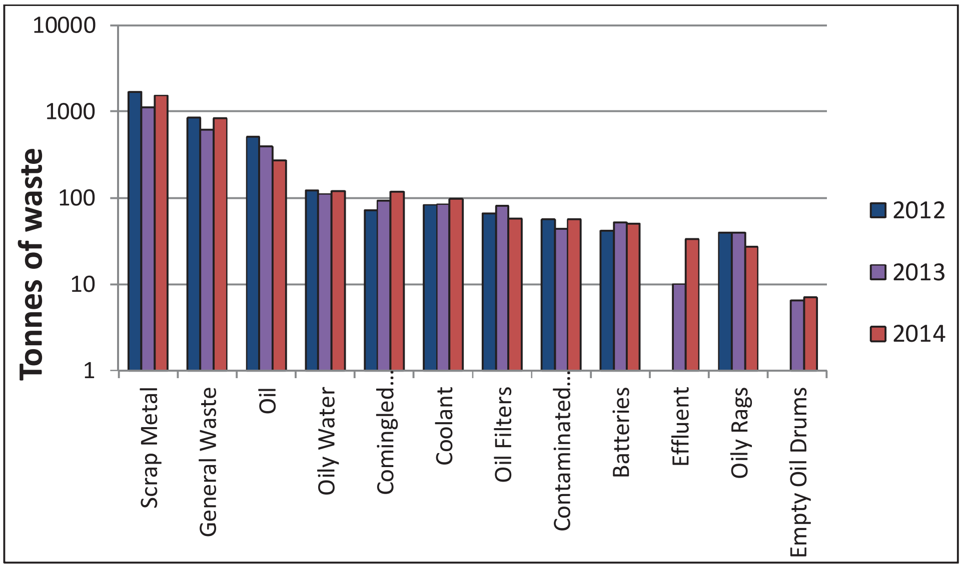


Figure 103: Waste disposed off-site from HVO activities from 2012 to 2014

3.11.2.2 Recycling

HVO has continued to have a focus on training and reinforcing the principles of a good waste management across the site including recycling. In 2014 just over 20 per cent of non-mineral waste material generated at HVO was disposed to licensed offsite landfill facilities. To improve recycling, HVO set an internal recycling target of 85 per cent. A recycling result of 78.8 per cent was achieved in 2014, as shown in Figure 102. A waste audit was conducted in early 2014 to assess what was contributing to HVO's waste streams. The audit found instances of incorrectly disposed wastes, which was shared with area supervisors and staff to improve performance.

3.11.2.3 Sewage Treatment/Disposal

The sewage treatment and disposal facilities at Coal & Allied's operations consist of packaged sewage treatment plants which treat, disinfect and re-use the treated effluent on-site. The remaining effluent from some septic systems that can't be treated on site is sent to approved facilities for disposal.

HVO currently has 19 on-site sewerage management systems, of which six are located in pit, a further six are associated with CPP's and the remaining seven systems are located at infrastructure associated with mining and administration. Two of the 19 systems are large scale systems that service up to four sub systems.

3.11.2.4 Hydrocarbons

In 2014 HVO used 928 kilolitres (KL) of waste oil in blasting as a replacement for diesel. Another 272 KL was taken offsite to be refined into a base oil for reuse in new oil products. Other hydrocarbons recycled via a licensed waste hydrocarbon disposal company include approximately 57 tonnes of grease.

3.11.2.5 Fuel Containment

The HVO fuel storage systems are located at several sites across HVO including:

- Hunter Valley Store area at the main workshop facility;
- West Pit Workshop service area; and
- Southern Facilities.

HVO also has three in pit fuel tanker locations. Each of these facilities are fully bunded to contain the capacity of the fuel being stored. Existing in-pit fuel tankers were replaced with new double skin tanks during 2009 to improve containment of fuel on site. New facilities are being constructed with a synthetic clay liner to reduce potential contamination, as explained in section 3.10.2.

3.11.2.6 Oil and Grease Containment and Disposal

Bulk oil and grease is stored at the Hunter Valley Store. The bulk oils and grease storage facilities are part of the fuel storage facility that complies with Australian Standard 1940. These storage facilities were upgraded in 2011.

3.11.2.7 Hydrocarbon Management and Performance

Management of hydrocarbon contaminated soil is ongoing at HVO. The current technique employs the use of bioremediation areas that are maintained and operated in accordance with Coal & Allied procedures.

Contaminated soil is taken to one of the bioremediation areas and placed in cells based on the time of contamination. To maximise air circulation, contaminated soil is spread out in windrows of no more than approximately 300 mm in height and approximately a grader width at the base. Windrows are oriented north south to achieve maximum exposure to sunlight. The windrows are tined by a grader or equivalent on regular intervals in order to provide aeration for the microbes.

Soil in the treatment area is sampled and tested on a regular basis until total hydrocarbon levels are below relevant government guidelines. Soil meeting this criteria is then removed and disposed of in the spoil dump.

3.11.3 Waste and Hazard Management Non-compliances during reporting period

There were no externally reportable incidents related to waste or hazard management during the reporting period.

4 STAKEHOLDER RELATIONS

4.1 Complaints

During 2014 a total of 34 complaints were received by HVO. This represents an increase of 3 community complaints from the previous year. A full register of environmental complaints is detailed in Appendix 3 Complaints were received in relation to noise, dust and blasting. Figure 104 shows the breakdown of the environmental complaints for 2014, and also compares these complaints with those of previous years.

Coal & Allied provides a 24 hour Community Complaints Hotline (telephone: 1800 656 892) for community members to comment on concerns relating to its operations. All complaints details are recorded in accordance with Condition M4.2 of Environmental Protection Licence 640.

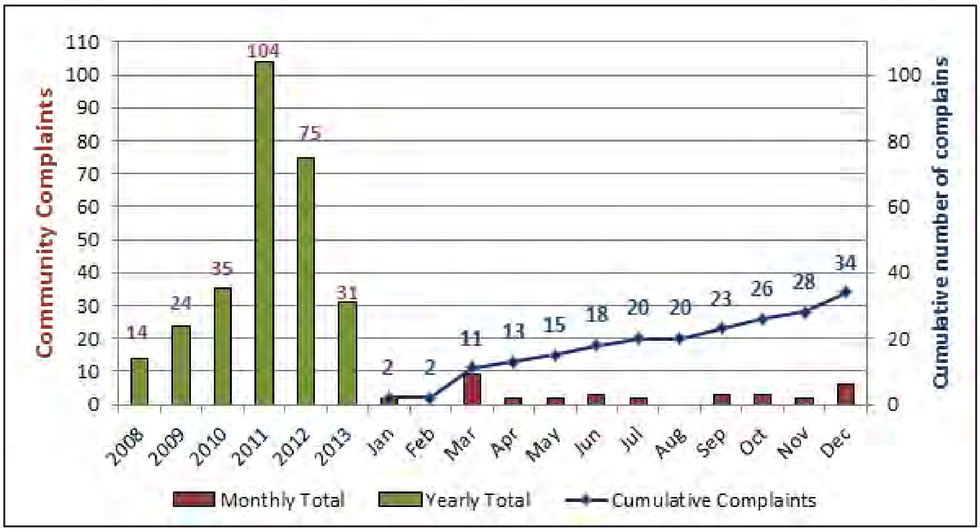


Figure 104: Community Complaints Breakdown

4.2 Review of Community Engagement

4.2.1 Community Relations

Coal & Allied's approach to external relations is focused on building enduring relationships based on mutual respect, active partnerships and long term commitment.

To ensure that individuals remain informed about their local communities, Coal & Allied continued their participation in the Upper Hunter Region Domestic Omnibus Survey. Individuals are also informed by other local research activities, including the Hunter Research Foundation's Environmental Attitudes Survey and Wellbeing Watch. The information gathered through these studies is used to inform Coal & Allied's community relations programmes, Coal & Allied's Community Development Fund (CDF) and its Aboriginal Community Development Fund (ACDF). Results have also supported presentations to senior managers and other staff, all operational sites, Community Consultation Committees (CCC) and community partners. Information about Coal & Allied's approach to sustainable development in 2014, including targets and results, is available on the Rio Tinto website.

4.2.1.1 Communication

The Coal & Allied shopfronts in Singleton (127 John Street) and Muswellbrook (77 Bridge Street) continue to ensure that Coal & Allied remains an active and accessible member of the community.

Coal & Allied operates a free call Community Information Line (1800 727 745), which provides an avenue for community members to seek information regarding Hunter Valley Operations (HVO), as well as other Coal & Allied operations and activities. This number is advertised regularly in local newspapers, phonebooks, Coal & Allied community newsletters and on their website at www.riotinto.com.

Similarly, Coal & Allied operates a free call 24-hour Community Complaints Hotline (1800 656 892), which enables community members to make enquiries or lodge an official complaint 24 hours a day, 7 days a week. This number is publically advertised in the same mediums as the Community Information Line.

Coal & Allied provides regular updates on HVO and other activities in the community through its Hunter Valley Community Newsletter. Four editions of the newsletter were distributed to businesses and residences in the Singleton and Muswellbrook Local Government Areas (LGAs) in 2014. Coal & Allied also send quarterly letters to its near neighbours to provide an overview of HVO mining operations and other relevant activities, and to inform residents about what is being done to manage impacts.

In addition, Coal & Allied issued correspondence to specific near neighbours informing them about changes that they might be affected by, such as the renewal of EL5291 exploration licences.

The community is invited to learn more about Coal & Allied's operations and projects by visiting the Rio Tinto website where copies of newsletters, public reports and information about the HVO's Community Consultative Committee (CCC) can be downloaded.

4.2.1.2 Consultation

Coal & Allied's approach to community engagement and consultation involves providing information regarding its activities in a timely, clear and transparent manner, and then seeking feedback from communities to understand the potential impacts of its activities.

Coal & Allied engages in regular consultation and ongoing communication with their stakeholders regarding relevant operations and projects. Further, feedback from near neighbours and local communities is used to inform future decision-making.

In 2014, Coal & Allied undertook a range of consultation and engagement activities, including:

- HVO CCC meetings
- Consultation with near neighbours to provide project updates at key project milestones and activities, and to response to concerns/queries raised by individual near neighbours
- Sirolli Institute Enterprise Facilitation community scoping sessions held at Singleton, Muswellbrook and Broke to understand community development needs and opportunities for local economic development and diversification
- School engagement- working with teachers and students to assist and enhance learning outcomes and build relationships
- Two community breakfast events and HVO site tour with near neighbours to share information and answer any community queries
- Local Shire Council briefings
- Proactive near neighbour visits for residents living in the HVO area to discuss current operations and future plans for near neighbour engagement, as well as consultation to provide project updates at key project milestones and activities
- Participation in the Upper Hunter Mining Dialogue- a programme coordinated by the NSW Minerals Council to engage the community across the Hunter Valley
- Participation in the NSW Minerals Council Industry Business Agreement Steering Group

Coal & Allied's relationships with local communities were strengthened through involvement in events, such as the Singleton Show and Coal & Allied's Singleton Professions Forum. The Professions Forum was a career expo style event planned and organised by student leaders from Singleton High School, St Catherine's Catholic College and the Australian Christian College (Figure 105). The event aimed to support career options and diversity within the Singleton area.

Figure 105: Singleton Community Professions Forum Committee 2013

Across the Hunter Valley, Coal & Allied is continually focused on building the capacity of local Aboriginal businesses and community organisations to bid for and win small to medium contracts in the mining industry. This involved Procurement and Projects team site visits, and support for the development of teaming agreements with mainstream contractors.

4.2.1.3 Community Consultative Committee

The HVO CCC was re-established in 2013 in accordance with updates to HVO's consent conditions and it continues to meet on a quarterly basis. Presentations delivered at meetings provide committee members with updates on mining operations, environmental monitoring data, land management and community relations. The HVO CCC comprises an independent chair, and community and local Council representatives. In 2014, members included:

- Dr Col Gellatly (Chair – commenced August 2013)
- Cr Hollee Diemar-Jenkins
- Charlie Shearer
- Dr Neville Hodkinson
- Di Gee
- Brian Atfield
- Gail Easton (retired during 2014)

In accordance with Coal & Allied Development Consent, copies of the minutes are available on the Rio Tinto website. Following CCC meetings, a letter is mailed to near neighbours to update them about what was discussed and provide any additional information about HVO's operations.

4.2.1.4 Community Development

In 2014 Coal & Allied continued our focus on the long term sustainability of the communities in the vicinity of their operations, through our community development programmes:

- Coal & Allied Community Development Fund (CDF)
- Coal & Allied Aboriginal Community Development Fund (ACDF)
- Hunter Valley Operations Site Donations Committee
- Community partnerships

4.2.1.5 Community Development Funding Programmes

Priority areas for community development in 2014 included education, economic, environment and social/cultural. A total of 29 new and 25 ongoing programmes were supported by Coal & Allied's CDF and ACDF. Together these programmes allocated more than $1.8 million in 2014 to support capacity building and contribute to the long term sustainability of surrounding communities. For more information about Coal & Allied's community funding programmes visit http://www.riotinto.com/energy/community-funds-10413.aspx.

Community Development Fund (CDF)

The year 2014 marked 16 years of operation of the CDF, which has invested $13.5 million to support over 120 community projects in the Hunter Valley since its establishment in 1999, across the areas of health, education, environment and economic development. In 2014, Coal & Allied announced that a further $3 million would be made available to the CDF over a three year period (2015 – 2017) for projects in the Singleton, Muswellbrook and Upper Hunter LGAs.

In 2014, the CDF invested more than $1.2 million in 11 new programmes aimed at delivering long term benefits for communities in the CDF catchment, which included the Singleton, Muswellbrook, Maitland, Cessnock and Upper Hunter LGAs (see Table 50 to Table 52).

Aboriginal Community Development Fund (ACDF)

In 2006, Coal & Allied, in partnership with the Upper Hunter Valley Aboriginal Community, launched the ACDF (formerly the Aboriginal Development Consultative Committee). Since its inception, the fund has invested approximately $600,000 each year to projects benefiting Upper Hunter Valley Aboriginal communities.

The ACDF is accessible to any Aboriginal person or organisation in the Upper Hunter Valley region who is undertaking a project to benefit specific target groups, or that has the potential to benefit the wider Aboriginal community.

Through the ACDF, Coal & Allied has been supporting education, cultural events, and community and business development projects most likely to deliver long term sustainable outcomes for Aboriginal communities in the Singleton, Muswellbrook and Upper Hunter LGAs.

In 2014, the ACDF invested $641,030 (100% of available funds) in programmes aligned with its priority funding areas: economic development, health, community and cultural development and education. See Figure 106 and Figure 107 for distribution of ACDF investments across priority areas and LGAs.

Table 50: Currently approved Coal and Allied Development Programmes

Programme	Partner
Place making in Singleton	Singleton Council
Supporting Children's Developing Social Competence	Early Links Inclusion Support Service
Voices of the Hunter	University of Newcastle
Outward Bound Youth Leadership Project (2014 - 2017)	Outward Bound
Tocal Schools Steer Challenge (2014 - 2017)	Department of Primary Industries- Tocal College
Business Development Officer (2014 – 2016)	Singleton Business Chamber
Club House Feasibility Study Project	Muswellbrook Golf Club
Enterprise Facilitation Project	Sirolli Institute
Community First Response Vehicle	NSW Rural Fire Service- Hunter Valley
Science and Engineering Challenge, and SMART Programme (2014 - 2017)	University of Newcastle
Upper Hunter Education Fund Scholarships (2015 - 2017)	Upper Hunter Education Fund

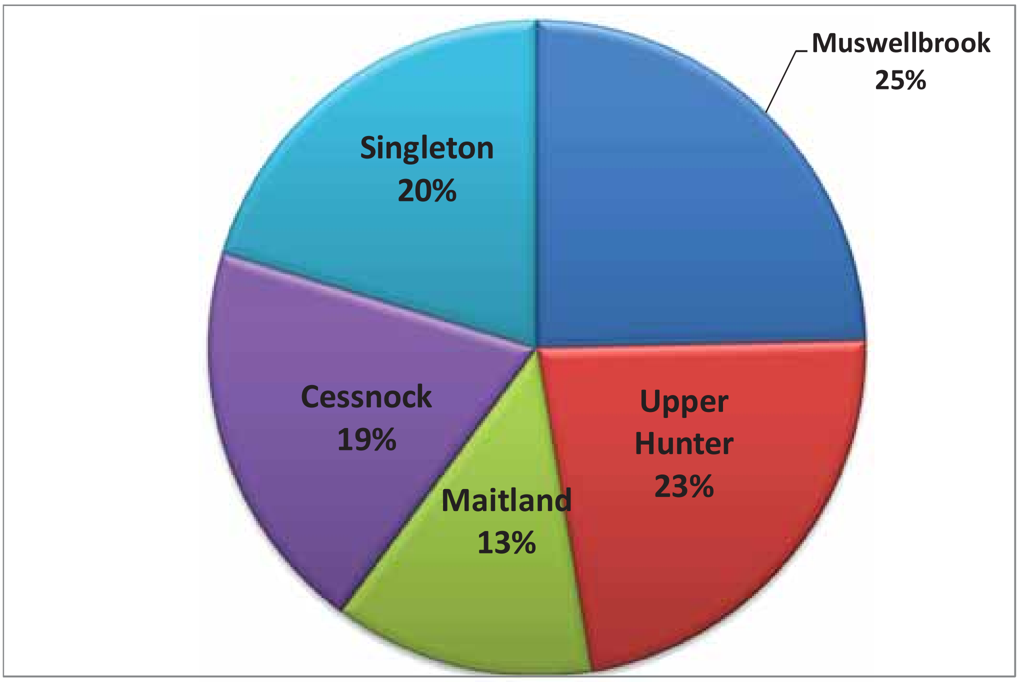


Figure 106: Distribution of Aboriginal Community Development Fund by LGA 2014

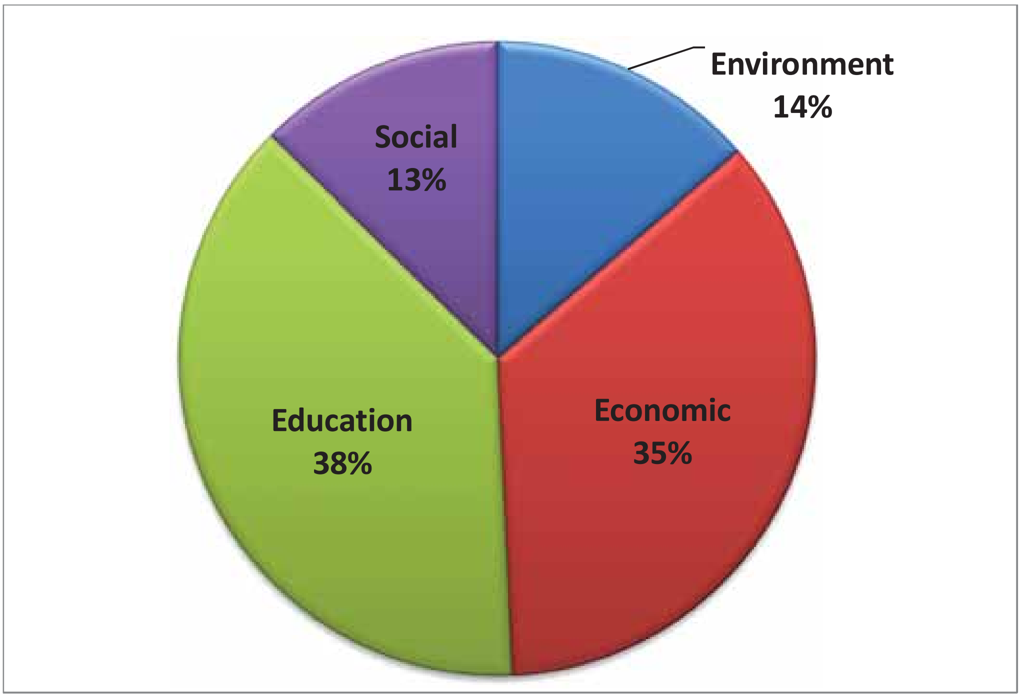


Figure 107: Distribution of Aboriginal Community Development Fund by category 2014

Table 51: Approved Sponsorship

Programme	Partner
Max Potential	Future Achievement Australia Foundation
The Gundi Programme (2014 – 2016)	St Heliers Corrective Centre
National Indigenous Tertiary Education Student Games	University of Newcastle
Hydrogen on Demand (2014 – 2016)	Darryl Brock (Many Rivers Microfinance)
Dookal Group Pty Ltd (2014 – 2016)	Ungooroo Aboriginal Corporation
The Australian Outward Bound Scholarships	The Australian Outward Bound
New South Wales Koori Knockout	Wanaruah Hunters
New South Wales Koori Knockout	Wonnarua United Rugby League Football Club
NAIDOC week activities (2014 - 2016)	Wanaruah Local Aboriginal Land Council
NAIDOC week activities	Singleton Management Group
Singleton Schools Aboriginal Dance Group (funding renewed)	Broke Public School
Singleton Art Prize (2014 – 2016)	Rotary Club of Singleton on Hunter Inc.
Study Assistance	Michael Hutt
Parents and Learning (PAL) (renewed 2015-2017)	Napranum Pre-School
Partnerships for Success (renewed 2015-2017)	Polly Farmer Foundation
Warrae Wanni School Readiness (renewed 2014-2015)	Muswellbrook South School
Dental Health Pilot Programme	Happy Tooth
Wupa@Wanaruah	Ungooroo Aboriginal Corporation

Table 52: Educational Development

Programme	Partner
Sustainable Employment and Training	Compass Housing
Ka-wul New Beginnings (2013 – 2015)	Singleton High School
Social and Emotional Wellbeing Worker	Upper Hunter Drug and Alcohol Services
Indigenous Scholarships (2013 – 2015)	University of Newcastle
CEO & Strategic Plan Update	Wonnarua Nation Aboriginal Corporation
YINPI - Post School Pathways Programme (2013 – 2017)	Singleton High School

4.2.1.6 HVO Site Donations

In addition to these programmes, Coal & Allied considers applications for local donations and sponsorships that have a clear community benefit. In 2014, HVO provided approximately $88,000 to support 31 local projects and initiatives (shown in Figure 108), including:

- Relay for Life
- Centenary of Coal
- Facility upgrades to Singleton Men's Shed, Singleton Heights Preschool, Singleton Pony Club, Singleton Historical Society and Jerrys Plains Community Hall
- Hunter Valley Rural Fire Service Catering Brigade mobile kitchen
- Singleton Beef and Land Management Prime Stock Competition
- Singleton Council Pictures in the Park
- Braxton Art Show

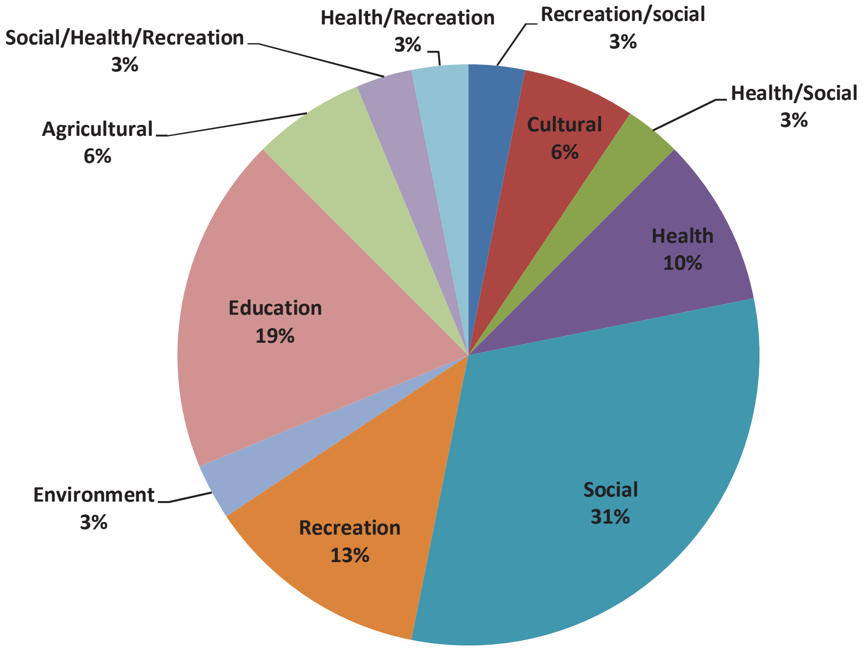


Figure 108: CNA Community Sponsorship Breakdown

4.2.1.7 Community Partnerships

Coal & Allied has retained an active partnership programme in 2013 with key organisations that provide a service valued by the community and have an approach to their business that is aligned with Coal & Allied principles. Partners include:

- Hunter Medical Research Institute
- Hunter Valley Research Foundation
- Westpac Rescue Helicopter Service
- The University of Newcastle

4.3 Public Safety

Public safety at HVO is managed primarily through the implementation of the Rio Tinto Health, Safety, Environment and Quality (HSEQ) management system. Fencing, signposting, restricted access areas and locked external gates form part of the safety measures to ensure the safety of the public, with daily inspections by on site security. In addition, there is no public access from the mine entrance to pit areas, as part of the constraint on public safety. During the reporting period, there was no occurrence detected of private vehicles on the HVO mining lease.

4.5 Employment

At 15 January 2015, HVO employed 1,444 permanent employees. Gender and demographic statistics are provided in Table 53 and Table 54.

HVO contracts local companies to undertake cleaning, electrical maintenance, mechanical maintenance, rehabilitation and land management works, and earthmoving. Local companies are the preferred contractors and are used when possible.

Coal & Allied has achieved steady growth in Aboriginal employment levels over the past seven years through their Aboriginal Employment Strategy. They continue to progress towards the Rio Tinto Coal Australia target of 5 percent Aboriginal employment.

In 2012, Coal & Allied established the Conserving Country Training Programme (CCTP) to provide employment opportunities for Aboriginal people, respond to local Aboriginal people's aspiration to be involved in the rehabilitation of mined land, support wider work to embed Aboriginal relations within the business and build cross cultural understanding. The CCTP supports the Rio Tinto Australia Aboriginal Employment Strategy, Reconciliation Action Plan and more recently the Coal & Allied Diversity and Inclusion Strategy.

In 2014, Coal & Allied continued its partnership with Novaskill, a local not-for-profit Registered Training Organisation and Group Training Company, to manage recruitment, schedule work and deliver training packages for participants. The CCTP is utilised by Environmental Services, Land and Property, Projects and Offsets teams.

Table 53: Employee Demographic Breakdown by Gender

	Number of Employees
Male	1,308
Female	136
TOTAL	1,444

Table 54: Permanent Employee Demographic Breakdown by LGA

Local Government Area	Postcodes	Employees (%)
Singleton Shire	2330, 2335	34.7
Maitland Shire	2320, 2321, 2323, 2324, 2334, 2421	28.8
Cessnock Shire	2325, 2326, 2327	13.8
Muswellbrook Shire	2328, 2333, 2336	13.8
Newcastle Council	2287, 2289, 2291-2300, 2302-2305, 2322	6.1
Upper Hunter Shire	2337, 2340	2.8

5 REHABILITATION AND LAND MANAGEMENT

5.1 Summary of Rehabilitation

Rehabilitation at HVO is undertaken in accordance with commitments made in the various Mining Operations Plans (MOPs) covering the site: Hunter Valley Operations North MOP (includes Newdell CHPP and Hunter Valley Load Point) and Hunter Valley Operations South MOP.

Rehabilitation plans incorporate considerations such as conservation objectives, community expectations, pre-mining land use, final land use, drainage, stability, soils, erosion control and visual compatibility.

The conceptual final landscape across HVO South is planned to be an undulating, free-draining landform with a post mining land capability which supports agricultural land for predominately cattle grazing and native habitat. This landform will reflect the natural features and complement the previously created landforms.

The aim of the rehabilitation at HVO North is to:

- Rehabilitate all mined land to its original land capability class or better;
- Restore 70 per cent of mined land for grazing with native or introduced pasture crops, which will provide some biodiversity values for native fauna species that are able to persist in grazed or disturbed areas;
- Restore 30 per cent of the landscape to a state that provides potential habitat for populations of threatened species that are currently known to occur in and around HVO;
- Create an area of woodland vegetation that links with existing remnants, adding to a more uniform cover of vegetation throughout the Hunter Valley floor. Specifically, the aim will be to link up the rehabilitated and regenerated woodland in HVO north of the Hunter River with a patch of remnant woodland east of HVO and with the north south regional corridor outlined in the DMR's Synoptic Plan; and
- The revegetation strategy in areas rehabilitated for agriculture and grazing will incorporate a variety of native and introduced pasture species.

5.1.1 Management

Performance criteria for each rehabilitation phase have been detailed in the Mining Operations Plan (MOP) for HVO North (2012-2018). These criteria have been developed so that the rehabilitation success can be quantitatively tracked as it progresses through the phases outlined below:

- Stage 1 – Decommissioning
- Stage 2 – Landform Establishment
- Stage 3 – Growing Media Development
- Stage 4 – Ecosystem and Land use Establishment

- Stage 5 – Ecosystem and Land use Sustainability
- Stage 6 – Rehabilitation Complete

The performance criteria are objective target levels or values that can be measured to quantitatively demonstrate the progress and ultimate success of a biophysical process. A monitoring methodology has been developed to measure the performance criteria outlined in the MOPs utilising a combination of tools that provide quantitative data to assess changes occurring over time. The overall monitoring methodology comprises the following tools:

- Accredited soil analyses;
- Ecosystem Function Analysis (CSIRO Tongway & Hindley 1997);
- Assessment of Land Capability (Emery 1985);
- Various measures of ecosystem diversity and habitat values;
- BioBanking Assessment Methodology – Site Value Score (DECC 2008); and
- Assessment of pasture productivity, carrying capacity and stocking rates.

Although the criteria have been set, the target levels or values will be based on monitoring results from reference sites and therefore not determined until the end of 2015. After 2015, the results of the rehabilitation monitoring programme will be able to be compared against the target levels to determine if rehabilitation has been successful or if additional intervention is needed.

Monitoring of grazing sites has been commenced for both reference sites and rehabilitation sites across HVO and MTW. Eight reference sites have been selected across Coal & Allied owned land adjacent to HVO and MTW. These sites were selected to cover the various soil types found in the area and to cover different Land Capability Classes (five sites on Land Capability Class IV to VI; and three sites on Land Capability Class I-III). Monitoring has also been conducted on four sites each at HVO and MTW on rehabilitated land returned to grazing. AECOM have prepared a report detailing the monitoring results and this has been included in Appendix 9.

The monitoring programme for rehabilitated land returned to native vegetation has not yet commenced due to delays in finalising the Common Biodiversity Reference Site project being sponsored by the Upper Hunter Mining Dialogue (UHMD). This project is aimed at allowing mining companies that are re-establishing native vegetation communities to share monitoring information from a common pool of reference sites. It would also provide for commonality in performance criteria and monitoring methods used to measure the success of native vegetation rehabilitation in the Hunter Valley. Coal & Allied have delayed monitoring of native vegetation rehabilitation until the UHMD project gets underway to avoid undertaking monitoring that is not compatible with the monitoring methods that will be developed as part of the UHMD project.

In order to determine whether rehabilitated land is suitable for relinquishment, monitoring data from reference sites will be needed to set target levels for the performance criteria detailed in the HVO North MOP. Similar performance criteria will be developed and included in the next revision of the HVO South MOP, to be submitted in early 2015.

Monitoring results from rehabilitation areas will then be able to be compared against the performance criteria to identify areas that are suitable for relinquishment.

5.2 Rehabilitation Performance

A total of 192.5 ha rehabilitation was undertaken during 2014. Details of the rehabilitation areas and the works undertaken are provided in Appendix 6. A map outlining the location of completed rehabilitation is included in Figure 109.

Table 55 and Table 56 detail the amount of rehabilitation and disturbance completed during the reporting period compared with commitments in the respective MOP's. Appendix 5 provides the Annual Rehabilitation Report Form, including rehabilitation progress for each domain through the rehabilitation phases.

Table 55: Summary of completed rehabilitation in 2014

MOP	Pit	2014 Rehabilitation (ha)		Cumulative Rehabilitation During Current MOP Period (ha)	
		Actual	MOP Commitment	Actual	MOP Commitment
Newdell	n/a	0	0	0	0
HVO North	West Pit	65.2	63.2		
	Carrington	25.6	12.7		
	North Pit	0	0		
	HVO North Total	90.8	75.9	174.6	253.5*
HVO South	Riverview	67.7	65		
	Cheshunt	34	47.4		
	Lemington South	0	0		
	HVO South Total	101.7	112.4	412.2	374.2*
HVO Total		192.5	188.3	586.8	627.7

Notes:
Comparison with HVO North MOP (2012 to 2018) and HVO South MOP (2009 to 2015);
*Cumulative MOP figures are for periods: HVO North 2012-2014 and HVO South 2008-2014

Table 56: Summary of completed disturbance in 2014

MOP	Pit	2014 Disturbance (ha)		Cumulative Disturbance During Current MOP Period (ha)	
		Actual	MOP Commitment	Actual	MOP Commitment*
Newdell	n/a	0	0	0	0
HVO North	West Pit	97.4	101.3	252.5	233.5
	Carrington	0	0	38.1	40
	North Pit	0	0	0	0
	HVO North Total	97.36	106.5	290.6	273.5
HVO South	Riverview	25.8		122.4**	
	Cheshunt	5.0		110.3**	
	Lemington South	0		0	
	HVO South Total	30.8	35.9	232.7**	223.04**

Notes:

Comparison with HVO North MOP (2012 to 2018) and HVO South MOP (2009 to 2015);

*Cumulative MOP figures are for periods: HVO North 2012-2014 and HVO South 2009-2014

** Includes new disturbance only, not disturbance of rehabilitation areas

Rehabilitation figures presented relate to areas at or past the phase of Ecosystem and Landuse Establishment. The area of rehabilitation that was sown during the reporting period was approximately 4.2 hectares above the MOP target.

The area of land disturbed at HVO during 2014 was 128.2 ha which was lower than the projected MOP disturbance of 197.9ha. Disturbance of rehabilitation land accounted for 32.5ha of the total area disturbed with most of this rehabilitation disturbance occurring in West Pit to allow dumps to be lifted to the level of the MOP final landform.

A comparison for rehabilitation progression against predictions in Figure 9 of the HVO West Pit Extension and Minor Modifications Environmental Impact Statement (EIS) Volume 4 (October 2003) indicate that rehabilitation progression is generally consistent with EIS predictions. At the end of 2014, rehabilitation area totalling 1,788ha has been completed for HVO North compared to the EIS projection at 2011 of 1,733ha. West Pit rehabilitation is ahead of projections while Carrington/North Pit is behind. Contributing factors for this lag are: Southeast and Central TSF’s haven’t been rehabilitated due to geotechnical instability preventing capping; Carrington Out of Pit Dump planned to provide capping material for North Void, SE and Central TSF’s and hence not rehabilitated; and approval gained from Carrington Pit Extended Statement of Environmental Effects (October 2005) for additional disturbance of previously rehabilitated areas that are included in the EIS 2003 rehab polygons for 2011.

As at the end of 2013, rehabilitation progress for HVO South is ahead of the predictions in the HVO South Coal Project Environmental Assessment Report (January 2008). Figure 19.3 of the Environmental Assessment Report shows 597.2ha of rehabilitation completed as at the end of 2007 with a prediction of a further 275.5ha to be completed in the period 2008 to 2016. The actual rehabilitation area at the end of 2014 is 963.17ha which is ahead of the EA report predictions for the end of 2016 of 872ha.

Maps in Appendix 8 show the progression of rehabilitation in the various pits at HVO, including comparisons to the EA predictions.

5.3 Rehabilitation Programme Variations

The variations to the rehabilitation programme are summarised in Table 57.

Table 57: Variations to the Rehabilitation Programme

Has rehabilitation work proceeded generally in accordance with the conditions of an accepted Mining Operations Plan	HVO North - Substantially (see below) Newdell – Yes HVO South – Yes
If not please cite any approval granted for variations, or briefly describe the seasonal conditions or other reasons for any changes and the nature of any changes which have been made.	
Actual rehabilitation completed in HVO North during period 2012 to 2014 = 174.6ha. MOP target for rehabilitation in HVO North during period 2012 to 2014 = 253.5ha. Slower progress of rehabilitation has been due to slower dump release in both West Pit and Carrington compared to what was forecast in the MOP. Rehabilitation activities at HVO have also been focused on rehabilitating high visibility areas at Cheshunt and Riverview, visible from Maison Dieu and Golden highway respectively. During 2014, there was 14.9ha more rehabilitation completed in HVO North than the MOP forecast which helped to reduce the deficit in rehabilitation over the period of the MOP to 78.9ha (from a deficit of 94ha at the end of 2013).	

Figure 109: Rehabilitation areas HVO 2014

5.3.1 Rehabilitation Maintenance

Management of Rehabilitated Areas is undertaken when required or when issues are identified through monitoring, auditing or inspections. During 2014, there was no application of fertiliser to established rehabilitation. Maintenance, in the form of contour bank repairs, drop structure construction and re-grading of the slope above the Riverview Void was conducted in 2014 and will continue in 2015. A licence agreement is in place for grazing 300ha of HVO North rehabilitation area. In January 2013 a licence agreement for cropping/grazing of the Alluvial Lands commenced. . The rehabilitated Land Capability Class I and II land has been used to grow Triticale during 2013 and 2014.

The area of rehabilitation affected by erosion cannot be accurately quantified at present. Erosion in new rehabilitation areas are identified and addressed by equipment conducting staged rehabilitation activities. The rehabilitation monitoring programme to be implemented during 2015, will allow erosion areas to be identified and programmes developed to repair rehabilitation areas affected by erosion.

5.4 Decommissioning

The Cheshunt Link Road Crib hut area was decommissioned during 2014. Contamination assessments and decontamination works were conducted in response. This area will be mined through for pit advance during 2015.

5.5 Topsoil Management

Topsoil is managed according to Coal & Allied Ground Disturbance Permit and land management procedures. Table 58 outlines the topsoil used and stockpiled during 2014. There were 148.7 ha of rehabilitation top soiled during 2014, using stockpiled and pre stripped soil resources. A significant effort of weed control on topsoil stockpiles was undertaken in 2013, with maintenance work conducted in 2014 as required.

Table 58: Soil Management and Erosion Control

Soil Used This Period (m^3)	Soil Prestripped This Period (m^3)	Soil Stockpiled to Date (m^3)	Soil Stockpiled Last Report (m^3)
148,700	172,900	1,798,013	1,410,000

5.6 Tailings Management

Rehabilitation of the Lemington No. 5 Tailings Storage Facility (TSF) was successfully completed during 2014 (Figure 110). Geotechnical investigations were conducted on the South East TSF during 2014 and Australian Tailings Consultants have been commissioned to design a Stage 1 Capping for this facility. Geotechnical investigations will be conducted on the Central TSF during 2015 to allow a capping design to be prepared for this facility. A Fine Rejects Management Strategy for HVO is being developed in accordance with Clause 28A of DA 450-10-2003 Mod 4. This strategy will be developed in consultation with DRE and NOW and will be submitted to DP&E by the 30 June 2015. The strategy will outline tailings management for the time horizon spanned by current approvals.

Figure 110: View from Maison Dieu Road showing the topsoiled landform that has been built over the Lemington No. 5 Tailings storage Facility.

5.7 Ground Disturbance Permit (GDP)

Coal & Allied operates a Ground Disturbance Permit process, which is activated prior to clearing or disturbance of vegetation, construction, topsoil stripping, disturbance to water management systems, exploration drilling etc. that is required to be undertaken on the mine site.

The GDP follows a systematic process, which ensures that a range of environmental conditions and licences are checked for the specific area of land to be cleared, and for the identification of any potential environmental issues such as drainage issues, threatened species, and the identification of any seed or timber resources that may be salvaged. The proposed disturbance area is pegged and clearly marked prior to any work commencing. The GDP must be approved by qualified Coal & Allied personnel and is issued with specific conditions that are required to be completed before any clearing may occur. Clearing of vegetated areas is timed to avoid the nesting and breeding seasons of threatened species.

Once a GDP is approved, the boundary of the agreed disturbance area is pegged and, where threatened species are known to be present, a threatened species management protocol is implemented.

A total of 66 new GDPs were approved for HVO in 2014. Site inspections were conducted to review sites being cleared during/prior to faunal breeding seasons. Any habitat trees were marked during site inspections and exclusion zones were developed within these GDPs until the completion of the breeding season to minimise any environmental effects.

5.8 Offset Management

The HVO South Project Environmental Approval (PA_06_0261) granted on 24 March 2009, provided permission to clear 48 hectares (ha)of native vegetation and 92 ha of regrowth . The modification to this approval on 31 October 2012 approved the offsetting of this impact through the securement of 140 ha Offset Area within the Goulburn River Biodiversity Area. In 2014, the Regional Offset Management Plan was approved by the NSW government, this plan identifies the long term protection and management of the Offset Area. Key conservation management strategies implement in 2014 included; removal of cattle grazing, control of feral animals and collection of baseline data on the biodiversity values and condition.

5.8.1 Carrington Billabong

Cattle grazing has been excluded from the Carrington Billabong since 2007 to reduce the impact on native vegetation. Weed and vertebrate pest control has also been undertaken to promote conditions for the recruitment of native species. Significant recruitment of *Eucalyptus camaldulensis* was observed in the Carrington Billabong following the June 2007 flood event and 300 *E. camaldulensis* seedlings were planted in the billabong in September 2009. Recent surveys indicate that a high proportion of the recruited and planted seedlings are now mature plants that are producing reproductive material.

Coal & Allied commissioned extensive surveys and monitoring of River Red Gum populations on HVO and MTW owned land in 2008. The River Red Gum Rehabilitation and Restoration Strategy 2010 subsequently developed by Umwelt (Australia) prioritised management and monitoring of the Carrington Billabong and eleven (11) other Priority sites on the Hunter River and Wollombi Brook. Results from recent monitoring of these River Red Gum stands are provided below.

In 2013, five-year monitoring of the Carrington Billabong and Priority sites, as defined by the River Red Gum Rehabilitation and Restoration Strategy 2010, was undertaken by Umwelt (Australia). Permanent monitoring locations, established in 2007 and 2010, were surveyed and monitored over a four day period in October. At the Carrington Billabong three permanent sites (400m^3) were monitored for floristic changes and three were monitored for seedling recruitment and success. A qualitative tree health assessment of 105 adult trees, *E. camaldulensis*, (living and dead) that were tagged in 2007 was also undertaken. Photographic record of sites was also taken through the utilisation of permanent photo points established in 2008.

In six (6) priority sites along Wollombi Brook and the Hunter River, ecological health assessments and photo monitoring was undertaken.

The results of a comparison of the floristic monitoring from baseline monitoring in 2007 to five-year monitoring in 2013 found the following changes within the Carrington Billabong:

- Decline in diversity of all species (46 from baseline survey to 28 in 2013);
- Increase in dominance of weed species;
- No or minimal recruitment to the mid or upper (canopy) strata[1]; and
- Ground cover remains dominated by weeds, with no notable native recruitment.

Note [1]: *E. camaldulensis* recruitment from 2007 flood event did not occur within the permanent monitoring plots used for floristic monitoring

These results indicate that passive regeneration has not been successful and Umwelt have recommended that active planting now be undertaken within the Carrington Billabong. Planting tubestock and supplementary seeding of a diverse range of local provenance native species will therefore be the focus for activities within the Carrington Billabong in 2015. Revegetation works will be aimed at creating a more structurally and floristically diverse woodland, with a predominantly native ground cover, shrub stratum, mid-tree stratum and canopy.

Fencing works were undertaken in 2014 to exclude cattle from a number of priority sites along the Hunter River and Wollombi Brook. Weed management commenced in these areas, which will continue in 2015 to reduce the weed population. Weed management activities were implemented in acccodance with the Weed Management Plan at the Billabong which included the use of selective herbicide to eradicate annual weeds, as well as targeting Galenia (*Galenia pubescens*), Tiger Pear (*Opuntia aurantiaca*), Prickly Pear (*Opuntia stricta*), Castor Oil (*Ricinus communis*), Farmer's Friend (Bidens pilosa) and various Thistles (*Onopordum acanthium*), (*Carthamus lanatus*), (*Silybum mariamum*). Throughout 2015 ongoing weed control will be targeted at facilitating survival of seedlings from planting activities and from natural recruitment of *E. camaldulensis*.

5.9 Weed Control

5.9.1 Environmental Management

The management and control of weeds at Hunter Valley Operations is governed by the Annual Weed Survey (AWS) produced by Rural & Environmental Management Pty Ltd (REM).

The AWS lists Weeds of National Significance (WoNS), noxious and environmental weed species as identified at Hunter Valley Operations, and provides a framework to allow for structured weed management prepared in November 2013 to provide a structured approach to weed management across operational and non-operational areas of Hunter Valley Operations.

The primary objectives of the weed control programme are to:

- Ensure Hunter Valley Operations complies with its legal and non-legal obligations;
- Protect and enhance the environmental values of Hunter Valley Operations by eradicating or substantially reducing the distribution and density of weed populations across Hunter Valley Operations, particularly in post-mining rehabilitated areas; and
- Ensure no net degradation of the environmental values at Hunter Valley Operations occurs as a result of weed infestations.

Monitoring of the weed control programme to assess the success of weed control works has been undertaken on a quarterly basis by REM Officers with feedback provided to Hunter Valley Operations Environmental Coordinator and Environmental Specialists. The annual weed survey provides an opportune time to assess the progress of the programme and provide planning for the year in advance. Assessment of the impact of weeds across the Hunter Valley Operations site is ongoing with the results of the regular monitoring programmes used to provide a services plan for the upcoming quarter as part of the quarterly HVO Weed Management Report.

5.9.2 Weed Treatment

Weed management and control work occurred between February and December 2014. Weed management targeted a variety of areas across the site, including mining rehabilitation areas, specific environmental areas (Carrington Billabong and River Red Gum Populations) and maintenance and improvement of environmental monitoring sites such as tracks and groundwater bores to improve accessibility and safety by monitoring contractors. A total of 115 days of weed treatment work was undertaken on site at Hunter Valley Operations during 2014 with a total of approximately 189.9ha of land treated, including maintenance of access tracks and approximately 82 environmental monitoring points. The target species and treatment areas are shown in Figure 111 to Figure 113.

The species focussed on during treatment included:

- African Boxthorn (*Lycium ferocissimum*)
- African Olive (*Olea europea subsp cuspidata*)
- Blackberry (*Rubus fructicosus)*
- Castor Oil Plant (*Ricinus communis*)
- Galenia (*Galenia pubescens*)
- Golden Dodder (*Cuscuta campestris*)
- Green Cestrum (*Cestrum parqui)*
- Mother of Millions (Bryophyllum delagoense)
- *Opuntia (*Pear*)* species (Tiger, Prickly and Creeping Pear)
- Thistles: Saffron Thistle *(Carthamus lanatus),* Scotch Thistle (*Onopordum acanthium*) and Variegated Thistle (*Silybum marianum*)

REM also carried out an additional seven days of weed control work for Hunter Valley Operations around traffic islands and haul roads. Approximately 16.5 ha of area was covered during the treatment.

5.9.3 Evaluation of Weed Controls

Assessing the effectiveness of weed control work is an important element in the ongoing control of weeds, ensuring that treatments being utilised are performing to expectations and follow-up treatments are undertaken in a timely manner where appropriate. Hunter Valley Operations staff and REM Rural Services Officers inspected weed treatment areas following the completion of periods of work to check effectiveness and schedule follow up work if required.

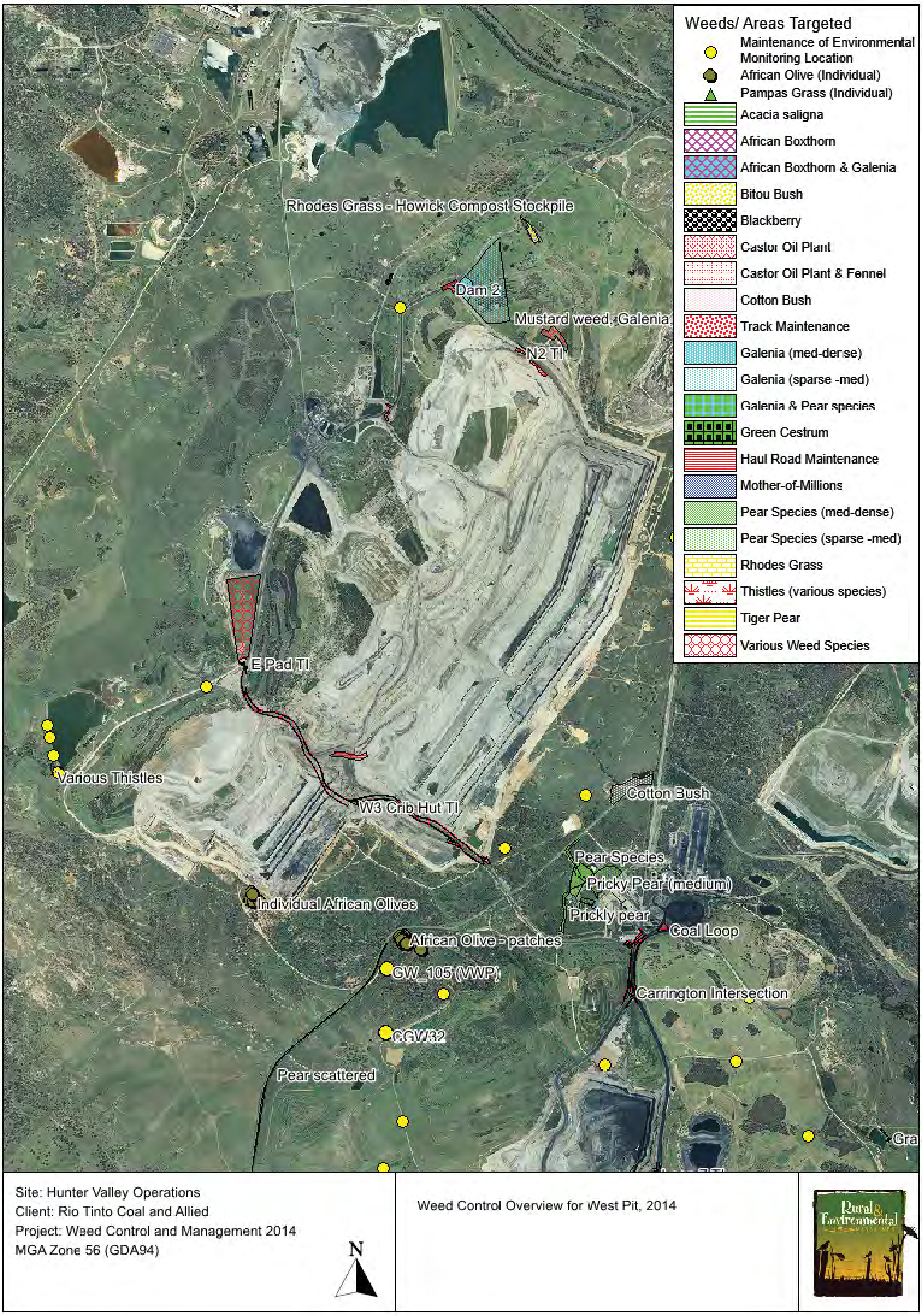
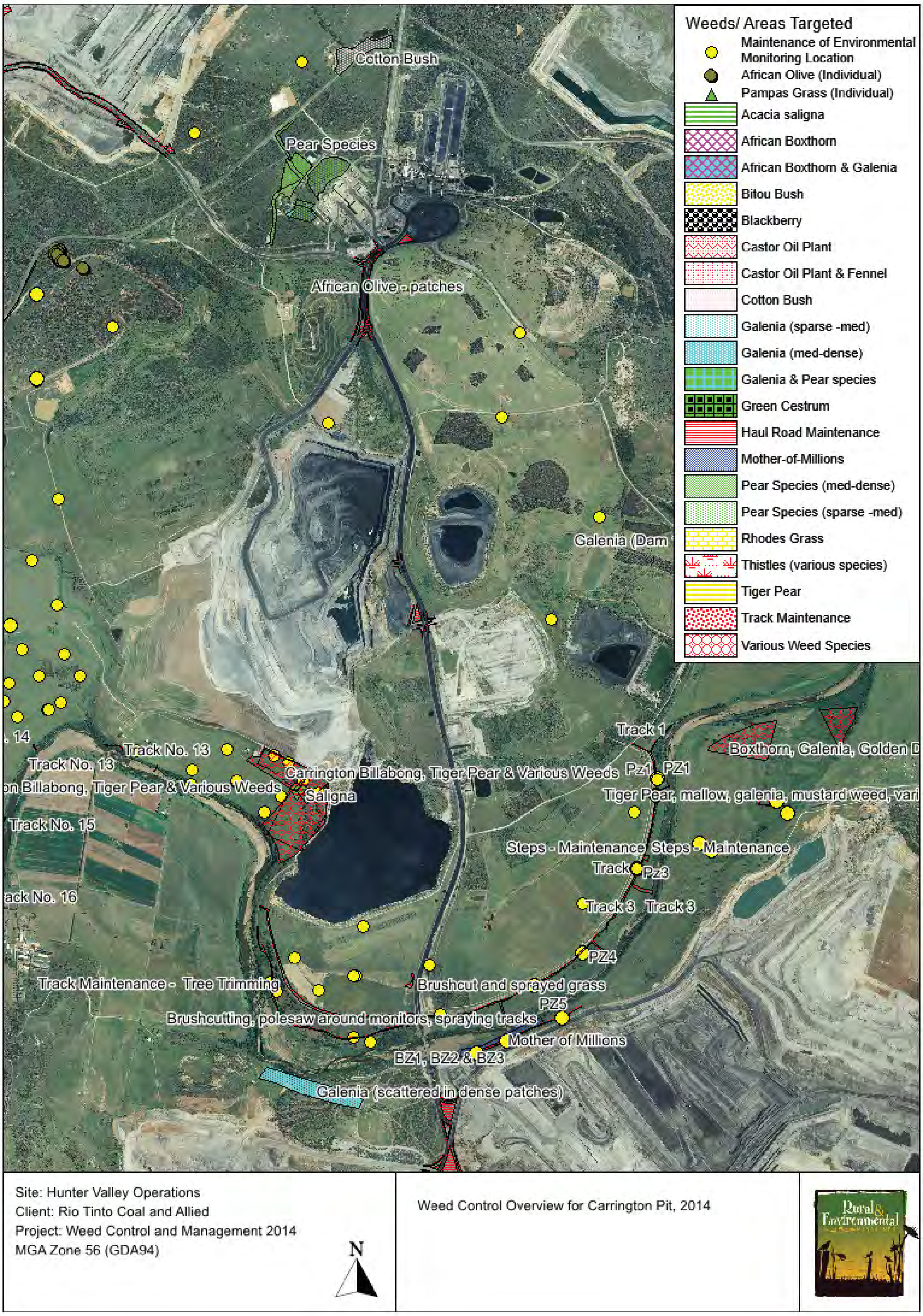


Figure 111: 2014 Weed Control Overview for West Pit Target Areas and Species



Site: Hunter Valley Operations
Client: Rio Tinto Coal and Allied
Project: Weed Control and Management 2014
MGA Zone 56 (GDA94)

Weed Control Overview for Carrington Pit, 2014

Figure 112: Carrington Weed treatment areas during 2014

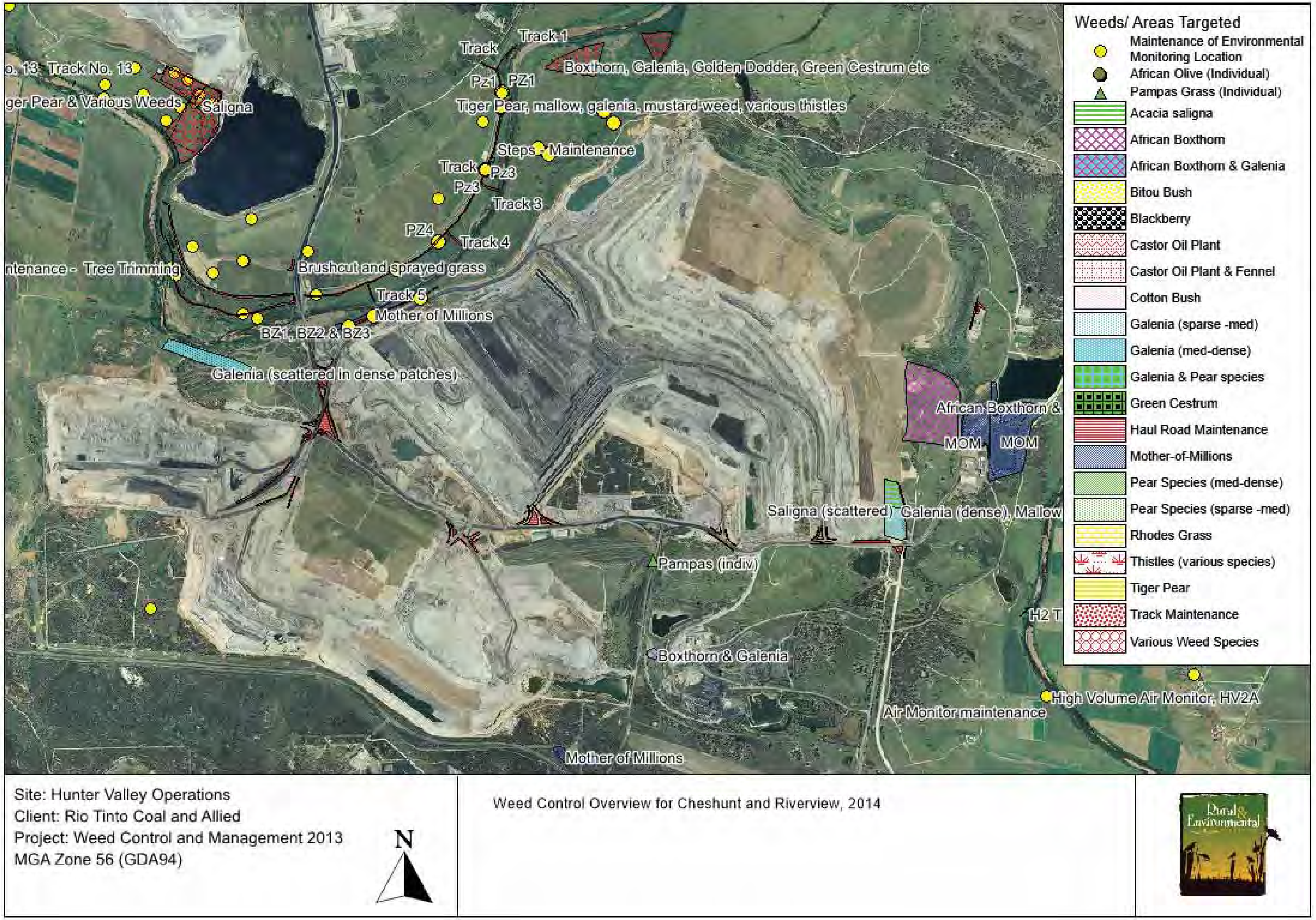


Figure 113: Cheshunt and Riverview weed treatment areas for 2014

5.10 Feral Animal Control

As part of HVO's Vertebrate Pest Action Plan, a control programme is carried out quarterly and on a seasonal basis. The results from each programme are considered when planning the next baiting programme. The 2014 vertebrate pest control targeted wild dogs and foxes using meat baits injected with *sodium monoflouroacetate* (commonly known as 1080). Table 59 summarises the vertebrate pest control undertaken at HVO during 2014, with baiting locations shown in Figure 114.

Table 59: Vertebrate Pest Control Summary 2014

	Total Lethal Baits Laid (2014)	Wild Dog Takes (2014)	Fox Takes (2014)	Total Lethal Baits Laid (2013)	Wild Dog Takes (2013)	Fox Takes (2013)
Summer	268	1	31	268	0	31
Autumn	234	11	14	213	4	32
Winter	234	12	20	0	-	-
Spring	234	9	25	176	8	31
Total	**970**	**33**	**90**	**657**	**12**	**94**

Winter and spring baiting in the 2014 programmes were extended from a 2 week to a 4 week period to increase exposure times to the target species. In late 2013 and early 2014 there was a spike in wild dog sightings in the area. To address this, the amount of bait laid was increased by 47% which is mostly accounted for in the addition of the winter programme which included 234 baits. This resulted in a significant increase of wild dog takes (from 12 takes in 2013 to 33 takes in 2014). The amount of fox takes remained high. Overall there was a 16% increase in total feral animal takes for 2014 compared to 2013.

Figure 114: HVO Vertebrate Pest Management Bait Locations 2014

5.11 Trials and Research

5.11.1 Compost Application and Incorporation

The benefits of adding compost material to soils have been well researched and are widely accepted including: improved soil structure, increased water holding capacity, addition of slow release nutrients, increased cation exchange capacities and re-introduction of beneficial soil microorganisms, with improved soil productivity and structure leading to better vegetation establishment. HVO commenced trials in 2011 using Mixed Source Compost from SITA composting plants at Kemps Creek and Raymond Terrace. Compost has been spread on all areas sown during 2014 at an average rate of 70 dry tonnes per hectare.

Two agricultural implements have been used to incorporate the compost through the top layer of growth medium. The first of these is a rock windrower which is typically used to sweep rocks into a windrow for removal from cropping paddocks (Figure 115). A rock picker is then used to pick up the windrowed rocks. The benefit of using the rock windrower and rock picker is that the soil surface is then free of rocks that would cause difficulties for the direct-drill that is used for sowing. Rock picking and aerating was completed on an as-needs basis during 2014, depending on ground conditions.

Figure 115: Rock windrower incorporating compost in rehabilitation, Cheshunt Pit

The second implement is an aerator which is typically used in minimal tillage cropping operations to aerate soil that has been compacted due to equipment or grazing (Figure 116). Because the compost is typically being added to freshly spread topsoil the aerating function is not required but this implement was found to incorporate the compost while minimising the breakdown of soil structure that can be caused by traditional cultivation equipment. Where compost is being added to soil that has already formed a surface crust, the aerator is also useful for breaking up the surface crust and providing a suitable seed bed for sowing. The aerator is also valuable as it does not pull rocks to the surface, as is typical with tyne-style equipment.

The outcome of trialling these two implements is that they were both beneficial for incorporating the compost and are used depending on the situation. The rock windrower and rock picker are used in areas containing surface rock that will cause problems for the direct-drill but it was found that the smooth surface left by the rock windrower was not suited to slopes. On slopes, the aerator is used after the rock windrower to leave a surface pattern that slows surface runoff and improves water harvesting. In areas without surface rock the aerator alone provides suitable incorporation of the compost.

Figure 116: Aerator showing tyne arrangement

5.11.2 Methods for Providing Soil Coverage of Seed during Broadcast Sowing

A direct-drill is used for the majority of sowing on rehabilitation areas due to its ability to correctly position the seed; and provide soil cover and soil/seed contact. The direct-drill is prioritised on sowing the more expensive native seed mixes, which benefit from this seed/soil contact.

Broadcast spreading of cover crop seed onto a freshly-prepared aerated surface has been found to be most effective in establishing initial cover on slopes. Seedlings that establish in the holes left by the aerator can survive dry conditions because of the improved water harvesting ability of the aerator pattern (Figure 117 and Figure 118). Harrows are not used to provide soil coverage after sowing because the seed that falls in the aerator holes is sufficiently buried by the movement of the fresh topsoil by rain and wind. Avoiding the use of harrows is important because they have been found to smooth out the aerator pattern and produce a slick surface less able to harvest water and more prone to erosion.

A new piece of machinery, employed during 2014, was an aerator fitted with an air seeder (Figure 119). This allows seed to be broadcast directly into the aerator pattern with the following benefits:

- One machinery pass; providing improved efficiency due to a larger machine performing two activities, and eliminating tractor tyre imprints on the aerated surface;
- The seed falls into the aerator pattern immediately after it is created. The movement of the soil down into the divots formed by the aerator then covers over the seed which provides good soil to seed contact;
- Reduced possibility of the aerator pattern being damaged by wind or rain, or crusting up prior to seed being broadcast.

Figure 117: An area which has been harrowed, demonstrating poorer crop establishment and rill erosion

Figure 118: An area which has been aerated (not harrowed), showing healthy cover crop establishment in the aerator pattern

Figure 119: Aerator implement fitted with an air seeder used in 2014 to allow soil preparation and seeding to be undertaken in a single pass.

5.11.3 Cover Crop Sowing

For the last few years, Coal & Allied has used more of an agricultural approach to establishing rehabilitation. Along with the various ground preparation and seeding techniques described in this section, Coal & Allied has also been sowing cover crops in new areas of rehabilitation, rather than immediately sowing the final seed mix. Common cover crop species include millet, oats and barley. The benefits of sowing a cover crop include:

- Fast-growing cover crops provide soil stability from their root system;
- Weed seed in the topsoil spread on a rehabilitation area can germinate and be treated with herbicide without impacting on sensitive native species;
- Quick-colonising weed species do not out-compete native species which can be slower to establish;
- When the cover crop dies or is slashed, this incorporates extra organic material into the topsoil.

Multiple cover crops may be used in an area until the weed load of the topsoil is manageable, when a native pasture or woodland mix can then be planted.

Trials of multi-species cover crops were conducted during 2014 to include legumes and deep-rooted species with the quick growing cereal crops. It is thought that the multi-species cover crops will benefit soil development through the nitrogen fixing and soil aerating functions performed by the additional species. The additional species included in the summer 2014 sown cover crops were: Lucerne (legume and deep-root), Burgundy Bean (legume), Red Clover (legume) and Chickory (deep-root).

It was found that the additional species were slow-growing under the vigorous growing cereal crop however investigations will be undertaken during 2015 to determine if the growth of these species accelerates with removal of the mature cereal crop by slashing/mulching or by weed wiping with herbicide.

5.11.4 Cover Crop Rolling

One of the aims of using sacrificial cover crops is to provide additional opportunities for weed control prior to sowing long term seed mixes. An issue that presented in 2013 was the difficulty of targeting small weed plants growing under a knee-high cover crop due to the high levels of herbicide spray interception on the standing cover crop.

The solution that was adopted was the use of a flexiroller to flatten the cover crop on the surface and allow the weeds to poke up through the flattened stubble (Figure 120 and Figure 121). The weeds are then exposed for effective herbicide spraying with a boom spray.

The configuration of the flexiroller lends itself to use in rehabilitation areas for this purpose because it is able to conform to the contours of the surface, whereas a conventional rigid roller will bridge across any low points. The bridging action of a rigid roller will result in over compaction of the high points and ineffective rolling in low areas.

Rolling the crop onto the surface rather than slashing/mulching the stubble was preferred because it leaves a more stable "attached" mulch (i.e. mulch still attached to roots) rather than small pieces of stubble which would be more prone to being washed or blown off the soil surface. Rehabilitation areas with the rolled cover crop on the surface have been found to be very stable and resistant to the effects of both wind and water erosion.

Figure 120: Crop rolling the millet cover crop on to the surface

Figure 121: The flexiroller is made up of individual rings which allow it to conform to the surface contours

5.11.5 Direct-drill Sowing of Native Seed

A direct-drill seeding machine has been sourced from an agricultural contractor for the purpose of seeding rehabilitation areas. The advantages of the direct-drill style machine over conventional broadcast seeding equipment are:

- Better placement of seed to enhance germination with lower seeding rates. The ability to get high germination levels with reduced seeding rates is particularly important for expensive or hard to source native seed;
- Minimal soil disturbance during sowing. Broadcast seeding requires a moderate amount of soil disturbance to prepare a fresh seed bed which can bring a new load of weed seed to the surface for germination. Use of cover crops and direct-drill seeder allows weed seeds to be depleted from the top soil layer and seed to be placed with minimal soil disturbance.
- Maintenance of mulch layer during seeding. Triple-disc configuration on direct-drill seeder allows seed to be planted through surface stubble.
- Soil stability and water holding capacity of the soil is maintained by leaving the mulch layer in place.

The direct-drill seeder in use across HVO and MTW has three seed boxes which allows for different depth of seed burial depending on seed size. Smaller seeds prefer shallower seed burial than large seeds and this can be accommodated by splitting the seed mix by seed size and allocating the various sizes to different seed boxes.

The seed mixes sown in 2014 using the direct-drill were split into three components: non-flowable, large-flowable and small-flowable. The non-flowable component is mainly made up of the native grass component which tends to be quite a bulky amount of seed compared to the other two components. The direct-drill was not able to be calibrated to meter out both the small amount of small-flowable and large-flowable seed with the bulky quantity of non-flowable seed. To make this possible, additional "bulking" material needed to be added to the flowable components. Vermiculite was trialled first as the bulking material but it caused blockages in the metering system. Additional bulking seed, in the form of Barley, Lucerne and Millet, was subsequently trialled which was successful from a seed metering viewpoint but additional seed introduces more potential germinants which compete with the species being sown.

Seed used as bulking material was chosen with the following attributes to counter the problem of introducing additional competition:

- Use of out-of-season species – for example millet sown in autumn/winter should either not germinate or be killed off by frost;
- Use of low viability seed – seed that has been stored incorrectly or actively treated to reduce viability of seed will result in less germinants.

In the trials that have been undertaken there appeared to still be excessive levels of germination of seed used as bulking material. It is unclear at this stage if the additional competition will negatively affect the germination of native species over the medium term but germination of natives appears to be delayed. Further investigation of bulking materials will be undertaken to further reduce the risk of competition effects.

The native grass seed box on the direct-drill is equipped with agitators to keep the seed mix from bridging and pick-wheels to help pull seed down into metering points. Despite this the initial trials showed the native grass seed was still causing some blockages during seeding. Further processing of the native grass seed mix, by putting it through a garden style mulcher, was needed to reduce blockages. A commercial thresher was used for processing seed in 2014. This machine uses stiff brushes and sieves to process the seed in order to improve the flowability of the seed mix through the direct-drill. The use of the thresher rather than the garden mulcher reduces potential damage to seed caused by spinning mulcher blades. Figure 122 shows an area in Cheshunt that has been sown to native seed mix using the methods described above.

Figure 122: Rehabilitation area in Cheshunt that has been sown to native seed mixes in 2013 after initial cover crop.

Trials have been undertaken in 2014 by native grass seed contractors using custom-designed machinery to improve the flowability of the native seed through the direct-drill seeder. These trials have used a combination of threshers, sieves and shaker tables to separate the seed from the awn and floret appendages, and remove stalk (Figure 123). Further refinement of these processes will be undertaken during 2015 to produce native seed mixes that are more suitable for direct-drilling and potentially suitable for broadcast seeding through air seeding equipment.

Figure 123: Native grass seed thresher used to process harvested seed into a form suitable for the direct-drill seeder.

5.11.6 Native Seed Collection

The species composition of the native vegetation seed mixes has been based on the species present in the Endangered Ecological Communities existing in the HVO/MTW area, namely the Central Hunter Box-Ironbark Woodland and Central Hunter Ironbark-Spotted Gum-Grey Box Forest communities. Diversity targets have been set for the various functional groups to ensure sufficient levels of species diversity are included in the native vegetation seed mixes to cover the progression of rehabilitation through the various phases. The species composition will change as the rehabilitation areas progress from bare areas to mature woodland communities so the seed mixes have been designed to include representatives of species from primary colonisers through to long term shade tolerant species.

In order to consistently achieve the high level of diversity required to construct a native ecosystem, Coal & Allied has engaged the services of native seed specialists. Coal & Allied owned properties have been surveyed to identify suitable areas for the wild collection of native species and to identify gaps in seed supply.

During 2014, seed from native species was collected in the local area from both Coal & Allied owned properties and other properties. Native pastures on Coal & Allied owned properties were managed to improve the yield and quality of native grass seed harvests. Management activities will include: herbicide spraying, slashing, aerating, oversowing with desirable species and sporadic grazing.

The amount of native under-storey seed collected by Coal & Allied during 2014 was approximately 4,500kg with an estimated species diversity of 20 native understorey species. A further quantity of 317kg of tree and shrub seed was collected in the Hunter Valley area for approximately 22 native species. Polytunnels have been built on Coal & Allied owned properties to provide a weather proof area to dry grass and other native seed. The elevated temperature inside the polytunnel causes the vegetation to dry out quicker and release the seed for collection on weed mats.

Figure 124 shows the Native grass seed harvesting implement used on Coal & Allied Properties and Figure 125 shows the harvested seed being dried prior to going into storage.

Figure 124: Native grass seed harvesting at a Coal & Allied owned property near Muswellbrook.

Figure 125: Harvested native grass seed material being dried before storage.

5.11.7 C20015 Sustainable Management of Forestry Plantations for Rehabilitation, Carbon and Wood Products

Since 1999 a number of replicated research trials have been established on mine lands in the Hunter Valley, NSW. This was done in order to assess the viability of tree plantations as a post mining land use and to assess their economic and environmental benefits of buffer land planting (timber, carbon, biodiversity amenity). Included in these trials is the previously funded ACARP Project C10043 (2001-2006) *The Use Of Soil Amendments To Maximise Wood And Carbon Values From Trees Planted In Overburden And Buffer Sites In The Hunter*. The research programme investigated the processes affecting successful establishment, survival and growth of trees and estimated maximum growth rates using best practice techniques on mine lands. HVO provided three types of trial plots for the project: rehabilitation plot, buffer plot and alluvial plot.

The subsequent ACARP project C20015 will use these existing forestry plots to investigate silviculture practices to ensure long term health and growth and to maximise timber and non-timber (carbon and biodiversity) products; and to minimise risk of death due to drought, water stress and disease induced by overcrowding. Management prescriptions that apply to higher rainfall areas on the coast are not necessarily suited to dry land areas such as the Upper Hunter.

Project C20015 will quantify the benefits of early thinning (year 10) on growth rates. It will also provide data mid rotation (15yrs), at which stage final growth projections are much more reliable. The information will form the basis of silvicultural management prescriptions specifically tailored to dryland plantings.

During 2011 sections of the trial plots were thinned and others left un-thinned for comparison purposes. In 2012 follow up activities were undertaken in thinned sections to remove regrowth or coppicing of thinned trees. A round of tree measurements was undertaken in December 2014. Preliminary results suggest there was an increase in growth rates for trees in the thinned sections. The final round of monitoring will be conducted by December 2016, with the final study report delivered in mid-2017.

5.11.8 Grazing Trials

Coal & Allied is hosting a grazing trial which was initiated through the Upper Hunter Mining Dialogue in 2014. The trial is designed to test the suitability of rehabilitated mined land for cattle grazing. The grazing trial consists of two trial sites, one on rehabilitated land at HVO, and a control site on neighbouring un-mined land. The trial sites are 40 hectares each, with 10 steers currently being grazed on each site. The number of cattle may be varied in subsequent years depending on the initial results for the carrying capacity of the pastures.

Comprehensive monitoring will be undertaken to inform the study results, including:

- Soil testing (annually)
- Pasture composition, quantity and quality (every 6 – 12 weeks)
- Ground cover (every 6 – 12 weeks)
- Animal live weight including condition score (every 6 – 12 weeks)
- Blood testing (on and off site)
- Mortality rates
- Supplementary feeding amounts (if required)

Data collected from the trials will provide robust information on the performance of rehabilitation returned to grazing land. This information will be useful to inform target setting for performance criteria related to grazing land rehabilitation. Initial results have indicated slightly higher weight gain in the steers on the rehabilitated site, gaining 1.1 kg per day, compared with 0.9 kg per day gained by the steers on the control site.

The trial will run for three years until mid-2017, with steers being turned off the trial and replaced annually or as dictated by livestock markets. A similar trial is also being conducted by BHP Billiton at their Mount Arthur Mine. The trial is funded through a combination of ACARP funding, DRE funding, provision of stock by the land lessees and in-kind support from Coal & Allied and BHP Billiton.

5.11.9 Seed Production Area Trial

Following surveys of the local area it has been identified that there are gaps in seed supply for some native species that would be useful to include in rehabilitation seed mixes. Seed for these species would either not be available in sufficient quantities or be very costly to collect from wild collections. In order to provide long term quantities of seed for selected species at reasonable cost a trial seed orchard was set up in 2013 at the Coal & Allied owned Wandewoi property near HVO. The 2ha trial plot was established in 2013 to investigate the viability of seed production areas for native species. Tubestock for planting in the seed orchard have been grown from seed collected locally. Seed collection methods used to provide the germplasm for the seed orchard were aimed at ensuring high levels of genetic diversity. Having genetically diverse parent plants in the seed orchard will provide seed with high levels of genetic diversity for use in rehabilitation activities.

6 Planned Activities for 2015

6.1 Mining Operations

Production Statistics

The pits that will be mined in 2015 include West, Cheshunt and Riverview Pit. Forecast total waste production for 2015 is 124.01 MTPA from HVO. A summary of forecast production at HVO during 2015 in comparison to MOP forecasts is provided in Table 60.

Table 60: Forecast Production for HVO 2015

	HVO MOP Production 2015	Reporting Period 2015 (14Q3 AOP – 2015)
Total Prime Waste (Mbcm)		**112.67**
North	48.6	41.82
South	41.48	70.85
Total Product (Mt)		**14.50**
North	5.7	4.77
South	6.87	9.73

Summary of changes

During 2015, mining will also involve two small satellite pits. The GRS Pit is located to the south of the existing West Pit and will be mined until mid-2015. The Glider Pit is located to the east of the existing Riverview Void and will be mined until mid-2016. The equipment planned to be used in 2015 is shown in Table 13.

6.2 Cultural heritage

Aboriginal Cultural Heritage Activities

Ongoing Aboriginal archaeological and cultural heritage management activities will occur in 2015 at HVO in accordance with the ACHMPs, to inform ongoing land management and development planning. Condition monitoring of those sites peripheral to authorised disturbance areas will be conducted at regular intervals to ensure operational compliance with the ACHMPs. The AHIMS sites database audit will continue in 2015.

Historic Heritage Activities

The Stage One Chain of Ponds Stabilisation works will be completed in early 2015. Further maintenance and structural repair works are planned for later in 2015. Coal & Allied will continue to consult with the neighbouring Liddell Coal Operations on any future mining plans that may interact with the Inn complex to ensure appropriate protective management measures are implemented where required.

6.3 Noise

Three Komatsu 830E-DC trucks will be retrofitted with attenuated mufflers during Q1 2015. See section 3.2.1.1 for more information on the sound attenuation programme.

The real-time directional monitoring network will be reviewed in consultation with DP&E during 2015 to ensure the monitoring locations remain adequate and representative, in line with progression of mining and changes to property ownership.

It is anticipated that further noise management improvements will be introduced through review of the HVO Noise Management Plan, in consultation with DP&E.

6.4 Blasting

During 2015, a new blast monitoring network will be rolled out. HVO will also review the current location of its blast monitoring equipment to ensure the most accurate capturing of blasting events. A new blasting permissions tool will be implemented to increase functionality and usability by operations.

6.5 Air Quality

Improvements in 2015 will continue focus on proactive measures such as activities associated with the EPA's dust pollution reduction programme, and minor improvements to the coal train loading facility in accordance with the EPA audit findings in 2014. Further development and implementation of the Early Warning dust monitoring system will also continue into 2015.

6.6 Water

Improvements to mine water management in 2015 will focus on water security and surface water management. This includes:

- Stage 2 of the Hunter River bridge project (targeting the South side of bridge) commenced in late 2014 and is expected to be completed in early 2015.
- Increasing capacity for stormwater runoff from the Hunter Valley Load Point. Originally scheduled for Q1 2015, this work is due for completion Q4 2015.
- Construction of deep production bore in the Alluvial Lands area. Drilling and construction of a (one) deep dewatering bore is scheduled to commence in mid-2015, with the bore to be commissioned by the end of 2015.

6.7 Waste and Hazard Management

Site documents and procedures for hazardous materials and contaminated sites management will be updated in 2015 to align with new legislative requirements and updated Rio Tinto standards.

6.8 Community Development and Involvement

Programme and Funding Renewed or Commencing in 2015

Priority areas for community development in 2014 included education, economic, environment and social/cultural. Coal and Allied currently support numerous foundations, programmes and scholarships in relation to these priority areas with continuation and commencement of these into 2015.

6.9 Rehabilitation

Performance Criteria and Rehabilitation Monitoring

The Rehabilitation Monitoring programme will continue in 2015. Previously collected results will be used to determine suitable target levels for the rehabilitation performance criteria.

Rehabilitation Maintenance

In 2015, a new method of herbicide application will be trialled in the form of a weed wiper. The weed wiper has a rotating carpeted roller which is soaked with herbicide. As the weed wiper travels across an area, the stems and leaves of the target plants are wiped with herbicide by the roller. The weed wiper is height adjustable, so can be raised or lowered apply herbicide to only the target species. This method will be used in areas where mature cover crops, exotic grasses or other tall weeds need to be targeted, but native species or desirable cover crop need to be retained.

Rehab drainage

Work will continue in 2015 on establishing a rehabilitation drainage specification, to guide bulk shaping activities and ensure that final landforms are stable and resistant to erosion. This will focus on rock lined drop structures, contours and sediment dams.

Native Seed Processing

Further methods of processing collected native grass seed will be investigated in 2015. This will include refinement of the thresher, sieve and shaker table arrangements to produce a seed mix that is more suitable for the direct-drill seeding equipment. Additional processing of individual species to a more flowable form will also allow seed to be transferred from the seed mixes going through the non-flowable seed box on the direct-drill to the seed mixes being distributed through the flowable seed boxes. Increasing the amount of native seed in the flowable seed mixes will reduce or eliminate the need for bulking seed to be included in the flowable seed mixes. This will lead to a reduced risk of competition effects from the germination of species included as bulking seed.

Processed native seed will also be trialled for sowing through the broadcast seeding equipment. This will be beneficial for seeding native seed on areas where spoil will be used as a replacement growth medium to topsoil. The rougher nature of the prepared spoil surface is more suited to broadcast seeding than drill seeding.

Spoil/Compost Growth Medium

The focus for trials of spoil/compost as a growth medium replacement for topsoil will be on seeding methods that are suitable to be used on a rough spoil surface. The germination results from a spoil/compost trial at Wilton, where the surface was cleared of rock using rock windrowing and rock picking in preparation for using the direct-drill seeder, were not as impressive as previous trials where a rough spoil surface had been maintained. Options that will be investigated for seeding native seed on spoil/compost areas include broadcast seeding using a further refined seed mix and hydroseeding.

Topsoil Stockpile Weed Management

The observations of galenia infestations from previous rehabilitation indicate that improved control of galenia (and other problematic weeds) on topsoil stockpiles is required. A detailed topsoil stockpile management Programme will be initiated at HVO in 2015 to initially address newly created stockpiles. Work will include herbicide treatment of weed species and sowing the stockpile surface with native grass seed. Establishing a cover of desirable native grass species will reduce the potential for weed seed to germinate thus reducing the overall weed load of the topsoil.

Appendix 1:

Reference to DRE and DPE guidelines

DRE - EDG TABLE OF CONTENTS	**Section of Annual Review**	**DP&I - Unreleased Draft AEMR GUIDELINE - SUGGESTED TOC**	**Section of Annual Review**
Introduction Title block and contents page	1	1 Introduction Title block and contents page	1
		4.2 Quick reference table	1.3
1.1 Consents, lease and licences	1.4	4.3 Consents, lease and licences	1.4
1.2 Mine contacts	1.5	4.4 Mine contacts	1.5
1.3 Actions required at previous AEMR review Table 1. Actions required	1.6	4.5 Actions required at previous AEMR review Table 1. Actions required	1.6
		6.7 Actions required from government agency's review of the last aemr	1.6
2 Operations during the reporting period	2	5.1 Operations summary 2012 reporting period	2
		Production statistics (related to approval limits)	2.1.4
2.1 exploration	2.1.1		
2.2 land preparation	2.1.2	Summary of changes (developments, equipment upgrades)	2.1.6
2.3 construction	2.1.6		
2.4 mining	2.1.2	Mitigation, salvages, heritage works	2.2
2.5 mineral processing	2.1.3		
2.6 waste management	2.1.3		
2.7 ore and product stockpiles	2.1.3		
2.8 water management	3.5		
2.9 hazardous material management	3.11		
2.10 other infrastructure management	n/a		
Table 2 production and waste summary	2.1.4		
Table 3: stored water (Water Balance)	3.5.2.1		
3.0 Environmental management and performance	3	6.0 Environmental Performance	3
3.1 air quality	3.4	Air quality	3.4
3.1 environmental management - whether proposed control strategies were adequate - variation from proposed control strategies	3.4.1	6.1 Review of monitoring results	3.4.2
		6.2 Monitoring & performance reports required by other department	3.4.2
		6.5 Outcome of any independent environmental audit	n/a

DRE - EDG TABLE OF CONTENTS	Section of Annual Review	DP&I - Unreleased Draft AEMR GUIDELINE - SUGGESTED TOC	Section of Annual Review
3.2 environmental performance - summarised monitoring data - list monitoring, performance reports required by other department. -review performance outcomes	3.4.2		
		6.6 Outcomes of any independent review	N/a
		6.8 Identify any trends in the monitoring data	3.6.2
		6.9 Identify any discrepancies between the predicted and actual impacts	3.4.7
3.3 reportable incidents	3.4.8	6.3 Non-compliances	3.4.8
		6.4 Actions to ensure compliance	3.4.1
3.4 further improvements	6.5		
3.2 erosion and sediment		Erosion and sediment	
3.1 environmental management - whether proposed control strategies were adequate - variation from proposed control strategies	5.2	6.1 Review of monitoring results	n/a
		6.2 Monitoring & performance reports required by other department	n/a
		6.5 Outcome of any independent environmental audit	n/a
3.2 environmental performance - summarised monitoring data - list monitoring, performance reports required by other department. -review performance outcomes	5.2		
		6.6 Outcomes of any independent review	n/a
		6.8 Identify any trends in the monitoring data	n/a
		6.9 Identify any discrepancies between the predicted and actual impacts	n/a
3.3 reportable incidents	n/a	6.3 Non-compliances	n/a
		6.4 Actions to ensure compliance	n/a
3.4 further improvements	n/a		
3.3 surface water	3.6	Surface water	3.6
3.1 environmental management - whether proposed control strategies were adequate - variation from proposed control strategies	3.6.1	6.1 Review of monitoring results	3.6.2
		6.2 Monitoring & performance reports required by other department	n/a
		6.5 Outcome of any independent environmental audit	n/a

DRE - EDG TABLE OF CONTENTS	Section of Annual Review	DP&I - Unreleased Draft AEMR GUIDELINE - SUGGESTED TOC	Section of Annual Review
3.2 environmental performance - summarised monitoring data - list monitoring, performance reports required by other department. -review performance outcomes	3.6.2		
		6.6 Outcomes of any independent review	n/a
		6.8 Identify any trends in the monitoring data	3.6.2
		6.9 Identify any discrepancies between the predicted and actual impacts	3.6.3
3.3 reportable incidents	3.6.6	6.3 Non-compliances	3.6.6
		6.4 Actions to ensure compliance	3.6.1
3.4 further improvements	6.6		
3.4 ground water	3.7	Groundwater	3.7
3.1 environmental management - whether proposed control strategies were adequate - variation from proposed control strategies	3.7.1	6.1 Review of monitoring results	3.7.2
		6.2 Monitoring & performance reports required by other department	n/a
		6.5 Outcome of any independent environmental audit	n/a
3.2 environmental performance - summarised monitoring data - list monitoring, performance reports required by other department. -review performance outcomes	3.7.2		
		6.6 Outcomes of any independent review	n/a
		6.8 Identify any trends in the monitoring data	3.7.2
		6.9 Identify any discrepancies between the predicted and actual impacts	3.7.2
3.3 reportable incidents	n/a	6.3 Non-compliances	3.7.2
		6.4 Actions to ensure compliance	3.7.1
3.4 further improvements	6.6		
3.5 contaminated land	3.10	Contaminated Land	3.10
3.1 environmental management - whether proposed control strategies were adequate - variation from proposed control strategies	3.10	6.1 Review of monitoring results	n/a
		6.2 Monitoring & performance reports required by other department	n/a
		6.5 Outcome of any independent environmental audit	n/a
3.2 environmental performance	3.10		

DRE - EDG TABLE OF CONTENTS	Section of Annual Review	DP&I - Unreleased Draft AEMR GUIDELINE - SUGGESTED TOC	Section of Annual Review
- summarised monitoring data - list monitoring, performance reports required by other department. -review performance outcomes		6.6 Outcomes of any independent review	n/a
		6.8 Identify any trends in the monitoring data	n/a
		6.9 Identify any discrepancies between the predicted and actual impacts	n/a
3.3 reportable incidents	3.10	6.3 Non-compliances	3.10
		6.4 Actions to ensure compliance	3.10
3.4 further improvements	6.7		
3.6 threatened flora	5.1.2	threatened flora	5.1.2
3.7 threatened fauna	5.1.2	threatened fauna	5.1.2
3.8 weeds	5.9	weeds	5.9
3.1 environmental management - whether proposed control strategies were adequate - variation from proposed control strategies	5.9	6.1 Review of monitoring results	5.9
		6.2 Monitoring & performance reports required by other department	n/a
		6.5 Outcome of any independent environmental audit	n/a
3.2 environmental performance - summarised monitoring data - list monitoring, performance reports required by other department. -review performance outcomes	5.9	6.6 Outcomes of any independent review	n/a
		6.8 Identify any trends in the monitoring data	5.9
		6.9 Identify any discrepancies between the predicted and actual impacts	n/a
3.3 reportable incidents	n/a	6.3 Non-compliances	n/a
		6.4 Actions to ensure compliance	n/a
3.4 further improvements	n/a		
3.9 blasting	3.3	Blasting	3.3
3.1 environmental management - whether proposed control strategies were adequate - variation from proposed control strategies	3.3.1	6.1 Review of monitoring results	3.3.2
		6.2 Monitoring & performance reports required by other department	n/a
		6.5 Outcome of any independent environmental audit	n/a
3.2 environmental performance	3.3.2		

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- summarised monitoring data - list monitoring, performance reports required by other department. -review performance outcomes		6.6 Outcomes of any independent review	n/a
		6.8 Identify any trends in the monitoring data	3.3.2
		6.9 Identify any discrepancies between the predicted and actual impacts	n/a
3.3 reportable incidents	3.3.4	6.3 Non-compliances	3.3.4
		6.4 Actions to ensure compliance	3.3.1
3.4 further improvements	6.4		
3.10 operational noise	3.2	Noise	3.2
3.1 environmental management - whether proposed control strategies were adequate - variation from proposed control strategies	3.2.1	6.1 Review of monitoring results	3.2.2
		6.2 Monitoring & performance reports required by other department	n/a
		6.5 Outcome of any independent environmental audit	n/a
3.2 environmental performance - summarised monitoring data - list monitoring, performance reports required by other department. -review performance outcomes	3.2.2		
		6.6 Outcomes of any independent review	n/a
		6.8 Identify any trends in the monitoring data	3.2.2
		6.9 Identify any discrepancies between the predicted and actual impacts	3.2.4
3.3 reportable incidents	3.3	6.3 Non-compliances	3.2.3
		6.4 Actions to ensure compliance	3.2.1
3.4 further improvements	6.3		
3.11 visual, stray light	3.9		3.9
3.1 environmental management - whether proposed control strategies were adequate - variation from proposed control strategies	3.9	6.1 Review of monitoring results	n/a
		6.2 Monitoring & performance reports required by other department	n/a
		6.5 Outcome of any independent environmental audit	n/a
3.2 environmental performance - summarised monitoring data - list monitoring, performance reports required by other	3.9		
		6.6 Outcomes of any independent review	n/a

DRE - EDG TABLE OF CONTENTS	Section of Annual Review	DP&I - Unreleased Draft AEMR GUIDELINE - SUGGESTED TOC	Section of Annual Review
department. -review performance outcomes		6.8 Identify any trends in the monitoring data	n/a
		6.9 Identify any discrepancies between the predicted and actual impacts	n/a
3.3 reportable incidents	3.9	6.3 Non-compliances	3.9
		6.4 Actions to ensure compliance	3.9
3.4 further improvements	n/a		
3.12 aboriginal heritage	2.2.1		2.2.1
3.1 environmental management - whether proposed control strategies were adequate - variation from proposed control strategies	2.2.1	6.1 Review of monitoring results	n/a
		6.2 Monitoring & performance reports required by other department	n/a
		6.5 Outcome of any independent environmental audit	n/a
3.2 environmental performance - summarised monitoring data - list monitoring, performance reports required by other department. -review performance outcomes	2.2.1.1	6.6 Outcomes of any independent review	n/a
		6.8 Identify any trends in the monitoring data	n/a
		6.9 Identify any discrepancies between the predicted and actual impacts	n/a
3.3 reportable incidents	2.2.1.2	6.3 Non-compliances	2.2.1.2
		6.4 Actions to ensure compliance	2.2.1
3.4 further improvements	6.2		
3.13 natural heritage	2.2.2		
3.14 spontaneous combustion	3.11		n/a
3.15 bushfire	n/a		n/a
3.16 mine subsidence	n/a		
3.17 hydrocarbon contamination	3.10		3.10
3.18 methane drainage/ventilation	n/a		n/a
3.19 public safety	4.3		4.3
4.1 environmental complaints	4.1	6.10 environmental complaints	4.1
4.2 community liaison	4.2	6.11 review of community engagement	4.2
5 REHABILITATION (this aemr	5	7.0 REHABILITATION	5

DRE - EDG TABLE OF CONTENTS	**Section of Annual Review**	**DP&I - Unreleased Draft AEMR GUIDELINE - SUGGESTED TOC**	**Section of Annual Review**
period)			
5.1 buildings	n/a		
5.2 rehabilitation of disturbed land	5.2	7.1 summary of rehabilitation undertaken on site	5.2
		7.3 rehabilitation progression - in accordance with mop commitments	5.3
5.3 other infrastructure	n/a	7.2 decommissioning	5.4
5.4 rehabilitation trials and research	5.11	7.5 rehabilitation trials and research	511
		7.4 rehabilitation relinquishment	5.1
		7.6 temporary stabilisation of disturbed mining area (aerial seeding)	3.4.2
		7.8 offset area management	5.8
5.5 Further development of the final rehabilitation plan	n/a		
		5.2 Operations summary - 2014 reporting period	2.1
6 Activities proposed in the next AEMR period	6	7(8) Proposed activities (next aemr)	6
Table 4 rehabilitation summary	5.2	Appendix 5 rehabilitation tables	Appendix 5

Appendix 2:

Summary of Complaints 2014

Hunter Valley Operations Complaints 2014

Type	Month	Date	Time	Method Received	Location
Blast	January	3/01/2014	1:17:00 PM	Complaints Hotline	Bulga
Blast	January	7/01/2014	11:35:00 AM	Telephone	Jerrys Plains
Noise	March	3/03/2014	11:09:00 PM	Complaints Hotline	Jerrys Plains
Blast	March	14/03/2014	9:23:00 AM	Telephone	Jerrys Plains
Blast	March	14/03/2014	10:01:00 AM	Complaints Hotline	Jerrys Plains
Blast	March	14/03/2014	11:13:00 AM	Email	Unknown
Noise	March	17/03/2014	9:51:00 PM	Complaints Hotline	Maison Dieu
Noise	March	23/03/2014	10:56:00 PM	Complaints Hotline	Jerrys Plains
Blast	March	27/03/2014	1:13:00 PM	Complaints Hotline	Jerrys Plains
Blast	March	27/03/2014	1:50:00 PM	Telephone	Jerrys Plains
Noise	March	31/03/2014	9:46:00 PM	Complaints Hotline	Jerrys Plains
Noise	April	2/04/2014	11:39:00 AM	In person	Jerrys Plains
Blast	April	5/04/2014	9:00:00 AM	Complaints Hotline	Jerrys Plains
Blast	May	22/05/2014	1:08:00 PM	Complaints Hotline	Long Point
Blast	May	29/05/2014	12:35:00 PM	Telephone	Jerrys Plains
Blast	June	19/06/2014	2:00:00 PM	Telephone	Jerrys Plains
Blast	June	20/06/2014	2:34:00 PM	Complaints Hotline	Long Point
Blast	June	26/06/2014	4:36:00 PM	Telephone	Jerrys Plains
Blast	July	11/07/2014	8:20:00 AM	Telephone	Unknown
Blast	July	11/07/2014	11:00:00 AM	Telephone	Long Point
Blast	September	15/09/2014	1:29:00 PM	Telephone	Jerrys Plains
Blast	September	15/09/2014	1:31:00 PM	Telephone	Jerrys Plains
Blast	September	23/09/2014	12:18:00 PM	Telephone	Jerrys Plains
Blast	October	8/10/2014	10:02:00 AM	Email	Unknown
Blast	October	8/10/2014	10:40:00 AM	Telephone	Jerrys Plains
Blast	October	29/10/2014	2:15:00 PM	Telephone	Jerrys Plains
Blast	November	20/11/2014	3:16:00 PM	Telephone	Jerrys Plains
Dust	November	23/11/2014	4:40:00 PM	Telephone	Golden Highway
Blast	December	1/12/2014	11:34:00 AM	Email	Jerrys Plains
Noise	December	7/12/2014	10:02:00 PM	Telephone	Jerrys Plains
Noise	December	8/12/2014	10:10:00 PM	Complaints Hotline	Jerrys Plains
Noise	December	14/12/2014	12:51:00 AM	Complaints Hotline	Unknown
Blast	December	19/12/2014	10:33:00 AM	Complaints Hotline	Jerrys Plains
Noise	December	31/12/2014	10:37:00 PM	Complaints Hotline	Jerrys Plains

Appendix 3:

Summary of Incidents 2014

Hunter Valley Operations Environmental Incidents 2014

Incident Number	Date	Details
1000258432	14.01.2014	A generator at an in-pit crib hut developed a small crack in the fuel tank due to fatigue of the tank. Approximately 100 litres of diesel was leaked. The generator was tagged out of service and remaining fuel removed from tank. Contaminated soil was removed to the bioremediation area and the fuel tank repaired.
1000261461	03.02.2014	A fuel plug on a haul truck came loose, and approximately 100 litres of diesel spilt onto the ground. The truck was parked at an in-pit crib hut. Fuel was contained within a windrow to prevent further contamination. The remaining fuel in the tank was removed. Contaminated soil was removed to the bioremediation area
1000279686	01.05.2014	A broken steering arm on a loader in-pit caused a puncture to the hydruallic tank, resulting in a spill of approximately 120 litres. The spill was bunded and contaminated material taken to the bioremediation area.
1000280372	09.05.2014	A Ground Disturbance Permit was issued for maintenance to power lines in Cheshunt Pit. Upon executing the works, a track was cleared without an agreed erosion and sediment control plan being in place and through an area with an outstanding land title matter in breach of GDP conditions. Appropriate water management structures where constructed and the outstanding land title matter was resolved. Subsequent improvements to the Ground Disturbance Permit process were implemented.
1000280834	13.05.2014	Noise exceedance measured against the HVO North consent area criteria for LA1, 1min (instantaneous, short term noise). A single truck engine surge from West Pit at approximately 11:40pm was measured at 47dB, 1dB above the allowable 46dB criterion. This measurement does not constitute a non-compliance against consent criteria due to the 2dB variance allowed for under the Industrial Noise Policy. An internal investigation was undertaken to determine source of noise. The Department of Planning and Environment were notified of the exceedence
1000282263	29.05.2014	Upon firing an overburden blast in the Barrys Pit (Cheshunt) a level 3 blast fume was produced. The Fume dissipated over the mining lease. An internal investigation was undertaken to determine likely cause of fume. Fume likely produced due to blast location in weathered material.
1000282264	30.05.2014	Upon firing an overburden blast in Cheshunt Pit a level 3 blast fume was produced. The Fume dissipated over the mining lease. An internal investigation was undertaken to determine the likely cause of the fume. Fume likely produced due to blast location in weathered material and adjacent to a relic water storage location. Suitable product selection to be taken into account for future blasts in heavily weathered material.

Incident Number	Date	Details
1000283624	18.06.2014	Noise exceedance measured against the HVO South consent LAeq Impact Assessment Criteria. Truck exhaust and engine noise from Riverview Pit was measured at 38dB, 2dB above the 36dB criterion. This measurement does not constitute a non-compliance against the consent criteria due to the 2dB variance allowed for under the Industrial Noise Policy. HVO notified of exceedence by noise monitoring contractor. In response, overburden dumping location changes were made, resulting in a reduction in noise level of approximately 5dB. Department of Planning and Environment notified of exceedence
1000284104	12.06.2014	When a pump was removed from its location near Lake James mine water storage, it was discovered the pump had been leaking diesel for an extended period of time, due to the presence of a hydrocarbon stain beneath the pump. Contaminated soil was recovered and taken to Bioremediation area. Directive that future pumps near discharge water storages should be placed within bunded areas. Water sampling undertaken to ensure no contamination from hydrocarbons.
1000284447	28.06.2014	Approximately 800 Litres of oil was spilt in the pit area when a truck ran over a demarcation tyre, rupturing a hydraulic line on the truck. Spill area was bunded and contaminated material was collected and taken to the bioremediation area. Ruptured line was repaired
1000284652	29.06.2014	Approximately 2000 Litres of diesel was spilt when the fuel tank on a haul truck ruptured during refuelling at an in-pit hard stand. Diesel was contained within the concrete bunded refuelling area. Diesel was recovered using a vacuum truck.
1000284665	20.06.2014	Upon firing the blast P114R0803A in Cheshunt Pit, the Knodlers Lane blast monitor recorded an overpressure reading of 115.3 dB(L), in exceedence of the internal criteria of 115 dB(L). Internal investigation undertaken and determined exceedence was valid. Exceedence likely caused by ejection from the initiation hole, or one of the first ten holes fired.
1000284928	03.07.2014	The fuel tank of a truck contacted a tyre marking an in-pit intersection, damaging a fitting under the tank and causing a fuel leak. The spill was contained and contaminated soil taken to Bioremediation area.
1000285471	02.07.2014	Maintenance / calibration work was undertaken on the Warkworth Blast monitor without authorisation.
1000285572	26.06.2014	Upon firing the CE10R0101A blast in Carrington Pit, Knodlers Lane and Maison Dieu blast monitors recorded overpressure readings of 118.1 dB and 117.2 dB respectively, exceeding the internal blasting criteria of 115 dB. Internal investigation undertaken, and determined that the recorded overpressure's were as a result of the blast.

Incident Number	Date	Details
1000285592	11.07.2014	Water was found to be pooling below Dam 17N. A small amount of water was found to have drained towards Farrell's Creek. No evidence could be found that water entered the creek. Water was observed to be dripping down the length of pipe (which was feeding water into Dam 17N) until contacting the ground and subsequently pooling below the dam. A new bund was constructed to prevent further water entering the creek embankment. Water sampling was undertaken by a monitoring contractor. Engineering solution developed to eliminate the possibility for this to reoccur.
1000287105	25.07.2014	Upon firing the blast P120WK203A in Cheshunt Pit, an overpressure exceedance of 120.2dB(L) was recorded at the Knodler's Lane blast monitor, in exceedence of the 120 dB(L) specified in the sites' Environmental Protection Licence. Internal investigation undertaken and determined exceedence was valid. The Environmental Protection Agency, Department of Planning and Environment and affected private properties were notified of the blast exceedance.
1000305610	30.08.2014	A small amount of water was observed to be leaking from butterfly valve on a pipeline adjacent the Lemington Underground Bore. The bolts on the valve were tightened, stopping the leak. Inspection of the pipeline was included in daily checklist carried out by water inspectors.
1000309236	09.10.2014	During a routine water infrastructure inspection it was identified that the water pipeline adjacent to the Lemington Underground Bore had ruptured. The pipe rupture appeared to have resulted in a discharge of water from the pipe. An investigation was undertaken which found the most likely cause to be water pressure in the pipeline exceeding the maximum rated pressure of the pipe.
1000311668	05.11.2014	Approximately 100 kilograms of ammonium nitrate emulsion was split at the Orica re-load facility whilst reloading a truck. The emulsion was cleaned up and disposed of.
1000312006	09.11.2014	Water was observed pooling adjacent Comleroi Road. Further inspection identified a rupture in a nearby pipeline, which was then isolated. An investigation was undertaken which found the most likely cause to be water pressure in the pipeline exceeding the maximum rated pressure of the pipe.
1000315439	15.12.2014	Approximately 45 litres of hydraulic fluid leaked when a seal failed on a lifting ram whilst unloading a trailer in-pit. The seal was repaired and the fluid was cleaned up.
1000315901	17.12.2014	A valve on a truck wash failed to fully close, allowing water to overflow out of the holding tank. The overflowing water entered dams designed to capture waste water from the wheel wash, and then into a gully towards Pikes Creek. The overflow water remained on the premises. The wheel wash was isolated to cease water flow and water monitoring was undertaken.
1000316713	31.12.2014	Approximately 100 litres of diesel was spilt when a seal on an in-pit pump failed. The seal was repaired and the spilt diesel was cleaned up.

Incident Number	Date	Details
1000316719	12.12.2014	Upon firing blast P203M1P04A in cheshunt Pit, the Moses Crossing blast monitor recorded an overpressure value of 115.3 dBa, exceeding the internal overpressure target of 115 dBa. Investigation found that the arrival time of the overpressure aligned with the arrival time of the blast. It is possible that reinforcement from the blast being a pre split has accumulated and arrived at the monitor at the same time.

Appendix 4:

Groundwater Impacts Reports

Australasian
Groundwater
and Environmental
Consultants Pty Ltd
(AGE)

Report on

HVO North

2014 Groundwater Impacts Report

Prepared for
Coal and Allied Operations Pty Ltd

Project No. G1593H February 2015
www.ageconsultants.com.au ABN 64 080 238 642

Document details and history

Document details

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Report on

HVO North
Annual Groundwater Impacts Review

1. Introduction

The Hunter Valley Operations (HVO) mining complex is located approximately 20 km north-west of Singleton, NSW. The complex is divided into its HVO North and HVO South components by the Hunter River (refer Figure 1). This report focuses on HVO North (the Project area), located approximately 500 m to the north of the Hunter River. The mine is owned by Rio Tinto Coal Australia (RTCA) and operated by Coal and Allied Operations Pty Ltd (Coal & Allied).
Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) was commissioned by Coal & Allied to review the impacts of mining on groundwater systems contained within the Project area. The assessment has included:

- preparation of water table and piezometric contours from monitoring data pertaining to the Project area;
- assessment of alluvial sediments and Permian strata groundwater flows over the 2014 monitoring period; and
- assessment of groundwater take from the Hunter River Alluvium.

2. Project setting

2.1 Mining

HVO North has been extensively mined since 1979, with several open-cut operations that have since been backfilled with spoil and rehabilitated. The rehabilitated pits include:

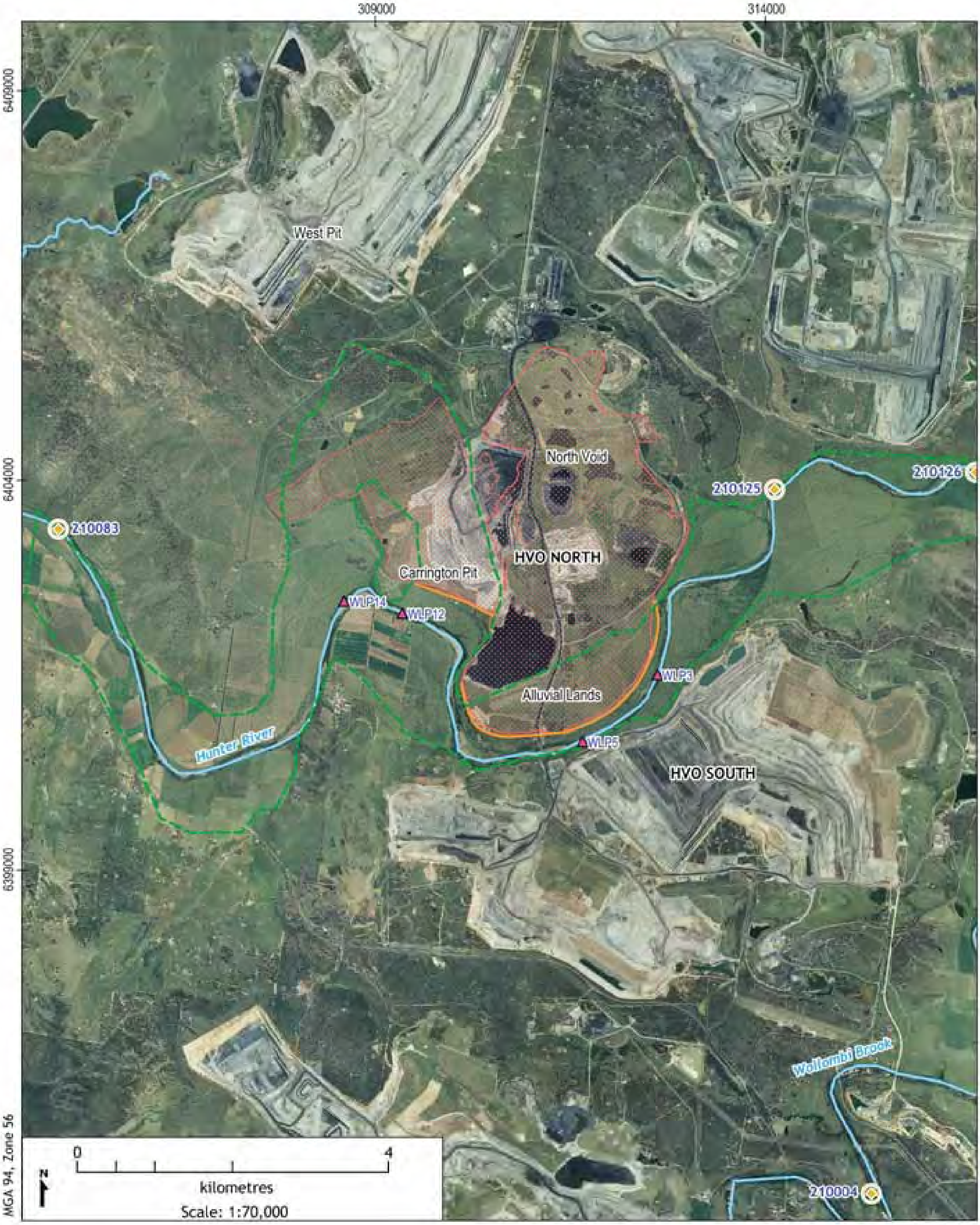
- North Void, which was mined from 1979 to around 2008 to the base of the Vaux Seam; and
- Alluvial Lands, which was the southern extension of North Void, mined from 1993 to 2003 to the base of the Vaux Seam.

The HVO North Carrington Pit commenced operations in August 2000. Mining in the Carrington Pit during 2014 was limited to a small cutback at its northern margin, with previously mined areas largely backfilled with spoil (Figure 1). Several other mines operated by Coal & Allied surround the Project area, including HVO South, located south of the Hunter River, and West Pit (Figure 1) which forms part of HVO North Consent, located north of the Project area. Other surrounding mines include the Ravensworth Operations open-cut and underground mines, located north-east of the Project area.

The Carrington Pit is located approximately 500 m to the north of the Hunter River. In 2010 a barrier wall constructed between the Carrington Pit and the Hunter River alluvium to:

- enable continued mining at Carrington Pit;
- conserve the Carrington Billabong, which contains groundwater dependent vegetation;
- minimise leakage from the alluvium to the open-cut; and
- contain groundwater within the mine, following mine closure.

The barrier wall was constructed as a compacted clay buttress wall, against an existing levee that extended across the eastern limb of a Tertiary palaeochannel. The wall was constructed to the base of the Vaux Seam. The extent of the barrier wall and the location of the Carrington Billabong are shown in Figure 1.



LEGEND

- Interpolated Palaeochannel & Alluvial Extent
- Spoil
- Watercourse
- Barrier Wall
- ▲ HVO Surface Water Monitoring Site
- ● NOW Stream Gauges

HVO North (G1593H)
2014 Groundwater Impacts Report

Project Area

DATE: 28/1/2015

FIGURE No: 1

2.2 Climate

The climate of the HVO area is mostly temperate, and characterised by hot, wet summers and mild, dry winters. Climate monitoring data collected by Coal and Allied at the HVO Corp Meteorological Weather Station during 2014 is summarised in Table 1.

Table 1 Climate averages: HVO Corp. Meteorological Data 2014

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean max temp (°C)	33.1	30.0	27.4	24.6	21.6	18.0	17.1	18.2	22.5	18.4	32.6	30.8
Mean min temp (°C)	17.6	17.7	16.4	13.8	10.4	8.4	6.2	7.2	8.8	12.8	15.8	17.2
Total monthly rainfall 2014 (mm)	6	85.2	133	48.4	8.6	22	33.4	75.8	24.4	11.2	18.2	136.6

The total annual rainfall for 2014 was 602.8 mm, with December being the wettest month with 136.6 mm.

Monthly Cumulative Rainfall Departure (CRD) using all available rainfall data has been calculated separately for the period January 1900 to December 2014 using rainfall data from the Jerry's Plains monitoring station, and the period 2007 to 2014 using the HVO Corp. Meteorological data. The CRD calculated using the Jerry's Plains data is considered to be more representative of the long term trends in rainfall for the area, and as such has been used on all hydrographs presented herein.

The CRD method is a summation of the monthly departure of rainfall from the long-term average monthly rainfall. A rising trend in the CRD plot indicates periods of above average rainfall, whilst a falling slope indicates periods when rainfall is below average. Assessment of the Jerry's Plains CRD for the period from January 2007 to December 2014 shows the area has experienced a general period of above average rainfall for the reporting period.

The CRD graph for the period 2007 to 2014 is shown in Figure 2. The CRD indicates that the site experienced intermittent periods of above average rainfalls between March and April, July and August, and in December 2014.

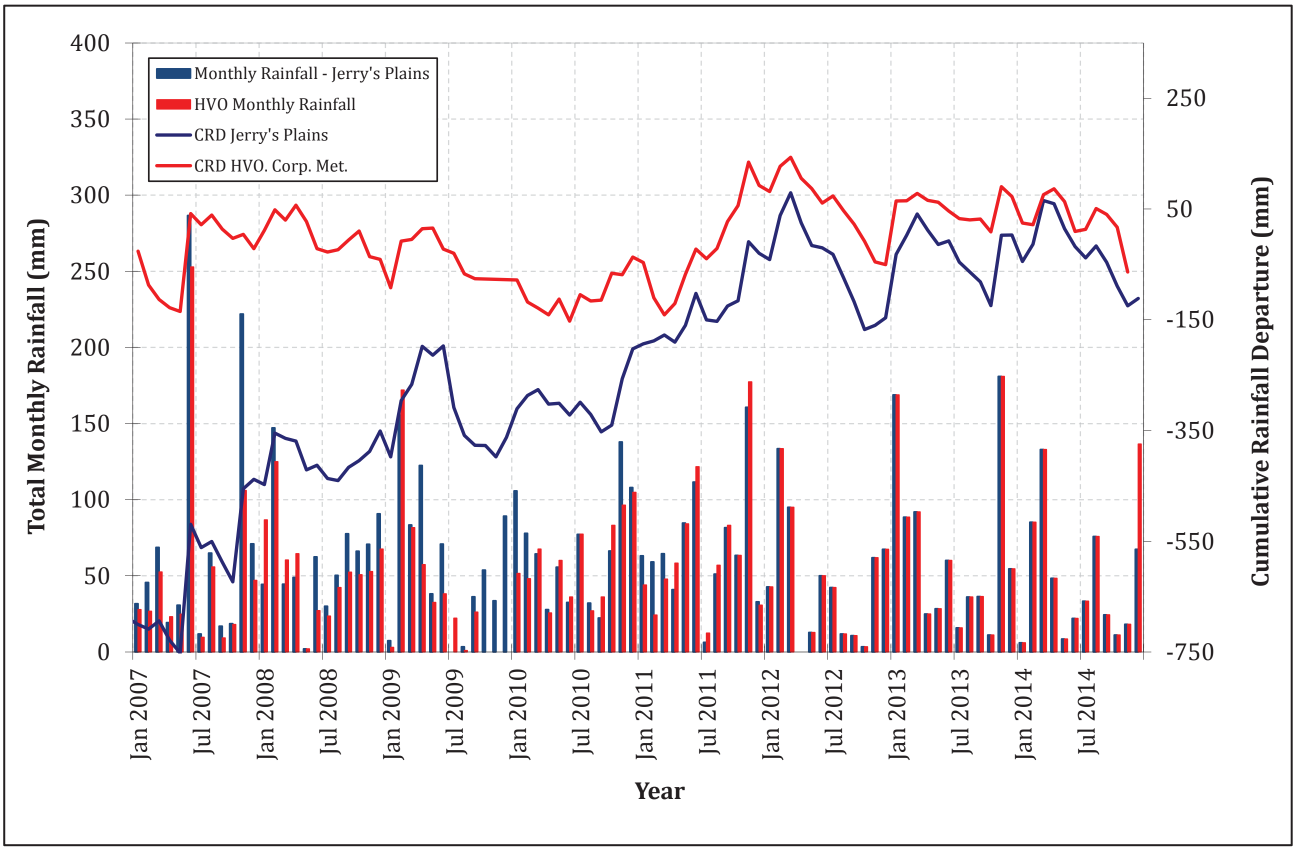


Figure 2 Cumulative rainfall departure comparison - HVO & Jerry's Plains data

2.3 Stream Flow

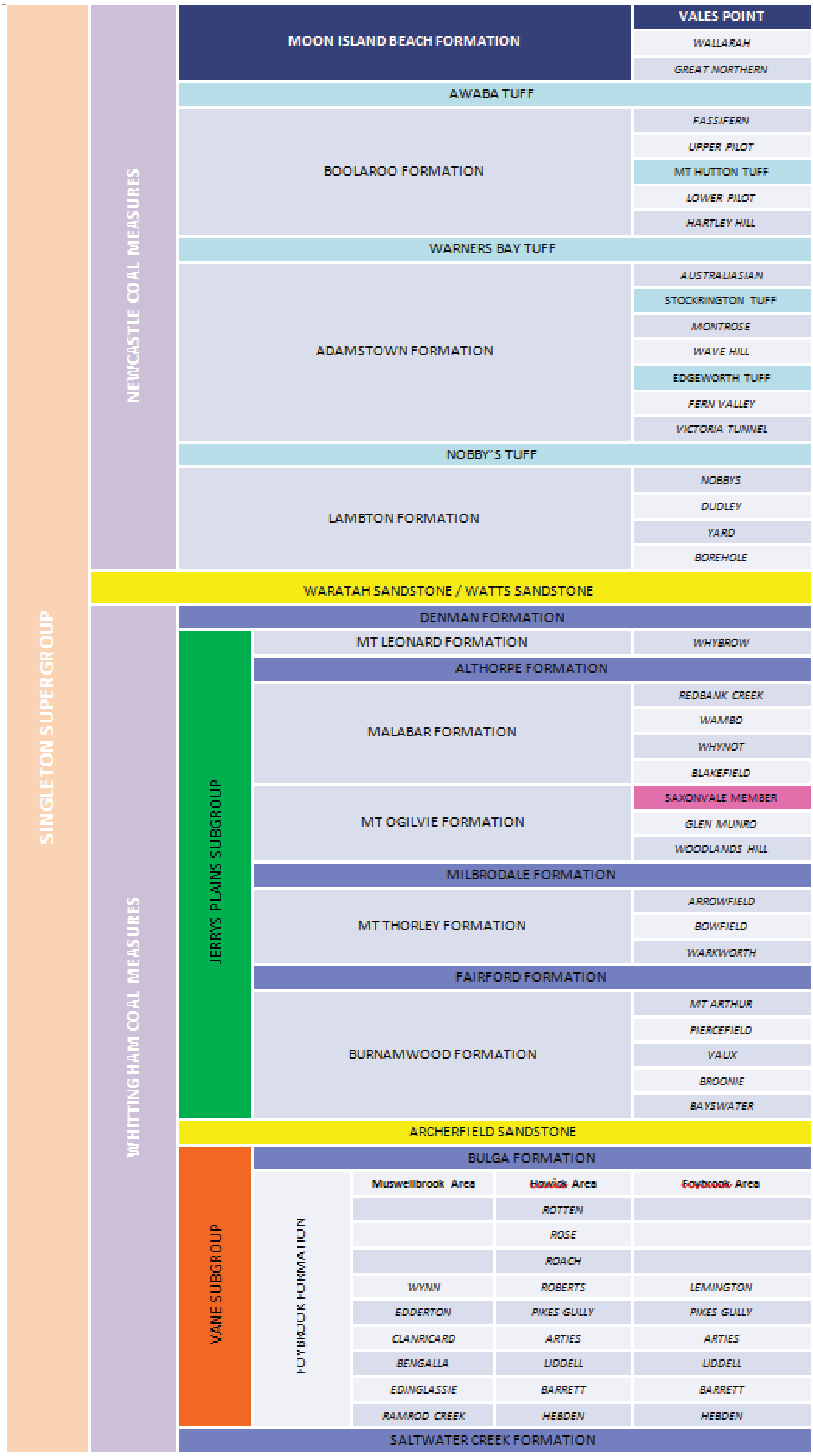
The New South Wales Office of Water (NOW) collects real time stream flow data via the Hunter Integrated Telemetry System (HITS). There are two NOW gauging stations on the Hunter River adjacent HVO North, these are:

- Station 210083 upstream of HVO North at Liddell (gauge zero at 60.951 mRL); and
- Station 210125 downstream of HVO North (gauge zero at 50.331 mRL).

HVO also collects monthly stream elevation data from four stations (WLP14, WLP12, WLP5 and WLP3 – in order up-stream to down-stream) along the Hunter River. The locations of the NOW and HVO stream sites are shown in Figure 1. It is noted that station WLP12 was replaced with WLP10 from November 2014, due to access and safety issues. The temporal distribution of stream flow levels since 2011, for both the NOW stream gauges and HVO gauges, are shown in Appendix A. The 2014 Hunter River level data, collected from the HVO stream gauges, are also tabulated in Appendix A. The stream flow data shows that Hunter River levels remained relatively stable over 2014, with only one main peak flow event visible each for March and April. Hunter River levels within the Project area ranged from around 60.6 mRL (WLP14) to 55.2 mRL (WLP3) over 2014, with the river flowing in an easterly direction.

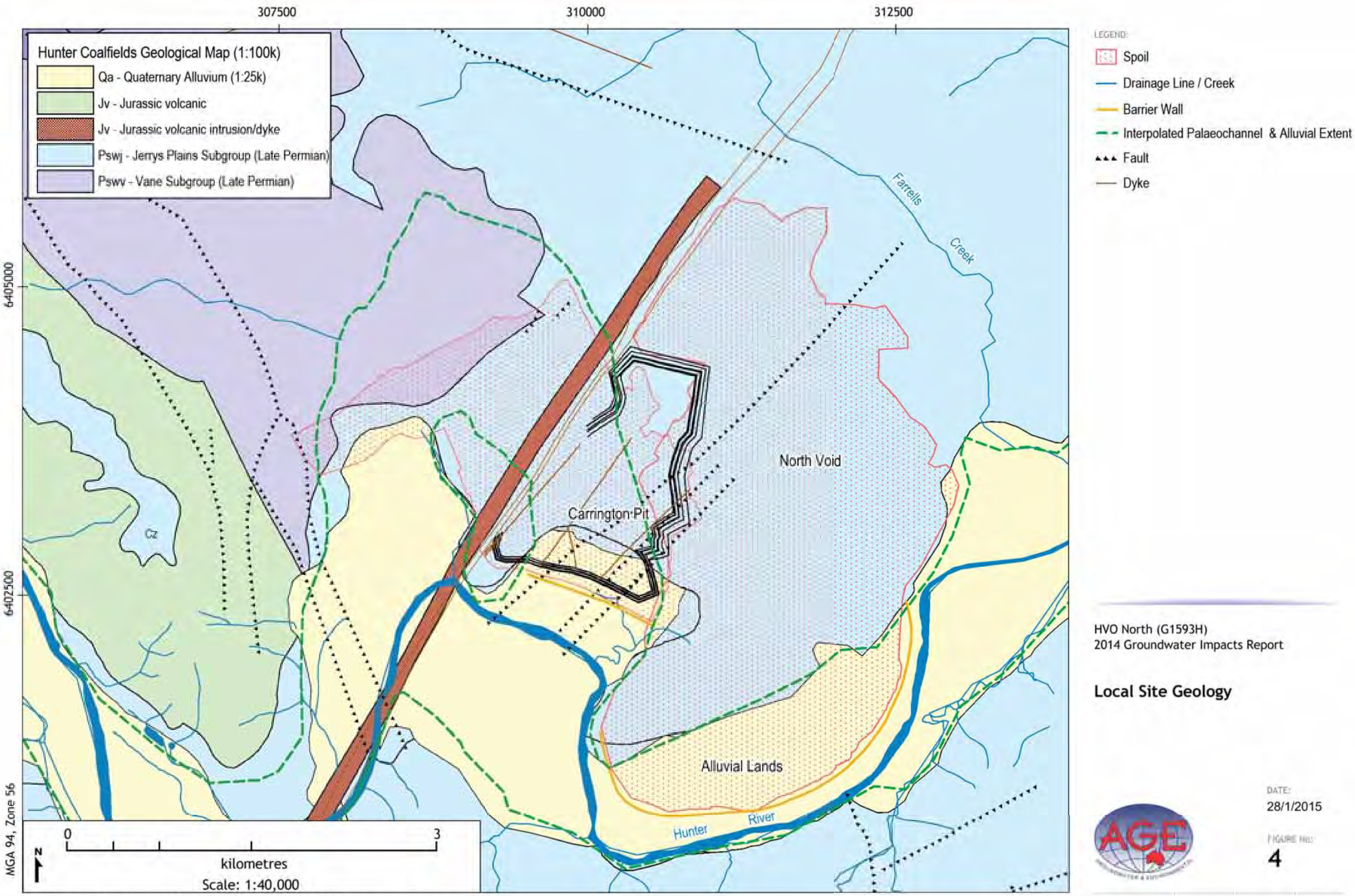
2.4 Geology

The stratigraphic sequence of the Hunter Region Permian coal measures is shown in Figure 3. The regional geology is shown on the 1:100,000 scale geological map, published by the Department of Mineral Resources (Glen & Beckett, 1993) and reproduced in Figure 4.



SINGLETON SUPER GROUP	NEWCASTLE COAL MEASURES		MOON ISLAND BEACH FORMATION			VALES POINT
						WALLARAH
						GREAT NORTHERN
			AWABA TUFF			
			BOOLAROO FORMATION			FASSIFERN
						UPPER PILOT
						MT HUTTON TUFF
						LOWER PILOT
						HARTLEY HILL
			WARNERS BAY TUFF			
			ADAMSTOWN FORMATION			AUSTRALASIAN
						STOCKRINGTON TUFF
						MONTROSE
						WAVE HILL
						EDGEWORTH TUFF
						FERN VALLEY
						VICTORIA TUNNEL
			NOBBY'S TUFF			
			LAMBTON FORMATION			NOBBYS
						DUDLEY
						YARD
						BOREHOLE
	WARATAH SANDSTONE / WATTS SANDSTONE					
	WHITTINGHAM COAL MEASURES	DENMAN FORMATION				
		JERRYS PLAINS SUBGROUP	MT LEONARD FORMATION			WHYBROW
			ALTHORPE FORMATION			
			MALABAR FORMATION			REDBANK CREEK
						WAMBO
						WHYNOT
						BLAKEFIELD
			MT OGILVIE FORMATION			SAXONVALE MEMBER
						GLEN MUNRO
						WOODLANDS HILL
			MILBRODALE FORMATION			
			MT THORLEY FORMATION			ARROWFIELD
						BOWFIELD
						WARKWORTH
			FAIRFORD FORMATION			
			BURNAMWOOD FORMATION			MT ARTHUR
						PIERCEFIELD
						VAUX
						BROONIE
						BAYSWATER
		ARCHERFIELD SANDSTONE				
		VANE SUBGROUP	BULGA FORMATION			
			FOYBROOK FORMATION	**Muswellbrook Area**	**Howick Area**	**Foybrook Area**
					ROTTEN	
					ROSE	
					ROACH	
				WYNN	ROBERTS	LEMINGTON
				EDDERTON	PIKES GULLY	PIKES GULLY
				CLANRICARD	ARTIES	ARTIES
				BENGALLA	LIDDELL	LIDDELL
				EDINGLASSIE	BARRETT	BARRETT
				RAMROD CREEK	HEBDEN	HEBDEN
		SALTWATER CREEK FORMATION				

Figure 3 Singleton Super Group sequence stratigraphy



HVO North (G1593H)
2014 Groundwater Impacts Report

Local Site Geology

DATE:
28/1/2015

FIGURE No:
4

2.5 Hydrogeology

The hydrogeological setting of the Project area comprises three main groundwater systems including, the Hunter River alluvium; the palaeochannel alluvium; and the Permian coal measures. The Project area also includes several mined-out areas that have been backfilled with spoil which can be considered to be a water receiving formation due to recharge from rainfall, surface water/run-off, pit inflows and in some cases, seepage from dams and tailings facilities. The hydrogeological characteristics of the alluvium, palaeochannel alluvium and Permian coal measures are detailed in Section 2.5.1 to Section 2.5.3 below.

2.5.1 Hunter River Alluvium

The Hunter River alluvial aquifer refers to groundwater within the Quaternary alluvium located along the Hunter River. The extent of the Quaternary alluvium is shown in Figure 4. The alluvium is generally comprised of 10 m to 20 m of unconsolidated gravels, sands, silts and clays. The alluvium typically includes three main stratigraphic units (Mackie, 2005) as follows:

- surface layer comprising of sands, gravels and minor clay;
- middle layer of silty gravels and sands interbedded with silt and clay layers; and a
- coarse cobble-gravel basal section.

Recharge to the alluvium is by direct infiltration of rainfall, with a lesser contribution from upward leakage from the underlying coal measures. Localised recharge also occurs via lateral seepage through the banks of the Hunter River during periods of high flows. Mackie (2005) found that the Hunter River shallow alluvium, downstream of Muswellbrook, was of sodium-chloride type-water.

2.5.2 Palaeochannel

The alluvial palaeochannel is located north of the Hunter River and west of the existing Carrington Pit (Figure 4). The alluvial palaeochannel is generally 12 m to 20 m thick and comprises of unconsolidated gravels, silts and clays. The depositional environment of the palaeochannel appears to have been dominated by flood surge events, resulting in deposition of gravels contiguously with silts and clays. The alluvial palaeochannel comprises three main layers (MER, 2010a):

- upper layer, comprising thin bands of sand, silt and clay;
- middle layer, which is approximately 3 m – 8 m thick that consists of stiff clays; and a
- basal layer, which is approximately 3 m – 8 m thick comprising of fine to coarse-grained silty clay gravels and cobbles or in some areas, sandy gravels.

2.5.3 Permian coal measures

The Permian coal measures can be categorised into the following hydrogeological units:

- the majority of the Permian comprises interburden/overburden, consisting of very low to low permeability and very low yielding sandstone, siltstone and conglomerate units; and
- low to moderately permeable coal seams, each typically ranging in thickness from 2.5 m to 10 m, which are the prime water bearing strata within the Permian sequence.

3. Monitoring

3.1 Monitoring bore network

The groundwater monitoring network at HVO North (excluding West Pit area), comprises of 59 monitoring bores (including both single screened bores and nested bore and/or piezometer installations). Of the 59 bores or piezometers, there are:

- • 39 around Carrington Pit; and
- • 20 in the North Void and Alluvial Lands.

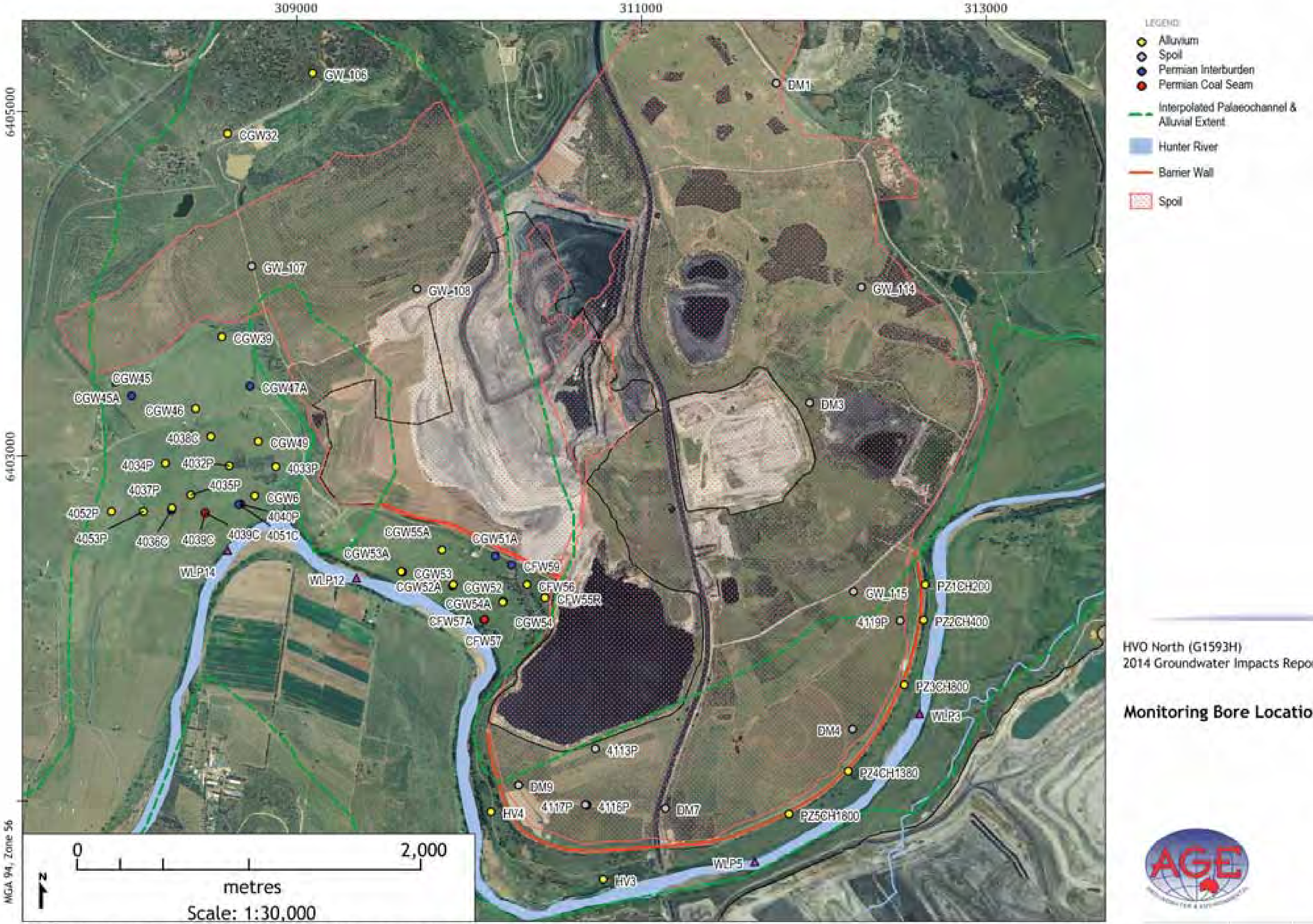
A summary of the bore target formations is included in Table 2 below. Monitoring bore locations are shown in Figure 5 and bore construction details are included in
Appendix B

Table 2 Monitoring bore network lithology

Statistic	Screened Lithology	No. of Bores
Carrington	Spoil	2
	Palaeochannel Alluvium	24
	Palaeochannel Alluvium/Permian interburden	2
	Permian interburden	6
	Permian Coal Seam (Broonie)	4
	Permian Coal Seam (Bayswater)	1
	Permian Coal Seam (Other)	1
North Void/Alluvial Lands	Alluvium	8
	Spoil	11

3.2 Groundwater monitoring

All 59 bores were monitored over 2014, with monthly or bi-monthly manual measurements undertaken at Carrington Pit and quarterly measurements at North Void/ Alluvial Lands. Of the 59 bores monitored, 18 were equipped for continuous monitoring with pressure transducers /dataloggers recording groundwater level every four hours; refer to Appendix C for hydrographs with both manual and data logger data presented.



HVO North (G1593H)
2014 Groundwater Impacts Report

Monitoring Bore Locations

DATE:
28/1/2015

FIGURE No:
5

4. Groundwater quality

Electrical conductivity (EC) and pH were measured in 53 bores in 2014 with a total of 201 individual measurements of pH and EC. These measurements were undertaken monthly, bi-monthly or quarterly. In addition, at 27 of these bore locations groundwater samples were obtained for laboratory analysis of major ions and selected metals. Either one or two sampling rounds were undertaken during 2014.

4.1 Field chemistry

Available 2014 EC and pH field values are graphed and tabulated in Appendix D to help identify trends throughout the year. Table 3 below summarises the field EC and pH measurements for 2014.

Table 3 Electrical conductivity (EC) and pH summary data

Location	Lithology	Total Bores	Number of Measurements	Mean EC (µS/cm)	Min EC (µS/cm)	Max EC (µS/cm)	Mean pH	Min pH	Max pH
Carrington	Spoil	2	0	-	-	-	-	-	-
	Palaeochannel Alluvium	21	94	2,674	607	9,180	7.4	6.6	8.1
	Permian Coal Seam	3	10	7,610	6,290	8,540	7.0	6.8	7.2
	Unknown	2	6	7,370	6,250	7,780	7.6	7.2	7.9
	Permian Interburden	6	26	5,670	2340	10,750	7.2	6.7	7.7
North Void / Alluvial Lands	Alluvium	8	27	810	160	4,190	7.1	6.7	7.4
	Spoil	11	38	7,308	1,230	13,280	7.1	6.5	8.1

Generally at Carrington, the groundwater types encountered are:

- Palaeochannel alluvium is mainly brackish type water, ranging from fresh (CGW45) to saline waters (GW106);
- Permian coals seams have been consistently measured between moderately saline to saline waters, and
- Permian interburden varies from brackish to saline waters.

In the North Void / Alluvial Lands, groundwater in the Hunter River alluvium is typically fresh to slightly brackish with peak occurrences of moderately saline water at HV3. The spoil typically has moderately saline to saline type water with the highest salinity occurring at 4116P.

Within each measured lithology at Carrington, the EC graphs in Appendix D show a gradual rise then fall in EC levels during the first and last quarters of 2014. The fluctuation in EC at Carrington is typically between 3% to 29% in the alluvial sediments, 21% to 27% in the Permian Coal Seams and 5% to 36% in the Permian interburden. Monitoring bores with EC above 6,000 µS/cm typically have a more pronounced fluctuation. The reason for this trend across different lithologies may be attributed to similar variances with recharge flux in the area.

The noticeable exceptions are CFW57 (125%) and CFW45 (134%), and CGW54A (50%) and CFW55R (65%) which are all located in the Palaeochannel alluvium. Monitoring bores 4038C, CFW55R, CFW57, CGW46 and CGW54A had bucked the general trend in July. Each bore had measured very similar EC (average: 3,020 µS/cm and range: 100 µS/cm), pH (average: 7.5 and range 0.3) and temperature (19.2°C and range: 0.8°C) readings.

The EC graph in Appendix D shows that monitoring bores located in the alluvium at the North Void / Alluvial Lands have relatively consistent levels below 800 µS/cm. The exception is HV3 which peaks at 4,190 µS/cm in contrast to the general trend value of approximately 1,400 µS/cm. Monitoring bores located in the spoil at the North Void / Alluvial Lands have typically consistent levels between 6,000 µS/cm and 13,300 µS/cm, with the exception of:

- 4119P which measures consistently at ~1,900 µS/cm, has a lower EC than most other spoil EC measurements;
- GW114 which initially measures at ~6,100 µS/cm, has increased in July to 8,370 µS/cm; and
- GW115 which initially measures low at about 1,230 µS/cm, has increased significantly in July to 7,840 µS/cm.

Groundwater found in all lithologies is typically between pH 6.5 and 8.1.

4.2 Laboratory analysis

Schoeller plots have been created in order to compare major ion chemistry of groundwater samples. Groundwater type comparison is possible even if some of the major ions were not analysed; as is the case at HVO North, where total alkalinity was not included in many of the previous sample analyses.

The Schoeller plots compare the normalised concentration of ions (in milliequivalents/litre) on a vertical logarithmic axis with the analytes identified on the horizontal axis. Points for each ion are then connected to form a line. Similar shaped lines from multiple samples indicate a similarity in origin and vertical displacement of similar line lines indicates dilution with fresh water (resulting in downward shift in the line) or concentration/evaporation (resulting in an upward shift).

Samples for Schoeller plot analysis have been prepared for Carrington palaeochannel alluvium and Permian interburden, and North Void / Alluvial Lands Hunter River Alluvium and spoil. Figure 6 shows a representative Schoeller plot from each of these lithological units for 2014. Detailed Schoeller plots for all the bores with sufficient water quality data are in included in Appendix D.

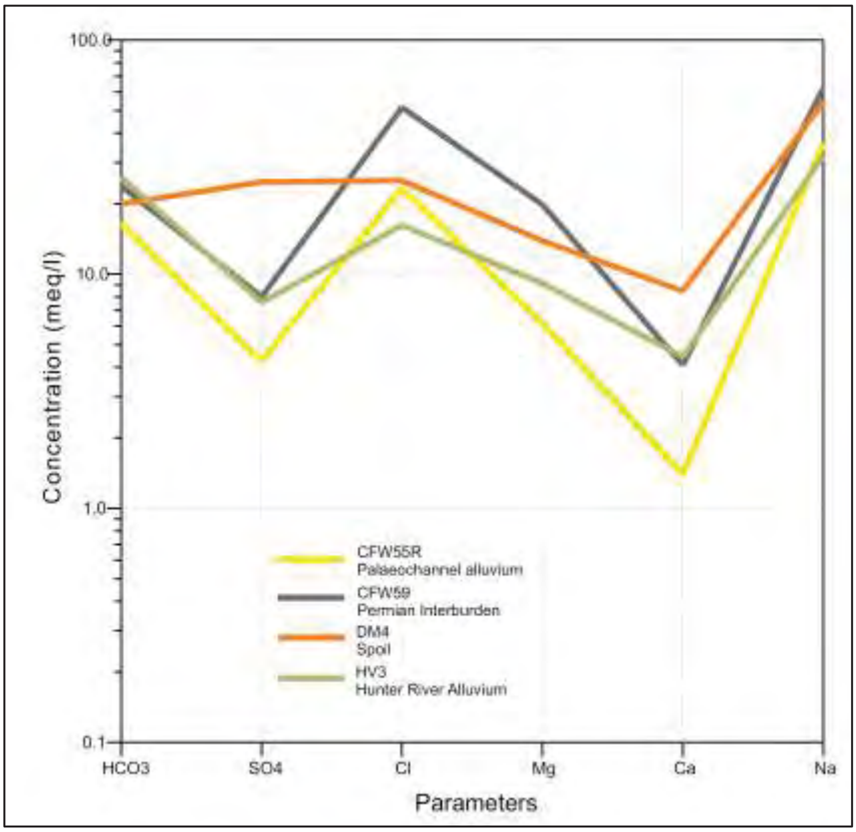


Figure 6 Schoeller plot of typical spoil, interburden and alluvium chemistry

The results of the above Schoeller plot analysis are that the chemistry appears similar in all samples. Sodium (Na) and chloride (Cl) are the most dominant ions. The samples generally have similar concentrations except having:

- elevated sulphate (SO4) in the spoil samples which may indicate leaching from the spoil; and
- depleted chloride (Cl) in some Hunter River alluvium and some spoil samples which may indicate infiltration of less saline water from the Hunter River and/or surface water/rain infiltration.

These results are considered to be consistent with those from the 2013 reporting period.

5. Groundwater levels

Groundwater level data has been collected for the Project area since 2001, with data-loggers installed in a number of locations since 2009. This report specifically looks at groundwater trends over the 2014 calendar year; however, all available data has been used to assess long-term trends. The groundwater hydrographs are included in Appendix C, and groundwater contours are included in Appendix E. Observations from the available data are detailed in Section 5.1 to Section 5.2.

The groundwater levels were compared against the CRD (HVO Rainfall Data), Hunter River water levels at NOW Station 210083 – Hunter River at Liddell (approximately 4 km west of Carrington Pit) and HVO Hunter River Stations WLP12 and WLP14, to better understand the connectivity between surface water and groundwater. Note that Hunter River Station WLP12 was replaced by WLP10 in November 2014 due to access and safety issues.

5.1 Hunter River/Palaeochannel Alluvium

Long-term groundwater trends from alluvial bores are shown in Appendix C. Groundwater contours for November 2014 (Appendix E) indicate that groundwater in the western limb of the alluvial sediments has a low hydraulic gradient, with a northerly flow direction. Both the western and eastern limbs of the alluvial sediments generally record groundwater levels between 55 mRL to 60 mRL.

5.1.1 Western Limb

The hydrographs for bores located on the western limb of the alluvial sediments (within 700 m of the Hunter River) appear to correlate to CRD (Appendix C). The groundwater level data indicates that:

- Alluvial groundwater levels are below the Hunter River elevations for all of the year. This indicates a recharge potential from the Hunter River to the alluvium throughout the year.
- The recorded groundwater level at 4034P appears anomalous as although it follows the trend of the other alluvium bores in 2014, its elevation is offset downwards by approximately 0.6 m. In the 2013 reporting period this decline in groundwater level was thought to be anomalous, however given that the data from this monitoring bore closely matches the trend seen in nearby monitoring bores, the trend is considered real.

Bores located greater than 700 m from the Hunter River (refer Appendix C), generally recorded groundwater levels below Hunter River water levels. This is consistent with the groundwater levels recorded in the alluvium closer to the river. Groundwater contours (refer Appendix E) indicate that flow in the alluvium was from the river northwards towards the backfilled pit. The lower elevation of groundwater levels in the pit spoil area, indicate the potential for groundwater in the alluvium within the west limb of the alluvial sediments to flow towards and into the Carrington Pit.

Bores CGW32, CGW39, CGW47 and CGW49 recorded relatively stable groundwater levels during 2014 whilst the groundwater level in bore CGW46 dropped by approximately 3m.

The sudden decline in groundwater level recorded in CGW46 may be a recording error whereby data for CGW46 and CGW46A may have been interchanged. The groundwater level recorded in monitoring bore CGW46 closely matches the historic groundwater level recorded in CGW46A. Data provided for borehole CGW46 has been assumed to actually be from borehole CGW46A for the 2014 monitoring period.

5.1.2 Eastern limb

In March 2010, a barrier (groundwater cut-off) wall was constructed across the eastern limb of the alluvial sediments, approximately 400 m north of the Hunter River. The groundwater level data recorded in bores located between the Hunter River and the barrier wall appear to correlate closely with CRD (Figure 2). The groundwater level data indicates that:

- Alluvial groundwater levels are below the Hunter River elevations for all of the year. This indicates the potential for recharge of the alluvium from the Hunter River throughout the year.
- Bore CFW56 was recorded as being dry throughout the year.

5.2 Permian coal measures

5.2.1 Permian coal seams

Long-term hydrographs for bores screened within the Permian coal measures are shown in Appendix C. There is an insufficient number of bores spread across the Project area and intersecting the same coal seam, to display reliable groundwater contours for the Permian coal measures. The groundwater level data indicates:

- That groundwater within the Broonie Seam is lower in the eastern limb of the alluvial sediments (CGW52, CGW53 and CGW54), compared to the western limb (4039-VW2). This likely relates to distance from the working Carrington Pit as well as geological structure.
- Hydrographs for the Permian coal seam bores, located south of Carrington Pit on the eastern limb of the alluvial sediments, show stable groundwater levels over 2014 (Figure 12).
- VWP 4039c is located on the western limb of the alluvial sediments and has sensors installed within the alluvium (VW1), Broonie 5 Seam (VW2) and Bayswater Seam (VW3). No data was provided for 4039c–VW3 (Bayswater). Sensor 4039c-VW2 (Broonie 5) showed a steady decline in pressure head measurements in 2014. A period of decreased pressure head measurements are present in the data (approximately 5 m) between July and October (Figure 14). This period of decreased pressure head measurements may be erroneous. 4039C_VW1 (alluvium) showed a stead increase in pressure head measurements (1.53 m), which can be correlated to 2014 being a wetter than average year.
- There appears to be a small decline in the Permian water levels in general.

5.2.2 Permian interburden

Long-term hydrographs for bores screened within the Permian interburden are shown in Appendix C, and groundwater contours are shown in Appendix E. There was insufficient data to draw conclusions as to the groundwater flow direction from the 2014 data; however, the little data available shows that groundwater levels have not varied considerably from previous years. This would suggest a continued south westerly flow direction.

The available 2014 groundwater level data indicates that:

- the data for CGW47A (as shown in Appendix C and Appendix E) may be incorrectly recorded (mistakenly swapped for CGW47).
- bore 4051C, located in the eastern limb of the Carrington alluvial sediments, show a small rise in groundwater level which coincides with CRD. The bore is less than 32 m deep and is constructed in Permian interburden, indicating the groundwater level responses may be due to rainfall recharge and/or recharge from alluvium groundwater.
- bore 4036C is located in the western limb of the alluvial sediments (constructed in the Permian interburden to a depth of 35 m). This bore shows a slight decline in groundwater level in 2014, similar to that seen in the underlying Broonie Seam. This is indicative of downward leakage in response to depressurisation caused by mining in the Carrington Pit; however, the groundwater level in the shallow interburden is lower than that calculated (from VWP data) in the underlying Broonie Seam (in bore 4039C-VW2). This is unlikely and so brings in to question the calculation of pressure head in 4039C-VW2 (the calculation of pressure head in 4039C-VW1 has previously been questioned).

6. Analytical assessment of impacts on hunter river baseflow

The following section details the estimated loss of alluvial groundwater due to mining operations at the Project area, based on calculations using "snap-shot in time" data. Groundwater leakage from coal seams and alluvium (through the barrier wall) into the pit (Q_{XY}), and vertical leakage of alluvial groundwater into the underlying coal seams (Q_Z) were calculated by applying Darcy's Law (Equation 1). The calculations and assumptions that were used to estimate the groundwater flow loss (Q_{XY} and Q_Z), are presented in Appendix F and Appendix G. Flow loss calculation results are shown and discussed in Section 6.1. Adjustments have been made to the calculations made from previous years of reporting, due to a greater understanding of the Project area and hydrogeological regime following recent studies and field investigations within the Project area.

Darcy's Law:

$$Q=KiA \qquad \textit{(Equation 1)}$$

where:

Q	is the amount of water discharged (m^3/day)
K	is the hydraulic conductivity (m/day)
i	is the hydraulic gradient (dimensionless)
A	is the area (e.g. exposed coal seam/alluvium) (m^2)

6.1 Flow loss calculation results

6.1.1 Horizontal discharge (Q_{xy})

The horizontal leakage of groundwater from the Permian coal measures and alluvium into the Carrington Pit (Q_{xy}) has been calculated using the principles of Darcy's Law. The results, shown in Table 4indicate that approximately 0.15 ML/day of groundwater from the Permian coal measures potentially enters Carrington Pit and approximately 0.01 ML/day of alluvial groundwater potentially seeps through the barrier wall into Carrington Pit.

Table 4 Estimated leakage of groundwater into pits

Location	Horizontal Hydraulic Conductivity (MER, 2010) K_{XY} (m/day)	Horizontal Hydraulic Gradient (i_{XY})	Pit Wall Length (m)	Exposed Face (m)	Horizontal Discharge from Coal Seams to Pit Q_{XY} (L/s)	Horizontal Discharge from Coal Seams to Pit Q_{XY} (ML/day)
Carrington Pit	6.0 x 10^{-03}	0.37	1,100	60.0	1.69	0.15
Barrier Wall	5.8 x 10^{-04}	1.52	1,100	10.0	0.11	0.01

Notes:

K_{xy}	*Derived from MER (2010a) and MER (2010b)*
i_{xy}	*Horizontal hydraulic gradient*
Q_{xy}	*Volume of groundwater discharging into mine pit*

Groundwater related impacts on the alluvial sediments and the Hunter River have been modelled by MER (2010a) since mining commenced at Carrington in 2000, until 2010. The MER (2010a) numerical model predicted long-term baseflow loss from the Hunter River would be up to 0.1 ML/day for both the eastern and western limbs of the alluvial sediments. MER (2011) also predicted baseflow loss into the coal measures, as underflow beneath the barrier wall, of about 0.05 ML/day, thus yielding a total leakage loss rate of about 0.15 ML/day. Coal & Allied reported pumping of in-pit water at a rate of around 50 L/s to 60 L/s for six to seven hours a day over 2014, which equates to 1.1 ML/day to 1.5 ML/day. While these pump rates are high, they are based on extraction of all water stored within the mined area and include surface water runoff and inflows from the spoil and all intersected Permian coal measures.

According to the OPSIM model estimates and water balance estimates presented by Water Solutions (2010), approximately 75% of water within the mine water budget is sourced from rainfall runoff. This reduces the estimated inflows from groundwater to around 0.3 ML/day to 0.4 ML/day.

The estimate using “snap-shot in time” data for overall leakage from alluvium of 0.15 ML/day is comparable with the rate of 0.15 ML/day presented by MER (2010a). The estimated leakage from alluvium is lower than the estimated pit dewatering rates. However, the dewatering rates account for extension of mining beyond our modelled area, and would therefore incorporate higher inflows from the intercepted Permian coal measures and spoil.

While the overall baseflow loss estimates are similar when compared to MER (2010a), the estimate carried in this study for leakage through the alluvium is lower, and inflows through the Permian sequences are higher. The analytical calculations presented in this report are a 2D simplification of the hydrogeological system, and therefore only flow through the highwall across the eastern limb of the alluvial sediments is reported. The higher estimates for leakage from the alluvium to the Carrington Pit by MER (2010a) account for flow from the western limb of the alluvial sediments, and are considered a more representative estimate of alluvial flow loss.

6.1.2 Vertical discharge (Q_z)

The vertical leakage of alluvial groundwater into the underlying coal measures (Q_Z) was calculated, and the results are shown in Table 5. The results indicate a total baseflow loss into the pit (via the coal measures) of 0.11 ML/day.

Table 5 Estimated leakage of groundwater into coal seams

Location / Pit	K_Z (m/day)	i_Z	Pit Wall Length (m)	Width of Alluvium (m)	Q_Z (L/s)	Q_Z (ML/day)	% Q_Z/Q_{XY}
Alluvial sediments east limb	2.60E-04	1.31	1,100	300	1.30	0.11	77%

Notes:		
	K_z	*Derived from MER (2011) for PCM Layer 2*
	i_z	*Vertical hydraulic gradient*
	Q_z	*Is the amount of water discharged (L/s)*

The vertical leakage rates (Q_z) defining the downward flow of groundwater from the alluvium to the coal seams were divided by the rate of groundwater leakage from target coal seams into the pits (Q_{xy}). The results (% QZ/Q_{xy}) indicate that approximately 77% of groundwater seepage is likely to be sourced from the alluvium at Carrington. With the additional 0.01 ML/day predicted flow of alluvial groundwater through the barrier wall, it is predicted that 0.12 ML/day of alluvial groundwater flows into Carrington Pit.

Real time river flow data and Hunter Integrated Telemetry System (HITS) data is collected by NOW at Station 210083. The time weighted discharge rate duration curve, which is based on historical streamflow data since 1969, shows that the Hunter River (at Station 210083) flows at a rate of around 150 ML/day approximately 75% of the time, and flows at a rate of around 60 ML/day 95% of the time. The total leakage of alluvial groundwater (Q_z) is estimated at 0.12 ML/day, which conservatively equates to a stream flow loss of 0.1% to 0.2% from the Hunter River, based on the 75th and 95th percentile of stream flow rates. It is anticipated that the 0.1% flow loss, based on the 75th percentile, is a more realistic estimate.

7. Conclusions

The following conclusions have been made based on groundwater quality and level data, detailed in Sections 4 and 5, as well as flow loss estimates detailed in Section 6.

- Based on 2014 river and groundwater elevations and groundwater hydrographs for the alluvium, the Hunter River can be considered to be losing water to the alluvium, which is consistent with that reported in the 2013 reporting period.
- Boreholes CGW46/CGW46A and CGW47/CGW47A should be resurveyed and water level gauged and base of well measured in each future monitoring round, so as to provide greater certainty as to the validity of the groundwater levels observed.
- Based on February 2014 data and the interpreted alluvial groundwater contours, groundwater in the western limb of the alluvial sediments has a low hydraulic gradient (55 mRL to 60 mRL) and flows in a northerly direction toward Carrington Pit. Groundwater levels within the eastern limb of the alluvial sediments also range between 55 mRL and 60 mRL, with the groundwater movement generally following the river flow, towards the east;
- Permian groundwater levels trends show that levels appear to be reducing, as expected in the vicinity of an operational mine.
- Darcy's Law steady state calculations indicate that approximately 0.15 ML/day of groundwater from the coal measures enter the Carrington Pit, while approximately 0.01 ML/day of alluvial groundwater enters the pit through the barrier wall. These results are comparable with the results presented by MER (2010a) who undertook a three dimensional numerical model for the Carrington mine area.
- Based on Darcy's Law steady state calculations, the total baseflow loss from the Hunter River alluvium into the Carrington Pit is estimated to be around 0.11 ML/day, which is equivalent to between 0.1% and 0.2% of Hunter River baseflows. This estimate is within the volumes predicted by previous modelling.

8. References

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Appendix A Surface water flow data

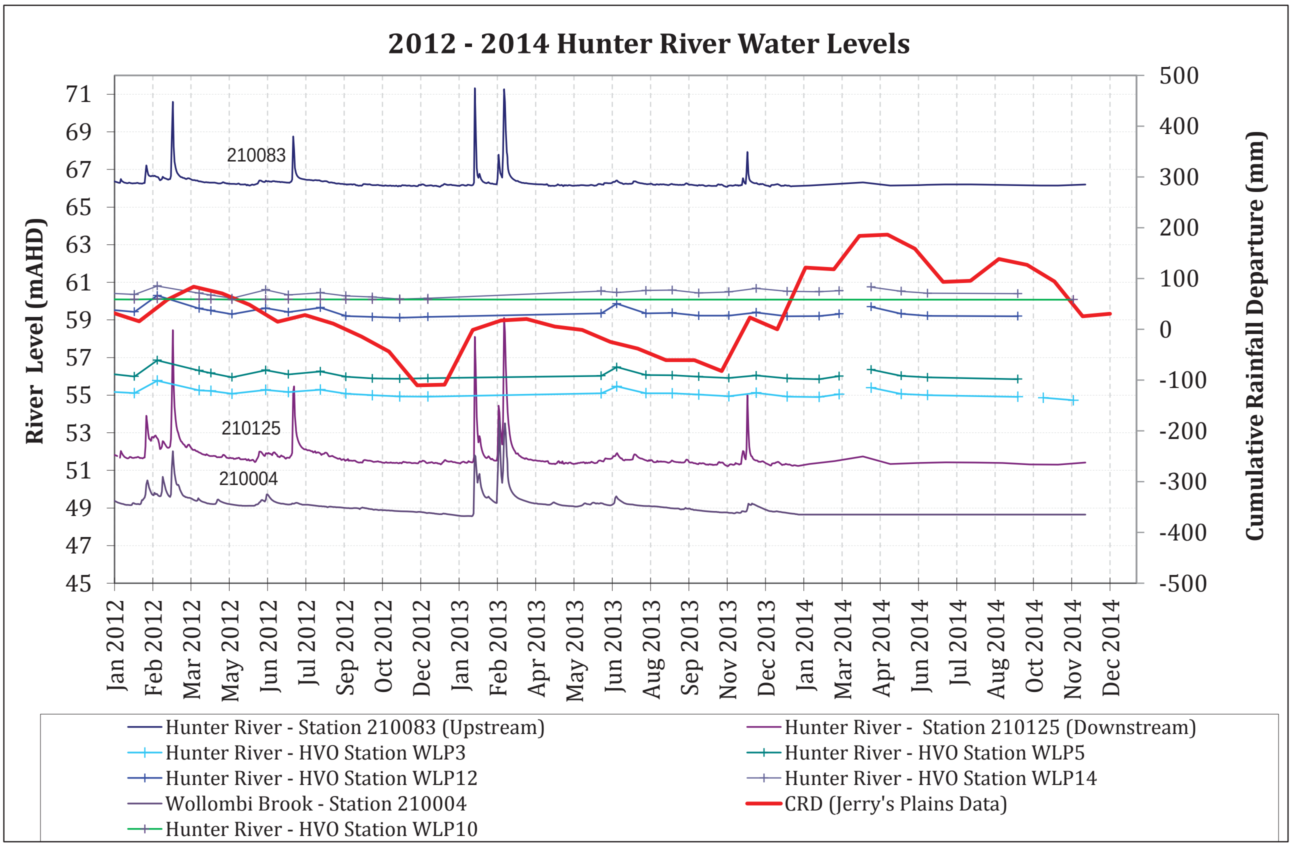


Figure 7 Hunter River levels

Table 6 2014 HVO Hunter River stream level (mRL) data

Station ID	Easting	Northing	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
WLP3	312612.6	6401505.3	54.9	54.9	55.1	55.4	55.1	55.0	n/a	n/a	54.9	54.9	54.7	n/a
WLP5	311655.1	6400647.0	55.9	55.9	56.0	56.4	56.0	55.9	n/a	n/a	55.9	55.8	55.7	n/a
WLP10	310079.7	6401633.6	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	58.47	n/a
WLP12	309346.1	6402293.6	59.2	59.2	59.3	59.7	59.3	59.2	n/a	n/a	59.2	59.1	n/a	n/a
WLP14	308597.7	6402452.9	60.5	60.5	60.6	60.7	60.5	60.4	n/a	n/a	60.4	60.4	60.3	n/a

Appendix B Monitoring bore construction details

Bore	Piezometer Install Date	Easting	Northing	Ground Level (mAHD)	Collar Height	Collar RL (mAHD)	Install Depth (mBCL)	Measured Bore Depth (mBGL)	Depth to Screen (mBGL)	Target Lithology	Location	Logger
4032P	-	308609	6402945	-	-	0	-	-	-	Alluvium	Carrington	-
4033P	-	308877	6402939	-	-	0	-	-	-	Alluvium	Carrington	-
4034P	-	308239	6402959	-	-	0	-	-	-	Alluvium	Carrington	-
4035P	-	308386	6402778	-	-	0	-	-	-	Alluvium	Carrington	-
4036C	-	308272	6402688	-	-	0	-	-	-	20m Below Alluvium	Carrington	-
4037P	-	308277	6402702	-	-	0	-	-	-	Alluvium	Carrington	-
4038C	-	308502	6403116	-	-	0	-	-	-	Alluvium	Carrington	-
4039C_A	-	308468	6402673	70.73	-	0	13.5	-	-	Alluvium	Carrington	VWP
4039C_Br	-	308468	6402673	70.73	-	0	52.3	-	-	Broonies5	Carrington	VWP
4039C_Ba	-	308468	6402673	70.73	-	0	65	-	-	Bayswater	Carrington	VWP
4040P	-	308675	6402724	-	-	0	-	-	-	Alluvium	Carrington	-
4051C	-	308664	6402721	-	-	0	-	-	-	20m Below Alluvium	Carrington	-
4052P	-	307924	6402680	-	-	0	-	-	-	Alluvium	Carrington	-
4053P	-	308112	6402680	-	-	0	-	-	-	Alluvium	Carrington	-
CFW55	2/04/2008	-	-	-	-	-	17.4	-	9.4	-	-	-
CFW55R	-	310439	6402180	-	-	70.32	-	-	-	Alluvium	Carrington	-
CFW56	-	310333	6402255	-	-	69.89	-	-	-	Alluvium	-	-
CFW57	28/03/2008	310084	6402053	69.988	-	70.21	15.44	-	8.44	Alluvium	Carrington	-

CFW57A	13/03/2008	310088	6402049	70.018	-	70.5	6	-	1.5	Alluvial Floor	Carrington	-
CFW59	27/03/2008	310245	6402370	68.358	-	69.43	13.3	-	7.5	Alluvium	-	-
CFW63	-	310828	6403724	-	-	0	-	-	-	Base of Spoil	Carrington	-
CFW64	-	310877	6403617	-	-	0	-	-	-	Base of Spoil	Carrington	-
CGW32	-	308598	6404872	-	-	84	-	-	-	Alluvium	-	-
CGW39	-	308566	6403694	-	-	77	-	-	-	Alluvium	Carrington	-
CGW45	-	308042	6403349	-	-	77	-	-	-	Bayswater	-	-
CGW45a	-	308044	6403349	-	-	77	-	-	-	Broonie	-	-
CGW46	-	308413	6403276	-	-	78	-	-	-	Bayswater	-	-
CGW46a	-	308415	6403276	-	-	78	-	-	-	Broonie	-	-
CGW47	-	308729	6403406	-	-	72	-	-	-	Bayswater	-	-
CGW47a	-	308731	6403405	-	-	72	-	-	-	Broonie 1	-	-
CGW49	-	308778	6403098	-	-	71	-	-	-	Bayswater	-	-
CGW51a	-	310149	6402419	-	-	70	-	-	-	Alluvium	Carrington	-
CGW52	-	309906	6402255	-	-	71	-	-	-	Broonie 2	Carrington	-
CGW52a	-	309902	6402249	-	-	71	-	-	-	Alluvium	Carrington	-
CGW53	-	309606	6402333	-	-	70	-	-	-	Broonie 1	Carrington	-
CGW53a	-	309606	6402333	-	-	70	-	-	-	Alluvium	Carrington	-
CGW54	-	310196	6402159	-	-	0	-	-	-	Broonie 1	Carrington	-
CGW54a	-	310196	6402159	-	-	69	-	-	-	Alluvium	Carrington	-
CGW55a	-	309840	6402457	-	-	71	-	-	-	Alluvium	Carrington	-

CGW6	1/05/2009	308756	6402770	69.3	0.82	70.1	-	21.82	-	Carrington Alluvium	Carrington	-
Cut-off1	-	310431	6402349	-	-	0	-	-	-	-	Carrington	-
Cut-off2	-	310298	6402421	-	-	0	-	-	-	-	Carrington	-
Cut-off3	-	310142	6402496	-	-	0	-	-	-	-	Carrington	-
Cut-off4	-	309983	6402575	-	-	0	-	-	-	-	Carrington	-
Cut-off5	-	309801	6402639	-	-	0	-	-	-	-	Carrington	-
DM1	-	311755	6405188	-	-	103.05	-	-	-	Pit Floor	North Void Alluvium	-
DM2	-	311640	6404635	-	-	105.65	-	-	-	Pit Floor	-	-
DM3	-	311910	6403310	-	-	95.17	-	-	-	Pit Floor	North Void Alluvium	-
DM4	-	312162	6401456	-	-	65	-	-	-	Pit Floor	North Void Alluvium	-
DM7	-	311162	6401051	-	-	-	-	-	-	Spoil	North Void Alluvium	-
DM9	-	-	-	-	-	-	-	-	-	-	-	-
EE4 HVO-W	-	312360	6406897	-	-	0	-	-	-	Rock/Coal	-	-
G1 HVO-W	-	305694	6407301	-	-	0	-	-	-	Alluvium	-	-
G10	-	310932	6403357	-	-	0	-	-	-	BAY	Carrington	-
G2 HVO-W	-	305660	6407451	-	-	0	-	-	-	Alluvium	-	-
G3 HVO-W	-	305636	6407556	-	-	0	-	-	-	Alluvium	-	-
G4(d)	-	310415	6402342	-	-	0	-	-	-	Bayswater	Carrington	-
G4(s)	-	310415	6402342	-	-	0	-	-	-	Geotechnical defect	Carrington	-

GS1	-	310690	6403854	-	-	0	-	-	-	Base of Spoil	Carrington	-
GS2	-	310899	6403921	-	-	0	-	-	-	Base of Spoil	Carrington	-
GS5	-	310890	6403612	-	-	0	-	-	-	Base of Spoil	Carrington	-
GS8	-	310901	6403304	-	-	0	-	-	-	Base of Spoil	Carrington	-
HV3	-	310667.96	6400582.02	-	-	-	-	-	-	Alluvium	-	-
HV4	-	310140	6400892	-	-	-	-	-	-	Alluvium	-	-
NPz1	-	305240	6406100	-	-	117.84	-	-	-	Sandstone/Siltstone	West Pit	-
NPz3R	-	307024	6407896	-	-	0	-	-	-	Sandstone/Siltstone	West Pit	-
NPz4	-	306240	6404584	-	-	135.97	-	-	-	Sandstone/Siltstone	West Pit	-
NPz5	-	310730	6406550	-	-	114.48	-	-	-	Sandstone/Siltstone	West Pit	-
PB2(d)	11/04/2008	309665	6402643	71.063	-	0	14.5	-	11.5	Alluvial Floor	Carrington	-
PB2(s)	11/04/2008	309665	6402643	71.063	-	0	14.5	-	6	Top of Gravels	Carrington	-
PB3(d)	16/04/2008	309815	6402620	75.726	-	0	16.1	-	13.1	Alluvial Floor	Carrington	-
PB3(s)	16/04/2008	309815	6402620	75.726	-	0	16.1	-	4.75	Top of Gravels	Carrington	-
PZ1CH200	-	312643	6402254	-	-	62.08	-	-	-	Alluvium	-	-
PZ2CH400	-	312633.14	6402050.41	-	-	62.6	-	-	-	Alluvium	-	-
PZ3CH800	-	312520.28	6401674.77	-	-	64.18	-	-	-	Alluvium	-	-
PZ4CH1380	-	312193.3	6401176.84	-	-	65.17	-	-	-	Alluvium	-	-
PZ5CH1800	-	311852.02	6400927.41	-	-	66.25	-	-	-	Alluvium	-	-
PZ6CH2450	-	311233.47	6400725.96	-	-	67.61	-	-	-	Alluvium	-	-
PB4(d)	2/04/2008	309952	6402570	70.141	-	-	16.7	-	13.7	-	-	-

PB4(s)	2/04/2008	309952	6402570	70.141	-	-	16.7	-	4.5	-	-	-
PB5(d)	22/04/2008	310134	6402487	63.387	-	-	16.3	-	13.3	-	-	-
PB5(s)	22/04/2008	310134	6402487	63.387	-	-	16.3	-	4.5	-	-	-
PB6(d)	29/04/2008	310256	6402424	68.547	-	0	16.75	-	13.75	Alluvial Floor	Carrington	-
PB6(s)	29/04/2008	310256	6402424	68.547	-	0	16.75	-	4.5	Top of Gravels	Carrington	-
PB7(d)	30/04/2008	310421	6402335	71.267	-	0	15.4	-	12.4	Alluvial Floor	Carrington	-
PB7(s)	30/04/2008	310421	6402335	71.267	-	0	15.4	-	6.1	Top of Gravels	Carrington	-
S2 HVO-W	-	311502	6407889	-	-	0	-	-	-	Rock/Coal	-	-
Wes136c	-	309641	6406483	-	-	0	-	-	-	LPG	West Pit	-

Appendix C Hydrographs

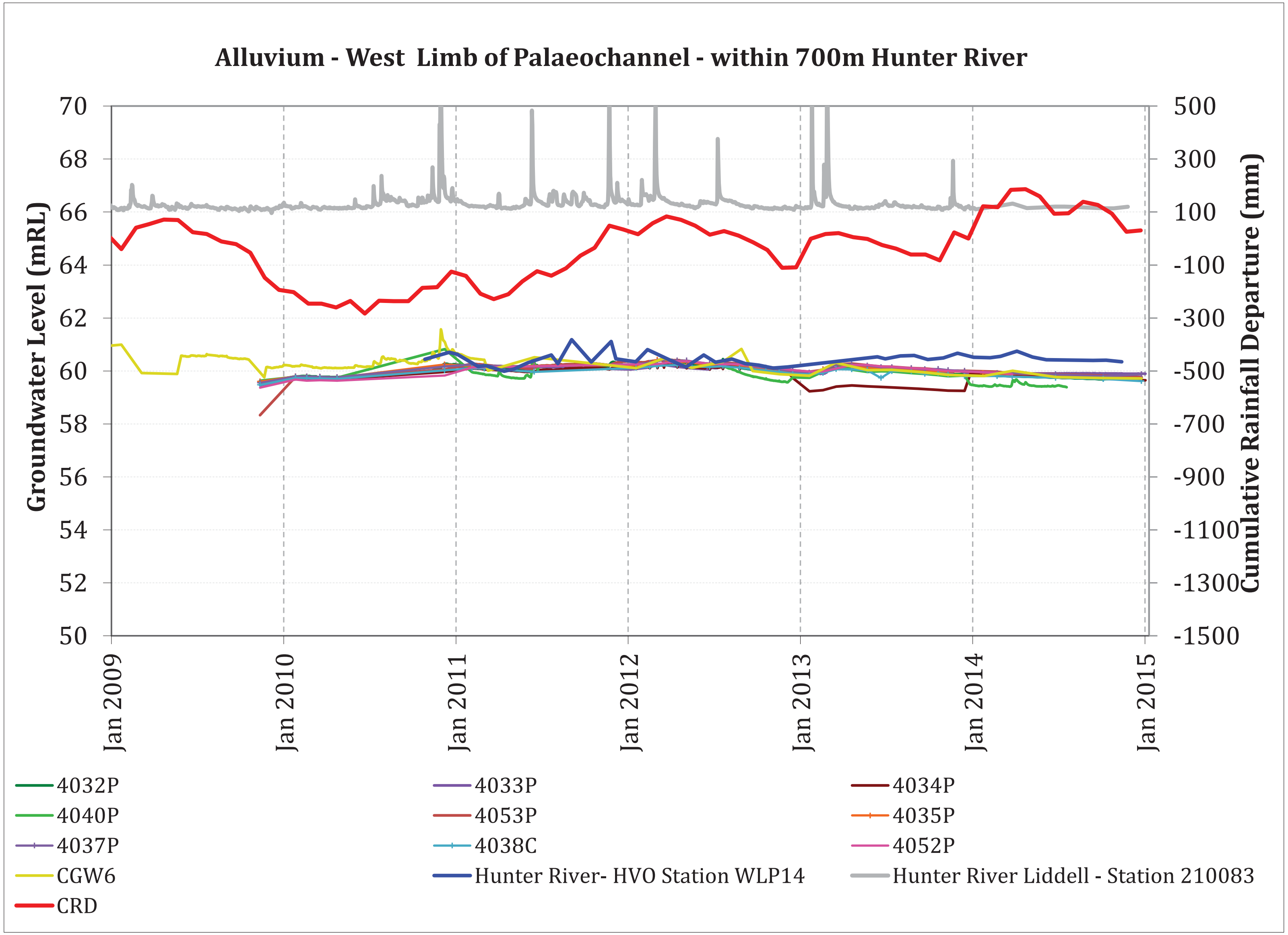


Figure 8 Hydrograph – West Limb of Paleochannel (within 700m of Hunter River)

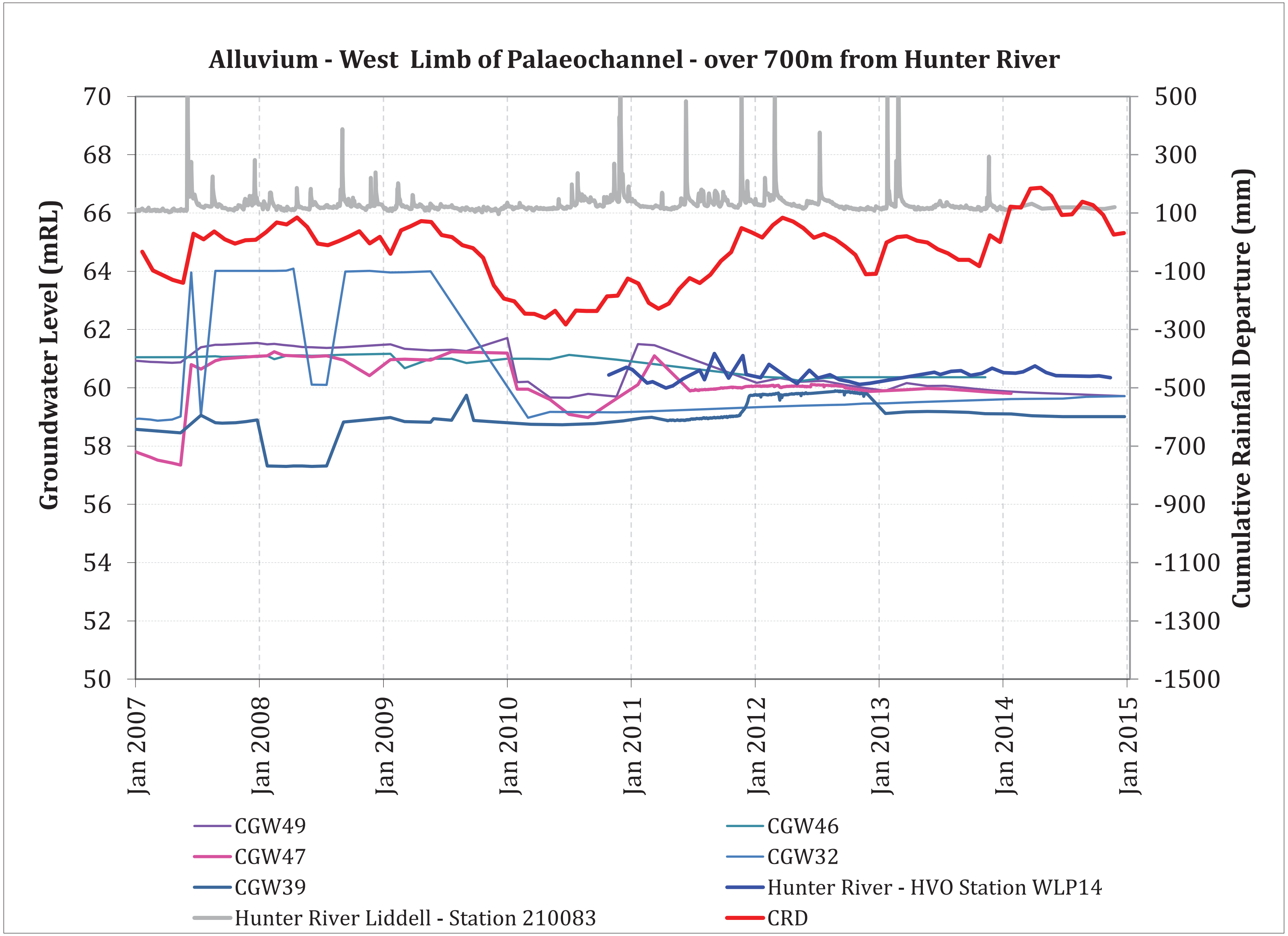


Figure 9 Hydrograph - Alluvium – West of Palaeochannel (over 700m from Hunter River)

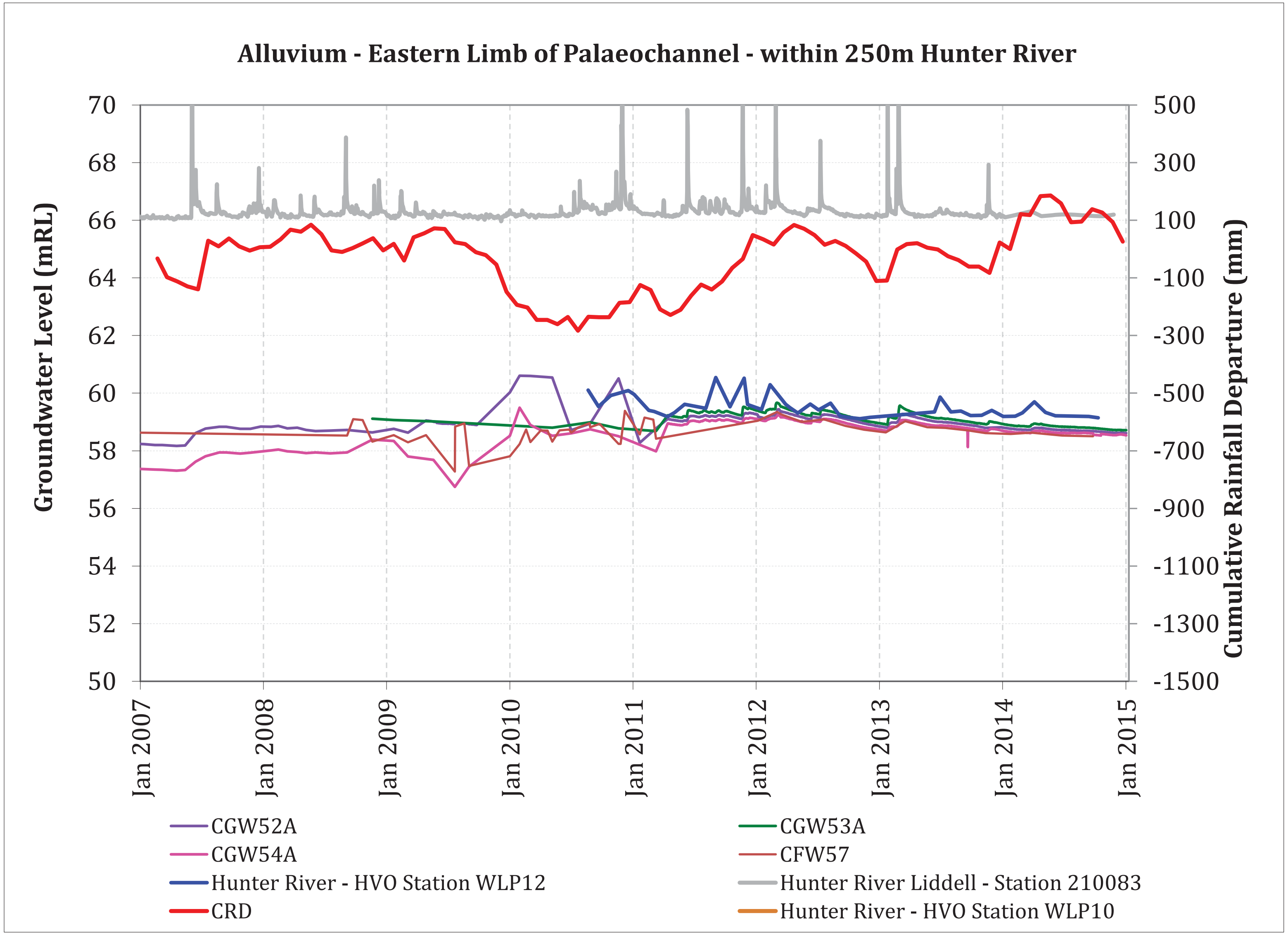


Figure 10 Hydrograph – Alluvium – East Limb of Paleochannel (within 250m of Hunter River)

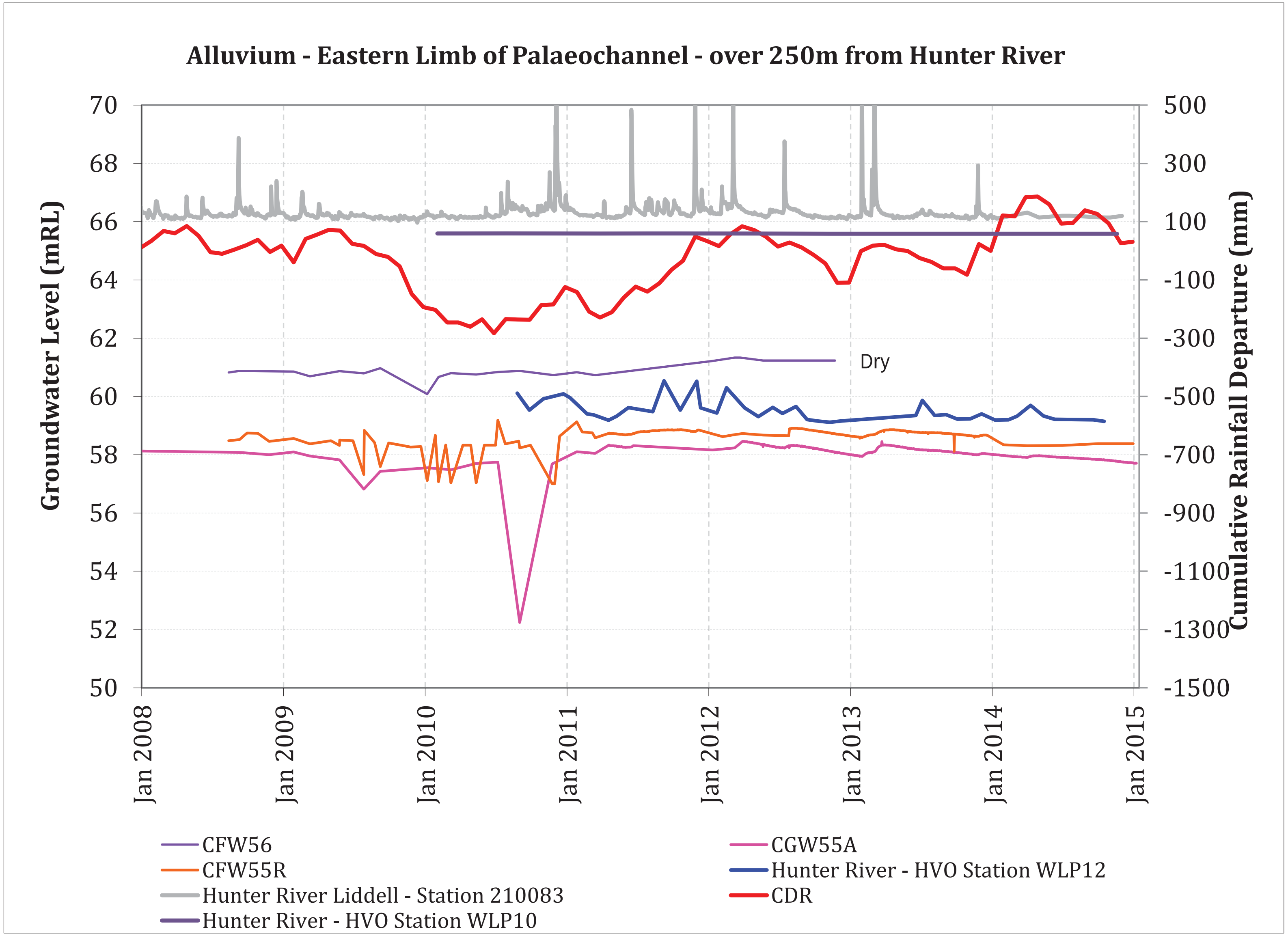


Figure 11 Hydrograph - Alluvium – East Limb of Paleochannel (over 250m from Hunter River)

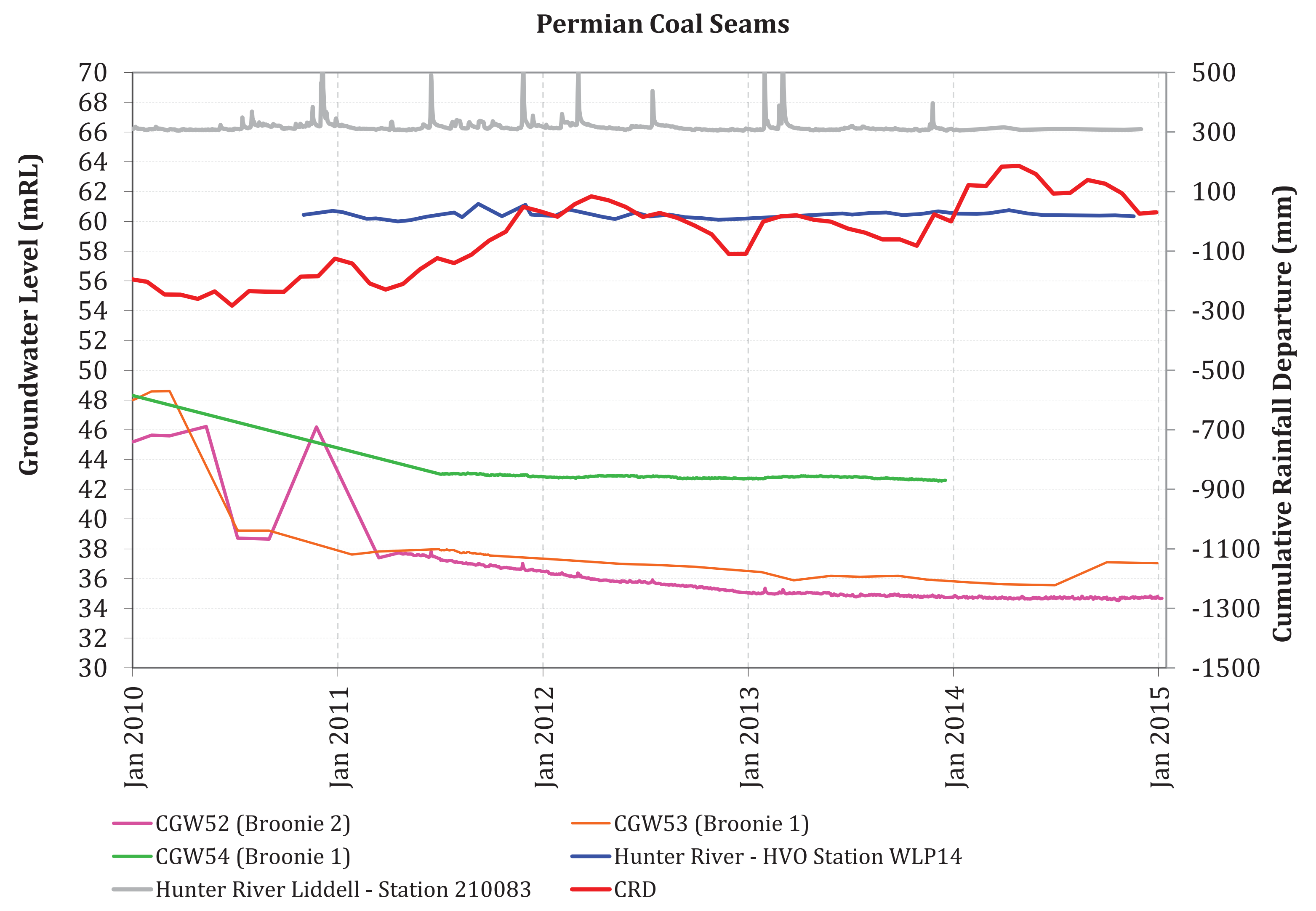


Figure 12 Hydrograph - Permian Coal Seams

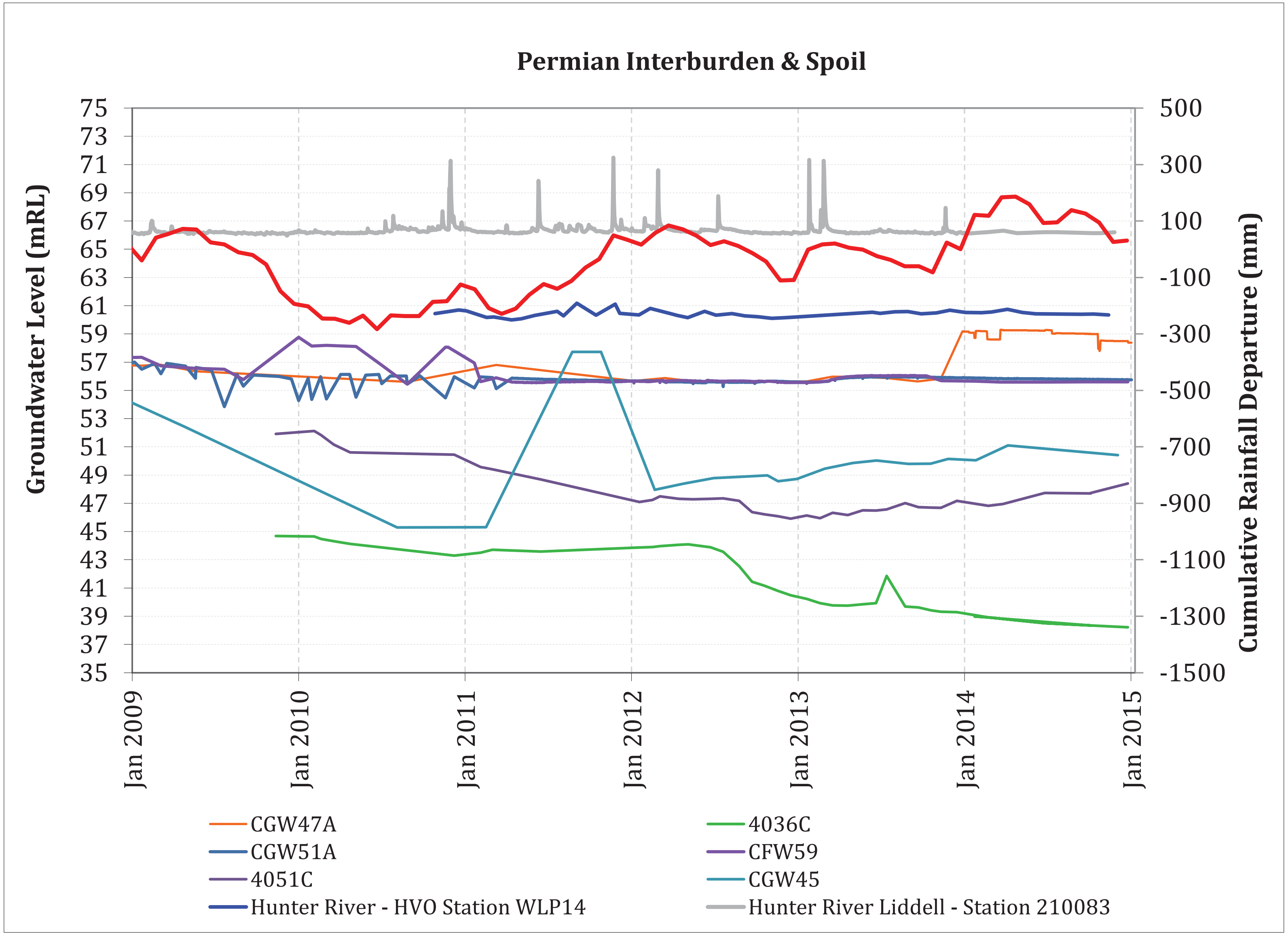


Figure 13 Permian Interburden and Spoil

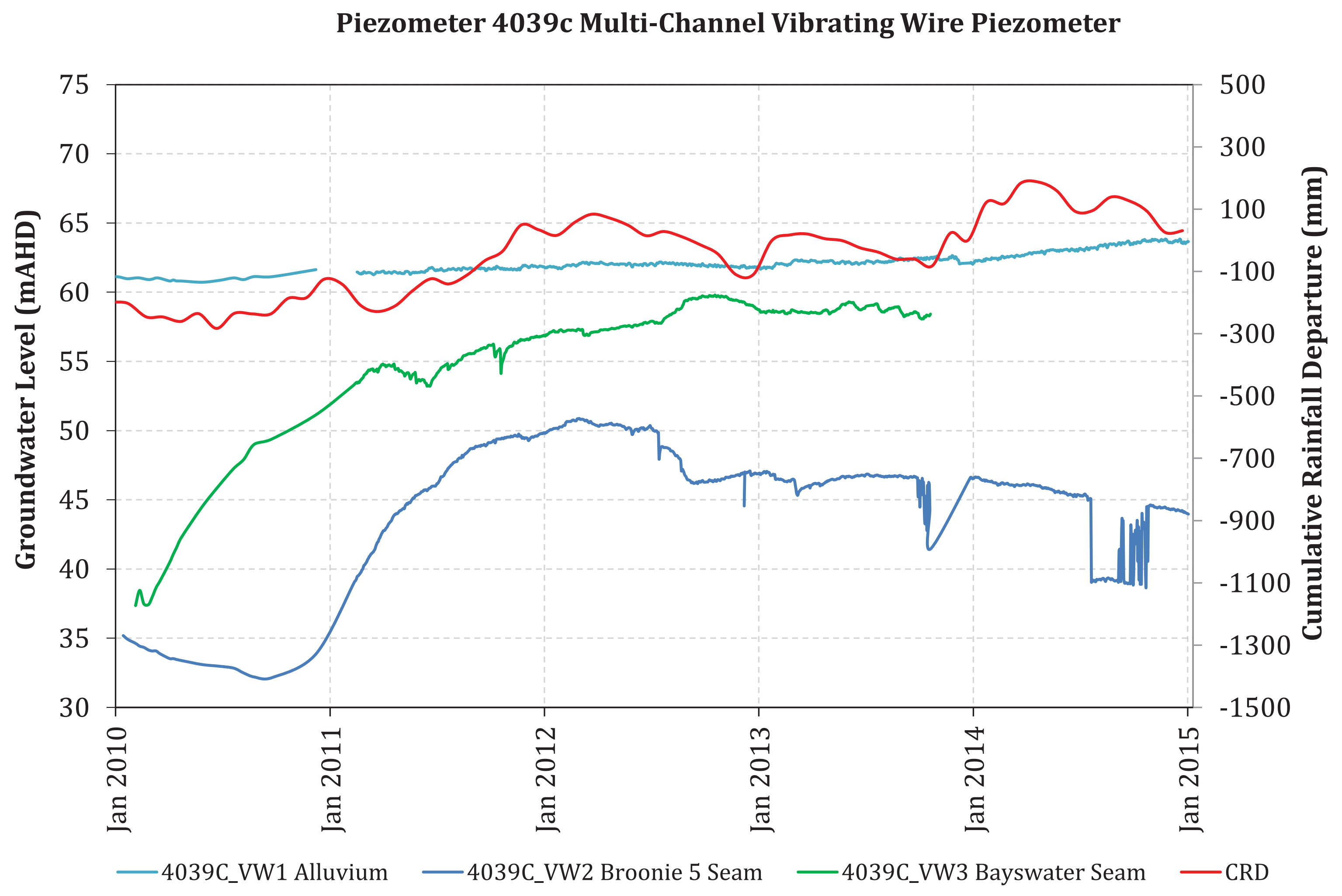


Figure 14 Hydrograph – Multi-Channel VWP 4039C

Appendix D Groundwater quality

2014 Groundwater Field Electrical Conductivity (EC)

Bore ID	Target Lithology	Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
GW-107	Carrington Spoil	Carrington	-	-	-	-	-	-	-	-	-	-	-	-
GW-108	Carrington Spoil	Carrington	-	-	-	-	-	-	-	-	-	-	-	-
4032P	Palaeochannel Alluvium	Carrington	1718	1910	1941	-	-	-	1960	-	-	1990	-	1930
4033P	Palaeochannel Alluvium	Carrington	-	-	-	-	-	-	-	-	-	-	-	-
4034P	Palaeochannel Alluvium	Carrington	1699	1920	1920	-	-	-	1940	-	-	1960	-	1880
4035P	Palaeochannel Alluvium	Carrington	1400	1619	1602	-	-	-	-	-	-	-	-	-
4037P	Palaeochannel Alluvium	Carrington	1431	1574	1608	-	-	-	1596	-	-	1598	-	1718
4038C	Palaeochannel Alluvium	Carrington	2700	3190	2670	-	-	-	3000	-	-	3220	-	2730
4040P	Palaeochannel Alluvium	Carrington	1141	1278	1306	-	-	-	1308	-	-	1318	-	1331
4052P	Palaeochannel Alluvium	Carrington	1940	2190	2240	-	-	-	-	-	-	-	-	-
4053P	Palaeochannel Alluvium	Carrington	1709	1930	1943	-	-	-	1900	-	-	1900	-	1830
CFW55R	Palaeochannel Alluvium	Carrington	2560	-	-	4050	-	-	2970	-	-	4220	-	3670
CFW56	Palaeochannel Alluvium	Carrington	-	-	-	-	-	-	-	-	-	-	-	-
CFW57	Palaeochannel Alluvium	Carrington	1810	-	-	3410	-	-	3010	-	-	3610	-	4080
CGW32	Palaeochannel Alluvium	Carrington	7520	-	-	8790	-	-	8710	-	8570	-	-	8520
CGW45	Palaeochannel Alluvium	Carrington	607	-	-	1038	-	-	1419	-	-	1127	-	1248
CGW46	Palaeochannel Alluvium	Carrington	-	-	-	3190	-	-	3070	-	-	3130	-	2940
CGW49	Palaeochannel Alluvium	Carrington	2420	-	-	2780	-	-	2790	-	-	2830	-	2750
CGW52A	Palaeochannel Alluvium	Carrington	1188	-	-	1460	-	-	1509	-	-	1533	-	1510

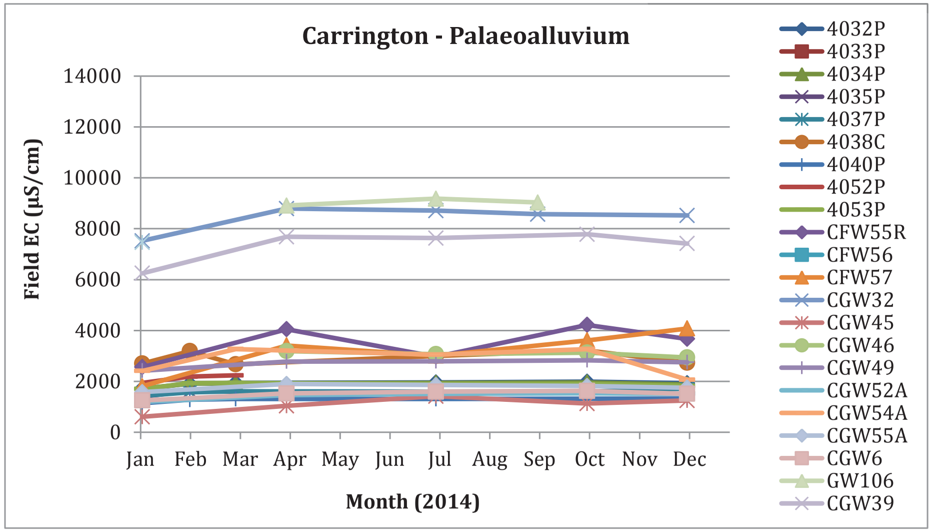
2014 Groundwater Field Electrical Conductivity (EC)

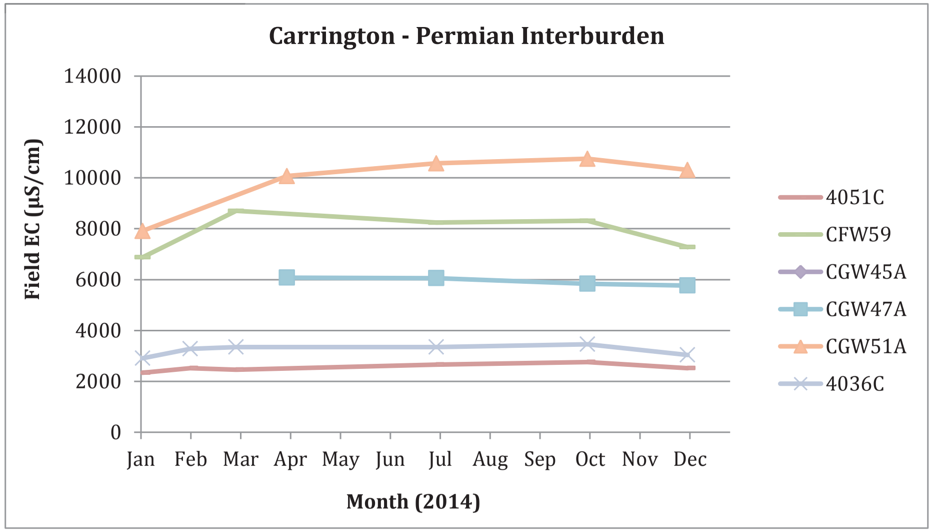
Bore ID	Target Lithology	Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CGW54A	Palaeochannel Alluvium	Carrington	2410	-	3270	-	-	-	3050	-	-	3270	-	2070
CGW55A	Palaeochannel Alluvium	Carrington	1576	-	-	1900	-	-	1860	-	-	1820	-	1752
CGW6	Palaeochannel Alluvium	Carrington	1256	-	-	1526	-	-	1597	-	-	1626	-	1513
GW-106	Palaeochannel Alluvium	Carrington	-	-	-	8910	-	-	9180	-	9030	-	-	-
CGW39	Palaeochannel Alluvium?/ Permian Interburden (Weathered Zone)/Spoil?	Carrington	6250	-	-	7680	-	-	7630	-	-	7780	-	7420
CGW47	Palaeochannel Alluvium?/ Permian Interburden (Weathered Zone)?	Carrington	7460	-	-	-	-	-	-	-	-	-	-	-
CFW57A	Permian Coal Seam	Carrington	-	-	-	-	-	-	-	-	-	-	-	-
CGW53	Permian Coal Seam (Broonie 1)	Carrington	6290	-	-	7500	-	-	7480	-	-	7590	-	7220
CGW52	Permian Coal Seam (Broonie 2)	Carrington	6740	-	-	8400	-	-	8250	-	-	8540	-	8090
4051C	Permian Interburden	Carrington	2340	2520	2460	-	-	-	2660	-	-	2760	-	2520
CFW59	Permian Interburden	Carrington	6880	-	8700	-	-	-	8240	-	-	8310	-	7280
CGW45A	Permian Interburden	Carrington	-	-	-	-	-	-	-	-	-	-	-	-
CGW47A	Permian Interburden	Carrington	-	-	-	6080	-	-	6060	-	-	5840	-	5770
CGW51A	Permian Interburden	Carrington	7910	-	-	10070	-	-	10570	-	-	10750	-	10310
4036C	Permian Interburden / Weathered Zone	Carrington	2910	3280	3350	-	-	-	3350	-	-	3460	-	3040
GA3	Alluvium	North Void/Alluvial Lands	-	-	-	-	-	-	740	-	731	-	736	756
HV3	Hunter River Alluvium	North Void/Alluvial Lands	-	-	-	-	-	-	1527	-	4190	-	1552	1408

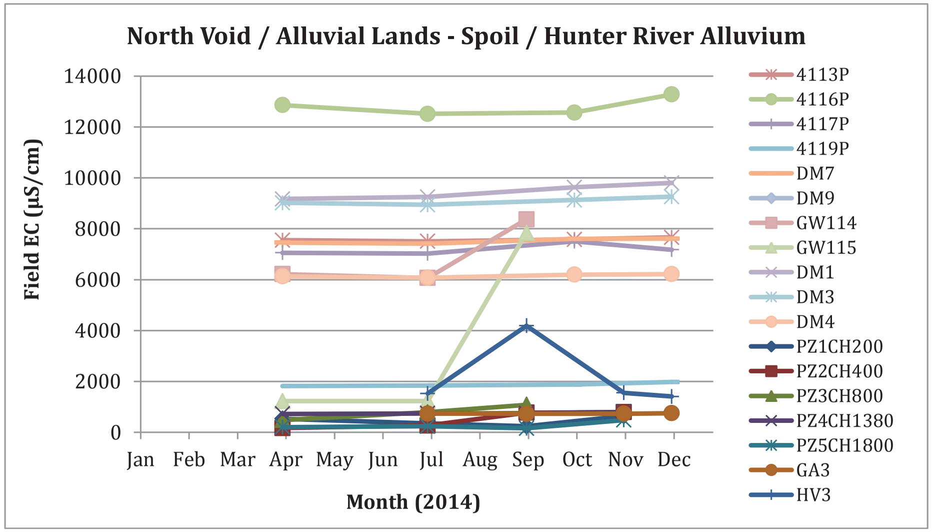
2014 Groundwater Field Electrical Conductivity (EC)

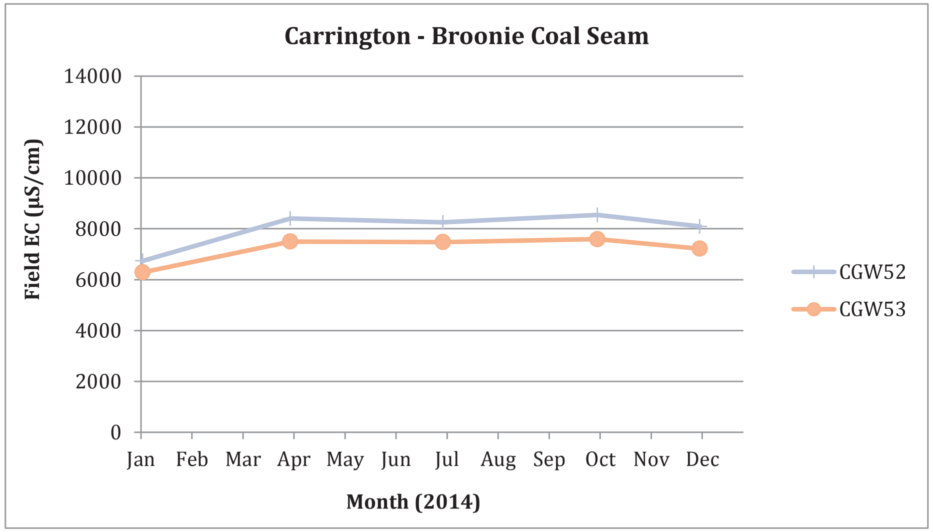
Bore ID	Target Lithology	Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
HV4	Hunter River Alluvium	North Void/Alluvial Lands	-	-	-	-	-	-	-	-	-	-	-	-
PZ1CH200	Hunter River Alluvium	North Void/Alluvial Lands	-	-	-	536	-	-	348	-	240	-	639	-
PZ2CH400	Hunter River Alluvium	North Void/Alluvial Lands	-	-	-	170	-	-	269	-	775	-	793	-
PZ3CH800	Hunter River Alluvium	North Void/Alluvial Lands	-	-	-	486	-	-	788	-	1083	-	-	-
PZ4CH1380	Hunter River Alluvium	North Void/Alluvial Lands	-	-	-	725	-	-	743	-	749	-	801	-
PZ5CH1800	Hunter River Alluvium	North Void/Alluvial Lands	-	-	-	203	-	-	242	-	160	-	486	-
4113P	Spoil	North Void/Alluvial Lands	-	-	-	7550	-	-	7510	-	-	7580	-	7660
4116P	Spoil	North Void/Alluvial Lands	-	-	-	12860	-	-	12520	-	-	12570	-	13280
4117P	Spoil	North Void/Alluvial Lands	-	-	-	7060	-	-	7030	-	-	7510	-	7180
4119P	Spoil	North Void/Alluvial Lands	-	-	-	1820	-	-	1840	-	-	1880	-	1980
DM7	Spoil	North Void/Alluvial Lands	-	-	-	7460	-	-	7420	-	-	7600	-	7610
DM9	Spoil	North Void/Alluvial Lands	-	-	-	-	-	-	-	-	-	-	-	-
GW-114	Spoil	North Void/Alluvial Lands	-	-	-	6220	-	-	6070	-	8370	-	-	-
GW-115	Spoil	North Void/Alluvial Lands	-	-	-	1230	-	-	1236	-	7840	-	-	-
DM1	Spoil (Base)	North Void/Alluvial Lands	-	-	-	9170	-	-	9250	-	-	9630	-	9800
DM3	Spoil (Base)	North Void/Alluvial Lands	-	-	-	9020	-	-	8940	-	-	9130	-	9260
DM4	Spoil (Base)	North Void/Alluvial Lands	-	-	-	6130	-	-	6080	-	-	6200	-	6220

Field Electrical Conductivity (EC)









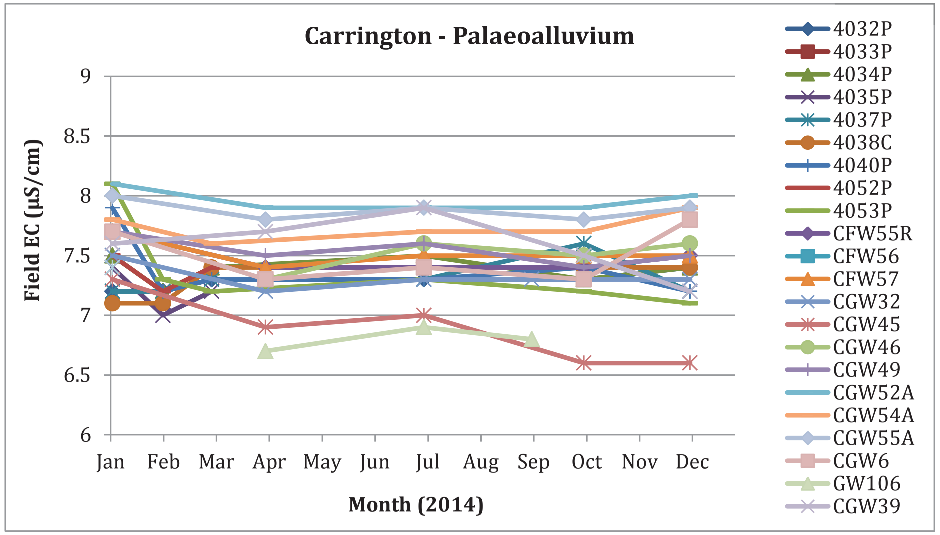
2014 Groundwater Field pH

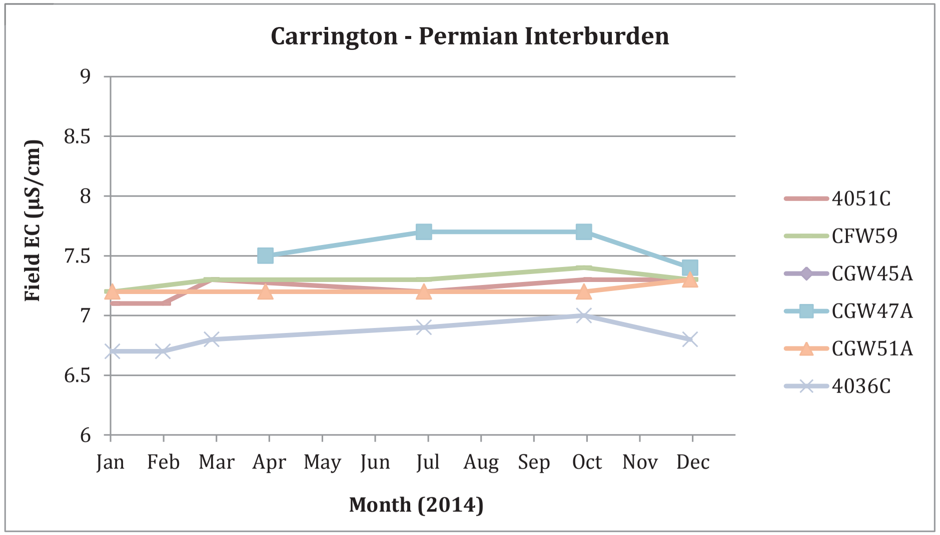
Bore ID	Target Lithology	Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
GW-107	Carrington Spoil	Carrington	-	-	-	-	-	-	-	-	-	-	-	-
GW-108	Carrington Spoil	Carrington	-	-	-	-	-	-	-	-	-	-	-	-
4032P	Palaeochannel Alluvium	Carrington	7.2	7.2	7.3	-	-	-	7.3	-	-	7.3	-	7.4
4033P	Palaeochannel Alluvium	Carrington	-	-	-	-	-	-	-	-	-	-	-	-
4034P	Palaeochannel Alluvium	Carrington	7.5	7.2	7.4	-	-	-	7.5	-	-	7.3	-	7.4
4035P	Palaeochannel Alluvium	Carrington	7.4	7	7.2	-	-	-	-	-	-	-	-	-
4037P	Palaeochannel Alluvium	Carrington	7.2	7.2	7.3	-	-	-	7.3	-	-	7.6	-	7.2
4038C	Palaeochannel Alluvium	Carrington	7.1	7.1	7.4	-	-	-	7.4	-	-	7.4	-	7.4
4040P	Palaeochannel Alluvium	Carrington	7.9	7.2	7.3	-	-	-	7.3	-	-	7.4	-	7.2
4052P	Palaeochannel Alluvium	Carrington	7.5	7.2	7.4	-	-	-	-	-	-	-	-	-
4053P	Palaeochannel Alluvium	Carrington	8.1	7.3	7.2	-	-	-	7.3	-	-	7.2	-	7.1
CFW55R	Palaeochannel Alluvium	Carrington	7.7	-	-	7.4	-	-	7.4	-	-	7.4	-	7.5
CFW56	Palaeochannel Alluvium	Carrington	-	-	-	-	-	-	-	-	-	-	-	-
CFW57	Palaeochannel Alluvium	Carrington	7.7	-	-	7.4	-	-	7.5	-	-	7.5	-	7.5
CGW32	Palaeochannel Alluvium	Carrington	7.5	-	-	7.2	-	-	7.3	-	7.3	-	-	7.3
CGW45	Palaeochannel Alluvium	Carrington	7.3	-	-	6.9	-	-	7	-	-	6.6	-	6.6
CGW46	Palaeochannel Alluvium	Carrington	-	-	-	7.3	-	-	7.6	-	-	7.5	-	7.6
CGW49	Palaeochannel Alluvium	Carrington	7.7	-	-	7.5	-	-	7.6	-	-	7.4	-	7.5
CGW52A	Palaeochannel Alluvium	Carrington	8.1	-	-	7.9	-	-	7.9	-	-	7.9	-	8
CGW54A	Palaeochannel Alluvium	Carrington	7.8	-	7.6	-	-	-	7.7	-	-	7.7	-	7.9

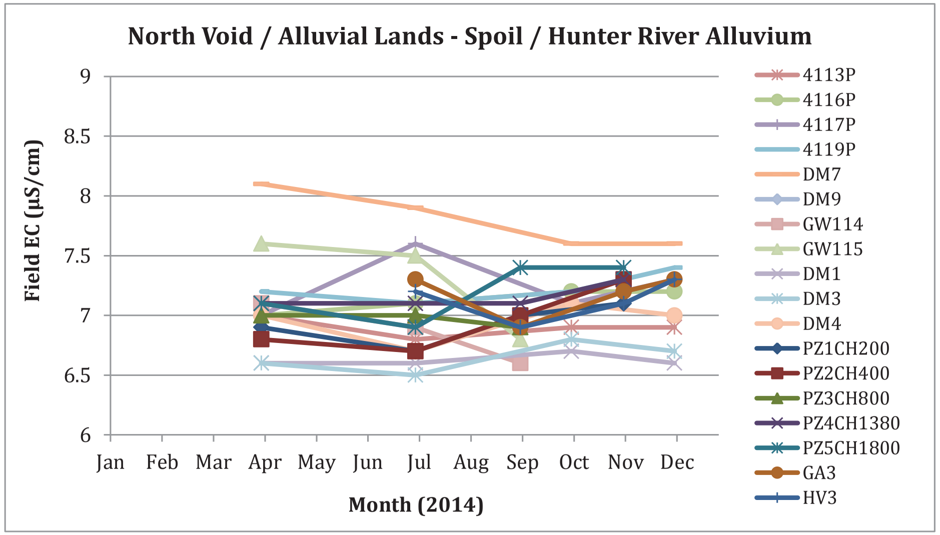
CGW55A	Palaeochannel Alluvium	Carrington	8	-	-	7.8	-	-	7.9	-	-	7.8	-	7.9
CGW6	Palaeochannel Alluvium	Carrington	7.7	-	-	7.3	-	-	7.4	-	-	7.3	-	7.8
GW-106	Palaeochannel Alluvium	Carrington	-	-	-	6.7	-	-	6.9	-	6.8	-	-	-
CGW39	Palaeochannel Alluvium?/ Permian Interburden (Weathered Zone)/Spoil?	Carrington	7.6	-	-	7.7	-	-	7.9	-	-	7.5	-	7.2
CGW47	Palaeochannel Alluvium?/ Permian Interburden (Weathered Zone)?	Carrington	7.4	-	-	-	-	-	-	-	-	-	-	-
CFW57A	Permian Coal Seam	Carrington	-	-	-	-	-	-	-	-	-	-	-	-
CGW53	Permian Coal Seam (Broonie 1)	Carrington	6.9	-	-	6.9	-	-	7	-	-	7	-	7.2
CGW52	Permian Coal Seam (Broonie 2)	Carrington	6.8	-	-	6.9	-	-	7	-	-	7	-	6.9
4051C	Permian Interburden	Carrington	7.1	7.1	7.3	-	-	-	7.2	-	-	7.3	-	7.3
CFW59	Permian Interburden	Carrington	7.2	-	7.3	-	-	-	7.3	-	-	7.4	-	7.3
CGW45A	Permian Interburden	Carrington	-	-	-	-	-	-	-	-	-	-	-	-
CGW47A	Permian Interburden	Carrington	-	-	-	7.5	-	-	7.7	-	-	7.7	-	7.4
CGW51A	Permian Interburden	Carrington	7.2	-	-	7.2	-	-	7.2	-	-	7.2	-	7.3
4036C	Permian Interburden / Weathered Zone	Carrington	6.7	6.7	6.8	-	-	-	6.9	-	-	7	-	6.8
GA3	Alluvium	North Void/Alluvial Lands	-	-	-	-	-	-	7.3	-	6.9	-	7.2	7.3
HV3	Hunter River Alluvium	North Void/Alluvial Lands	-	-	-	-	-	-	7.2	-	6.9	-	7.1	7.3
HV4	Hunter River Alluvium	North Void/Alluvial Lands	-	-	-	-	-	-	-	-	-	-	-	-
PZ1CH200	Hunter River Alluvium	North Void/Alluvial Lands	-	-	-	6.9	-	-	6.7	-	7	-	7.1	-
PZ2CH400	Hunter River Alluvium	North Void/Alluvial Lands	-	-	-	6.8	-	-	6.7	-	7	-	7.3	-
PZ3CH800	Hunter River Alluvium	North Void/Alluvial Lands	-	-	-	7	-	-	7	-	6.9	-	-	-
PZ4CH1380	Hunter River Alluvium	North Void/Alluvial Lands	-	-	-	7.1	-	-	7.1	-	7.1	-	7.3	-
PZ5CH1800	Hunter River Alluvium	North Void/Alluvial Lands	-	-	-	7.1	-	-	6.9	-	7.4	-	7.4	-

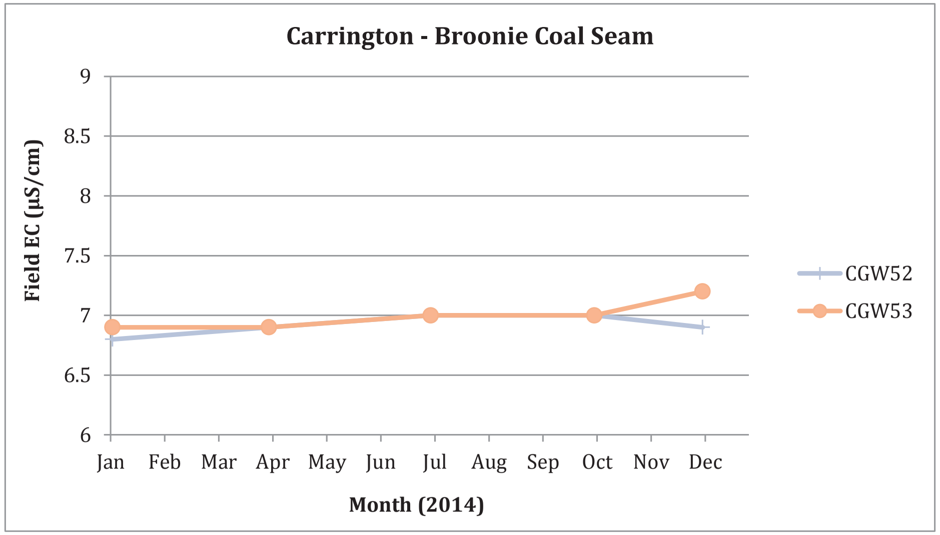
4113P	Spoil	North Void/Alluvial Lands	-	-	-	7	-	-	6.8	-	-	6.9	-	6.9
4116P	Spoil	North Void/Alluvial Lands	-	-	-	7	-	-	7.1	-	-	7.2	-	7.2
4117P	Spoil	North Void/Alluvial Lands	-	-	-	7	-	-	7.6	-	-	7.1	-	7.3
4119P	Spoil	North Void/Alluvial Lands	-	-	-	7.2	-	-	7.1	-	-	7.2	-	7.4
DM7	Spoil	North Void/Alluvial Lands	-	-	-	8.1	-	-	7.9	-	-	7.6	-	7.6
DM9	Spoil	North Void/Alluvial Lands	-	-	-	-	-	-	-	-	-	-	-	-
GW-114	Spoil	North Void/Alluvial Lands	-	-	-	7.1	-	-	6.9	-	6.6	-	-	-
GW-115	Spoil	North Void/Alluvial Lands	-	-	-	7.6	-	-	7.5	-	6.8	-	-	-
DM1	Spoil (Base)	North Void/Alluvial Lands	-	-	-	6.6	-	-	6.6	-	-	6.7	-	6.6
DM3	Spoil (Base)	North Void/Alluvial Lands	-	-	-	6.6	-	-	6.5	-	-	6.8	-	6.7
DM4	Spoil (Base)	North Void/Alluvial Lands	-	-	-	7	-	-	6.7	-	-	7.1	-	7

Field pH


Carrington - Palaeoalluvium
Field EC (µS/cm)
9
8.5
8
7.5
7
6.5
6
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month (2014)
4032P
4033P
4034P
4035P
4037P
4038C
4040P
4052P
4053P
CFW55R
CFW56
CFW57
CGW32
CGW45
CGW46
CGW49
CGW52A
CGW54A
CGW55A
CGW6
GW106
CGW39


Carrington - Permian Interburden
Field EC (µS/cm)
9
8.5
8
7.5
7
6.5
6
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month (2014)
4051C
CFW59
CGW45A
CGW47A
CGW51A
4036C

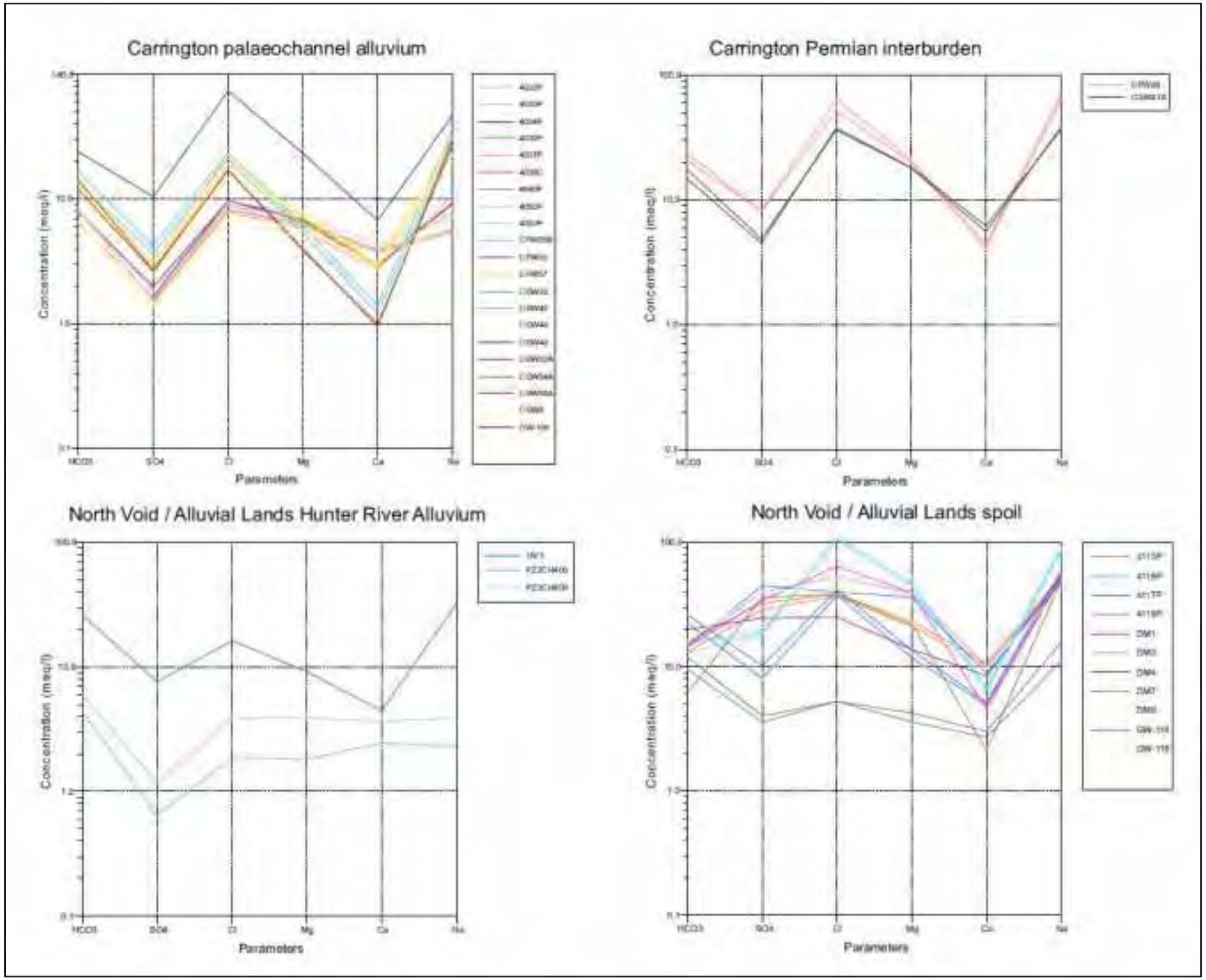

North Void / Alluvial Lands - Spoil / Hunter River Alluvium
Field EC (µS/cm)
9
8.5
8
7.5
7
6.5
6
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month (2014)
4113P
4116P
4117P
4119P
DM7
DM9
GW114
GW115
DM1
DM3
DM4
PZ1CH200
PZ2CH400
PZ3CH800
PZ4CH1380
PZ5CH1800
GA3
HV3


Carrington - Broonie Coal Seam
Field EC (µS/cm)
9
8.5
8
7.5
7
6.5
6
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month (2014)
CGW52
CGW53

Station	Geology	Site	Date	Al - Total (mg/l)	Alk - Total (mg/l)	As - Total (mg/l)	B (mg/l)	Ba (mg/l)	Ca - Total (mg/l)	CaCO3 - Total Hard (mg/l)	Cl- (mg/l)	Fe - Filtered (mg/L)	Hydroxide Alk (mg/l)	K - Total (mg/l)	Li (mg/l)	Mg - Total (mg/l)	Mn - Total (mg/l)	Na - Total (mg/l)	Nitrogen Ammonia (mg/l)	P - Total (mg/l)	Se (mg/l)	Si (mg/l)	SO4 - Total (mg/l)	Sr - Total (mg/l)	TDS - Total (mg/l)	Zn - Total (mg/l)
4032P	Palaeochannel Alluvium	Carrington	Mar	6.33	-	0.002	0.09	0.079	54	-	327	0.05	-	2	0.003	69	0.198	241	0.01	0.76	0.01	38.9	74	1.24	-	0.077
4032P	Palaeochannel Alluvium	Carrington	Oct	5.1	415	0.002	0.08	-	54	-	320	-	1	2	-	69	-	242	-	-	0.01	-	90	-	1120	0.116
4034P	Palaeochannel Alluvium	Carrington	Mar	0.76	-	0.002	0.08	0.034	61	-	348	0.05	-	3	0.003	84	0.097	212	0.09	0.57	0.01	35.7	80	0.957	-	0.02
4034P	Palaeochannel Alluvium	Carrington	Oct	0.22	384	0.002	0.08	-	58	-	342	-	1	2	-	81	-	214	-	-	0.01	-	96	-	1050	0.015
4035P	Palaeochannel Alluvium	Carrington	Mar	2.09	-	0.002	0.06	0.084	77	-	284	0.05	-	2	0.002	80	0.288	131	0.66	0.61	0.01	42.1	72	1.07	-	0.032
4037P	Palaeochannel Alluvium	Carrington	Mar	1.39	-	0.001	0.05	0.045	79	-	291	0.05	-	1	0.002	78	0.186	128	0.02	0.45	0.01	41.3	72	1.08	-	0.066
4037P	Palaeochannel Alluvium	Carrington	Oct	1.56	320	0.001	0.06	-	76	-	274	-	1	1	-	75	-	124	-	-	0.01	-	78	-	830	0.057
4053P	Palaeochannel Alluvium	Carrington	Mar	3.84	-	0.002	0.06	0.071	85	-	342	0.05	-	2	0.005	93	0.133	180	0.02	0.58	0.01	41.3	69	1.35	-	0.034
4053P	Palaeochannel Alluvium	Carrington	Oct	11.3	416	0.003	0.08	-	77	-	316	-	1	2	-	85	-	172	-	-	0.01	-	74	-	966	0.139
CFW55R	Palaeochannel Alluvium	Carrington	Apr	-	670	0.001	-	-	24	-	751	-	<1	16	-	66	-	708	-	-	-	-	176	-	-	0.007
CFW55R	Palaeochannel Alluvium	Carrington	Oct	0.65	823	0.001	0.14	-	28	-	829	-	1	21	-	75	-	830	-	-	0.01	-	204	-	2170	0.007
CFW57	Palaeochannel Alluvium	Carrington	Apr	-	549	<0.001	-	-	58	-	668	-	<1	5	-	77	-	521	-	-	-	-	134	-	-	<0.005
CFW57	Palaeochannel Alluvium	Carrington	Oct	0.32	680	0.001	0.1	-	59	-	817	-	1	6	-	86	-	716	-	-	0.01	-	146	-	1960	0.005
CGW46	Palaeochannel Alluvium	Carrington	Apr	-	712	0.003	-	-	60	-	522	-	<1	6	-	96	-	461	-	-	-	-	121	-	-	0.611
CGW46	Palaeochannel Alluvium	Carrington	Oct	2.26	806	0.002	0.11	-	61	-	524	-	1	7	-	98	-	529	-	-	0.04	-	122	-	1740	0.136
CGW54A	Palaeochannel Alluvium	Carrington	Mar	-	602	0.001	-	-	20	-	611	-	<1	7	-	47	-	611	-	-	-	-	126	-	-	<0.005
CGW54A	Palaeochannel Alluvium	Carrington	Oct	0.06	712	0.002	0.14	-	19	-	604	-	1	8	-	49	-	678	-	-	0.01	-	129	-	1780	0.005
CGW6	Palaeochannel Alluvium	Carrington	Apr	-	338	0.001	-	-	55	-	245	-	<1	2	-	59	-	164	-	-	-	-	63	-	-	<0.005
CGW6	Palaeochannel Alluvium	Carrington	Oct	0.01	399	0.001	0.07	-	62	-	273	-	1	3	-	68	-	195	-	-	0.01	-	68	-	865	0.005
GW-106	Palaeochannel Alluvium	Carrington	Sep	0.04	1200	<0.001	0.15	-	135	-	2620	-	<1	30	-	284	-	1080	-	-	<0.01	-	502	-	5390	<0.005
CGW39	Palaeochannel Alluvium?/ Permian Interburden (Weathered Zone)/Spoil?	Carrington	Apr	-	726	0.004	-	-	153	-	1930	-	<1	10	-	277	-	1080	-	-	-	-	306	-	-	0.065
CGW39	Palaeochannel Alluvium?/ Permian Interburden (Weathered Zone)/Spoil?	Carrington	Oct	0.54	936	0.001	0.08	-	154	-	2140	-	1	12	-	304	-	1200	-	-	0.01	-	330	-	5020	0.014
CFW59	Permian Interburden	Carrington	Mar	-	1040	<0.001	-	-	88	-	2270	-	<1	29	-	253	-	1580	-	-	-	-	390	-	-	0.014
CFW59	Permian Interburden	Carrington	Oct	0.84	1190	0.001	0.15	-	82	-	1830	-	1	32	-	241	-	1430	-	-	0.01	-	384	-	4830	0.006
CGW47A	Permian Interburden	Carrington	Apr	-	743	<0.001	-	-	123	-	1330	-	<1	9	-	220	-	834	-	-	-	-	215	-	-	0.014
CGW47A	Permian Interburden	Carrington	Oct	0.01	881	0.001	0.08	-	111	-	1280	-	1	10	-	218	-	868	-	-	0.02	-	232	-	3100	0.018

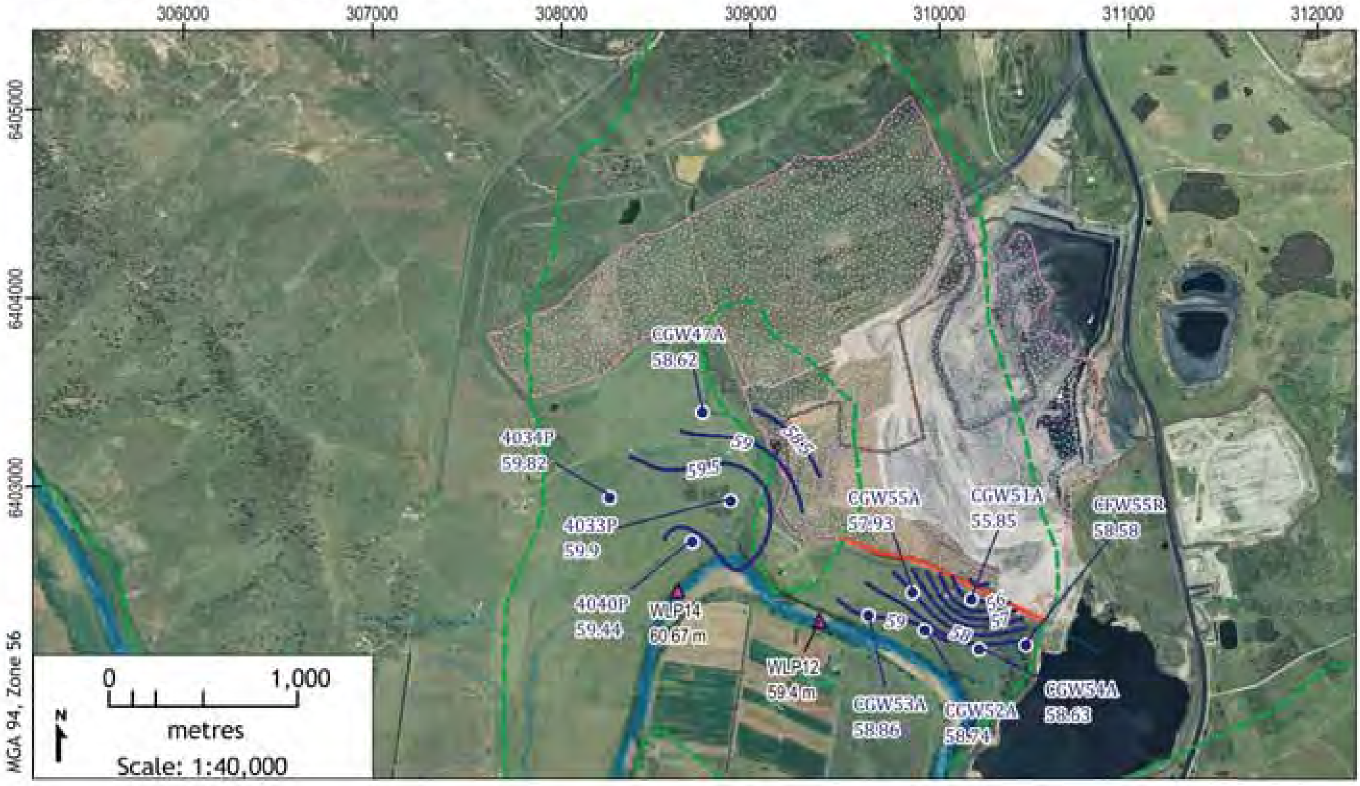
HV3	Hunter River Alluvium	North Void / Alluvial Lands	Sep	<0.01	1300	<0.001	0.13	-	89	-	574	-	<1	28	-	111	-	735	-	-	<0.01	-	364	-	2600	<0.005
PZ2CH400	Hunter River Alluvium	North Void / Alluvial Lands	Sep	1.94	220	0.003	<0.05	-	49	-	66	8.17	<1	8	<0.001	22	0.257	53	0.02	0.14	<0.01	21.6	31	0.342	312	0.018
PZ3CH800	Hunter River Alluvium	North Void / Alluvial Lands	Sep	0.32	296	<0.001	<0.05	-	73	-	136	0.05	<1	2	0.001	47	0.041	89	13.8	0.96	<0.01	27.6	56	0.599	593	0.006
4113P	Spoil	North Void / Alluvial Lands	Apr	-	664	0.005	-	-	202	-	1310	-	<1	35	-	258	-	1180	-	-	-	-	1390	-	-	0.397
4113P	Spoil	North Void / Alluvial Lands	Oct	2.24	800	0.002	0.14	-	214	-	1360	-	1	40	-	284	-	1260	-	-	0.01	-	1570	-	5110	0.18
4116P	Spoil	North Void / Alluvial Lands	Apr	-	653	0.006	-	-	138	-	3830	-	<1	48	-	554	-	2090	-	-	-	-	888	-	-	0.033
4116P	Spoil	North Void / Alluvial Lands	Oct	0.38	781	0.003	0.13	-	132	-	3780	-	1	51	-	553	-	2000	-	-	0.01	-	926	-	8480	0.026
4117P	Spoil	North Void / Alluvial Lands	Apr	-	1120	0.094	-	-	100	-	1340	-	<1	24	-	144	-	1250	-	-	-	-	391	-	-	<0.005
4117P	Spoil	North Void / Alluvial Lands	Oct	0.11	1310	0.068	0.14	-	104	-	1480	-	1	22	-	166	-	1360	-	-	0.01	-	490	-	4530	0.005
4119P	Spoil	North Void / Alluvial Lands	Apr	-	481	0.066	-	-	55	-	189	-	<1	15	-	44	-	258	-	-	-	-	173	-	-	0.011
4119P	Spoil	North Void / Alluvial Lands	Oct	0.01	598	0.07	0.09	-	61	-	188	-	1	19	-	52	-	366	-	-	0.01	-	194	-	1060	0.009
DM7	Spoil	North Void / Alluvial Lands	Apr	-	277	-	-	-	-	1290	-	-	<1	-	-	-	-	-	-	-	-	-	-	-	-	-
DM7	Spoil	North Void / Alluvial Lands	Jul	-	341	-	-	-	-	1280	-	-	<1	-	-	-	-	-	-	-	-	-	-	-	-	-
DM7	Spoil	North Void / Alluvial Lands	Oct	0.14	311	0.001	0.06	-	43	-	1360	-	1	37	-	269	-	1150	-	-	0.01	-	1750	-	5110	0.006
DM7	Spoil	North Void / Alluvial Lands	Dec	-	343	-	-	-	-	1222	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-
GW-114	Spoil	North Void / Alluvial Lands	Sep	0.05	750	0.013	0.19	-	178	-	1420	-	<1	52	-	443	-	1110	-	-	<0.01	-	2160	-	6230	0.12
GW-115	Spoil	North Void / Alluvial Lands	Sep	0.03	814	0.018	0.12	-	194	-	1540	-	<1	23	-	278	-	981	-	-	<0.01	-	1950	-	6170	0.026
DM1	Spoil (Base)	North Void / Alluvial Lands	Apr	-	716	-	-	-	-	2360	-	-	<1	-	-	-	-	-	-	-	-	-	-	-	-	-
DM1	Spoil (Base)	North Void / Alluvial Lands	Jul	-	849	-	-	-	-	2340	-	-	<1	-	-	-	-	-	-	-	-	-	-	-	-	-
DM1	Spoil (Base)	North Void / Alluvial Lands	Oct	20	722	0.024	0.14	-	92	-	2290	-	1	44	-	480	-	1210	-	-	0.01	-	1650	-	5420	0.183
DM1	Spoil (Base)	North Void / Alluvial Lands	Dec	-	806	-	-	-	-	2500	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-
DM3	Spoil (Base)	North Void / Alluvial Lands	Apr	-	712	-	-	-	-	2640	-	-	<1	-	-	-	-	-	-	-	-	-	-	-	-	-

DM3	Spoil (Base)	North Void / Alluvial Lands	Jul	-	863	-	-	-	-	2540	-	-	<1	-	-	-	-	-	-	-	-	-	-	-	-	-
DM3	Spoil (Base)	North Void / Alluvial Lands	Oct	0.11	741	0.001	0.08	-	202	-	1890	-	1	26	-	478	-	1140	-	-	0.01	-	1920	-	6640	0.023
DM3	Spoil (Base)	North Void / Alluvial Lands	Dec	-	826	-	-	-	-	2518	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-
DM4	Spoil (Base)	North Void / Alluvial Lands	Apr	-	782	-	-	-	-	1060	-	-	<1	-	-	-	-	-	-	-	-	-	-	-	-	-
DM4	Spoil (Base)	North Void / Alluvial Lands	Jul	-	935	-	-	-	-	1100	-	-	<1	-	-	-	-	-	-	-	-	-	-	-	-	-
DM4	Spoil (Base)	North Void / Alluvial Lands	Oct	2.7	998	0.206	0.14	-	170	-	892	-	1	44	-	169	-	1250	-	-	0.01	-	1190	-	8940	0.079
DM4	Spoil (Base)	North Void / Alluvial Lands	Dec	-	894	-	-	-	-	1037	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	-


Carrington palaeochannel alluvium
Carrington Permian interburden
North Void / Alluvial Lands Hunter River Alluvium
North Void / Alluvial Lands spoil
Concentration (meq/l)
Parameters
HCO3
SO4
Cl
Mg
Ca
Na
100.0
10.0
1.0
0.1
DM1
DM4

Appendix E Groundwater flow contours

Palaeochannel Alluvium Groundwater Contours



Permian Coal and Interburden Groundwater Contours

LEGEND:

- ☐ HVO Disturbance Area
- ▨ Spoil
- — Barrier Wall
- - - Interpolated Palaeochannel & Alluvial Extent
- 🟦 Hunter River
- ▲ Surface Water Monitoring Site
- ● Groundwater Moitoring Bores (observed water level, mAHD)
- — Groundwater Contour, Interpolated Water Level (mAHD)

HVO North (G1593H)
2014 Groundwater Impacts Report

Carrington Groundwater Contours

DATE:
28/1/2015

FIGURE No:
14

Appendix F Groundwater calculations assumptions

In order to apply Darcy's Law, several assumptions were made to calculate the hydraulic conductivity (K), hydraulic gradient (i) and area (A). These assumptions are detailed below.

Hydraulic Conductivity (K)

The steady state calculations utilised the hydraulic properties detailed in MER (c). In order to be conservative in the calculations, the highest hydraulic conductivity values for the coal measures (Bayswater Seam) were used to calculate the amount of seepage from the coal measures into the pit. A horizontal hydraulic conductivity (Kxy) value of 6x10-3 m/day and a vertical hydraulic conductivity (Kz) value of 2.60x10-4 m/day was used. The amount of alluvial groundwater seeping through the barrier wall was calculated using a Kxy value of 5.8x10-4 m/day.

Table 7 Hydraulic properties – MER (2010) Carrington Model

Strata	K_{xy} (m/day)	K_z (m/day)
Regolith	1 to 95	1
Alluvium	10	10
Shallow PCM (Layer 2-5)†	7.78×10^{-4}	7.00×10^{-5}
Bayswater Seam	6.00×10^{-3}	2.60×10^{-4}
Underlying PCM	$3.70 \times 1\ 0^{-3}$	2.10×10^{-6}
Barrier Wall	5.8×10^{-4}	

Note: *† Average of Permian Coal Measure (PCM) Layers 2 to 5 (MER, 2010)*
Kxy: Horizontal permeability
K_z: Vertical hydraulic conductivity

Hydraulic Gradient (i)

The hydraulic gradient values have been calculated using groundwater levels taken around December 2014. Equation 2 was used to calculate the horizontal hydraulic gradient (i_{xy}). The gradient of the Permian aquifer was estimated by calculating the difference in groundwater elevations for coal seam bore CGW52 and the Carrington Pit, divided by the distance of the bore from the pit. The groundwater elevation for the Carrington Pit was estimated to be around -20 mRL.

The gradient of the alluvial aquifer through the barrier wall was estimated by calculating the difference in groundwater levels for alluvial bore CGW55A, and the estimated basal elevation of the barrier wall. The results are summarised in Error! Reference source not found..

Horizontal Hydraulic Gradient Equation:

$$i_{xy} = \frac{\Delta h}{\Delta L} = \frac{h2 - h1}{length} \qquad \text{(Equation 2)}$$

where:

i_{xy} is the horizontal hydraulic gradient (dimensionless)
Δh is the difference between the hydraulic heads (m)
ΔL is the flow path length between the piezometer and edge of the pit (m)

Table 8 Horizontal hydraulic gradients

Carrington Pit Location	Bore	Discharge Point	Distance Between (m)	Groundwater Level (mRL)	Basal Elevation (mRL)	Horizontal Hydraulic Gradient (i_{XY})
Palaeochannel east limb	CGW52 (Broonie 2)	Carrington Pit	150	35.31	-20	0.37
Barrier Wall	CGW55A (Alluvium)	Base of Barrier Wall	5	57.59	50	1.52

Note: *† extrapolated width of barrier wall – through alluvium*
‡ extrapolated base of alluvium north of barrier wall

Equation 3 was used to calculate the vertical hydraulic gradient (iz) between the alluvium and the coal seam aquifers in three locations. In order to calculate iz, bore construction details and December 2014 groundwater levels were used for nested bores CGW52 and CGW53, which are screened within the alluvium and Permian coal seams at each site. The depth to the base of the alluvium was estimated to be around 50mRL, based on lithological log for bore CFW59 and extrapolation of the HVO geological model.

Vertical Hydraulic Gradient Equation:

$$i_z = \frac{\Delta h}{\Delta L} \qquad \textit{(Equation 3)}$$

where:

i_z is the vertical hydraulic gradient (dimensionless),

Δh hydraulic head in the alluvial bore (mRL) minus the hydraulic head in the coal seam bore (mRL),

ΔL thickness of interburden calculated from the depth of the alluvial bore (assumed as the base of the alluvium (mRL) minus the estimated depth to the base of the Permian overburden (mRL).

Table 9 Vertical hydraulic gradients

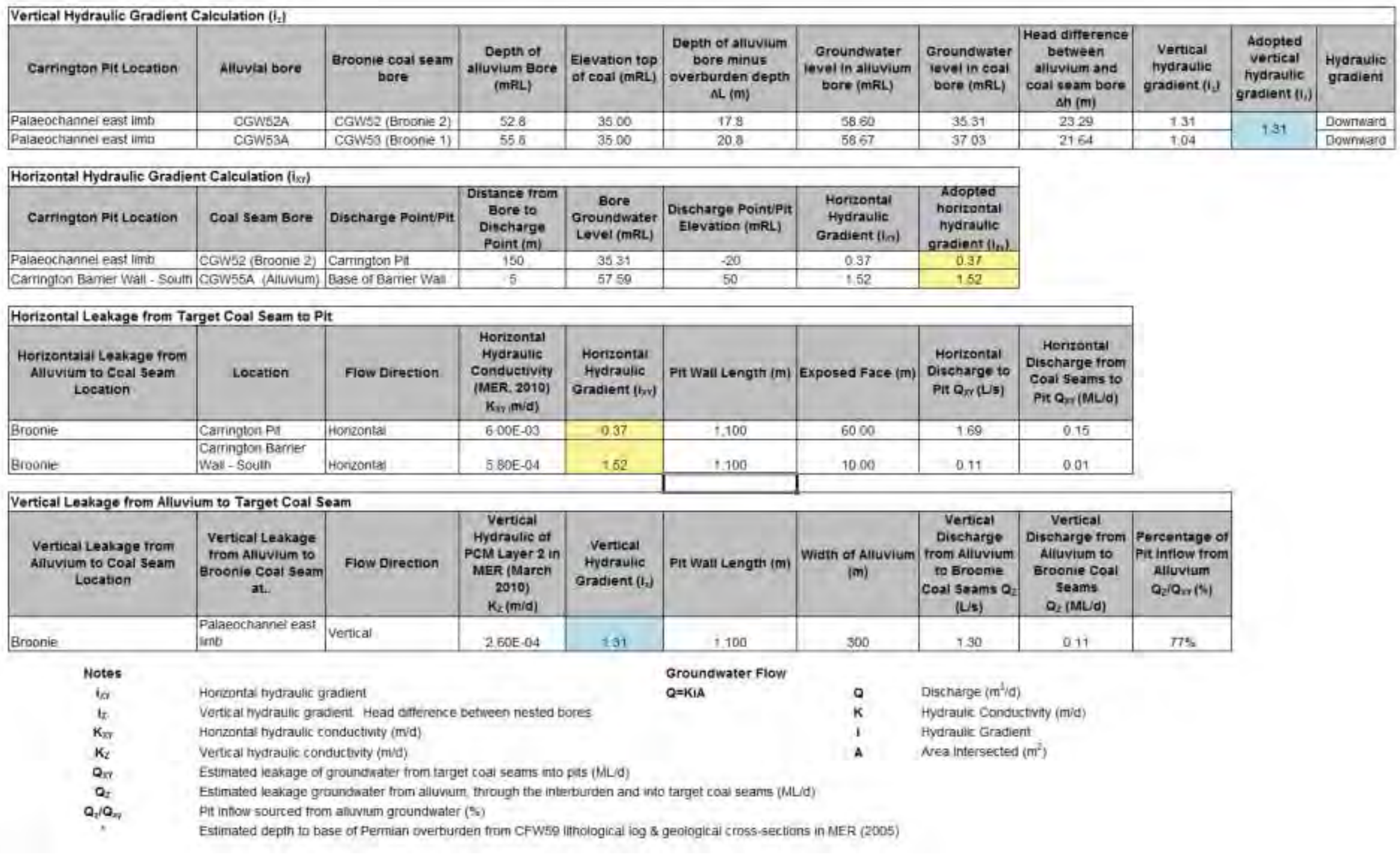
Alluvium Bore	Coal Seam Bore	Elevation of base Alluvium Bore (mRL)	Elevation of base of Permian Overburden (mRL)	ΔL (m)	SWL in Alluvium Bore (mRL)	SWL in Coal Bore (mRL)	Δh (m)	Vertical Hydraulic Gradient (i_z)	Average Vertical Hydraulic Gradient (i_z)
CGW52A	CGW52 (Broonie 2)	52.8	35.0	17.8	58.60	35.31	23.29	1.31	1.31
CGW53A	CGW53 (Broonie 1)	55.8	35.0	20.8	58.67	37.03	21.64	1.04	

Area (A)

The area (A) used to calculate leakage of alluvial groundwater into coal seam aquifers (Q_z) was based on the length of the pit wall and the width of the alluvium. The width of the alluvium was estimated from aerial photography measurements of the distance between the Hunter River and the edge of the pit wall.

The area (A) used to calculate leakage of coal seam groundwater into the pits (Q_{xy}) was calculated based on the length of the pit wall and the thickness of exposed Permian coal measures within the Carrington Pit highwall. The estimated thickness of exposed coal measures was extrapolated from the HVO geological model data.

Appendix G groundwater flow calculations



Vertical Hydraulic Gradient Calculation (i_Z)

Carrington Pit Location	Alluvial bore	Broonie coal seam bore	Depth of alluvium Bore (mRL)	Elevation top of coal (mRL)	Depth of alluvium bore minus overburden depth ΔL (m)	Groundwater level in alluvium bore (mRL)	Groundwater level in coal bore (mRL)	Head difference between alluvium and coal seam bore Δh (m)	Vertical hydraulic gradient (i_z)	Adopted vertical hydraulic gradient (i_z)	Hydraulic gradient
Palaeochannel east limb	CGW52A	CGW52 (Broonie 2)	52.8	35.00	17.8	58.60	35.31	23.29	1.31	1.31	Downward
Palaeochannel east limb	CGW53A	CGW53 (Broonie 1)	55.8	35.00	20.8	58.67	37.03	21.64	1.04		Downward

Horizontal Hydraulic Gradient Calculation (i_{XY})

Carrington Pit Location	Coal Seam Bore	Discharge Point/Pit	Distance from Bore to Discharge Point (m)	Bore Groundwater Level (mRL)	Discharge Point/Pit Elevation (mRL)	Horizontal Hydraulic Gradient (i_{xy})	Adopted horizontal hydraulic gradient (i_{xy})
Palaeochannel east limb	CGW52 (Broonie 2)	Carrington Pit	150	35.31	-20	0.37	0.37
Carrington Barrier Wall - South	CGW55A (Alluvium)	Base of Barrier Wall	5	57.59	50	1.52	1.52

Horizontal Leakage from Target Coal Seam to Pit

Horizontalal Leakage from Alluvium to Coal Seam Location	Location	Flow Direction	Horizontal Hydraulic Conductivity (MER, 2010) K_{XY} (m/d)	Horizontal Hydraulic Gradient (i_{XY})	Pit Wall Length (m)	Exposed Face (m)	Horizontal Discharge to Pit Q_{XY} (L/s)	Horizontal Discharge from Coal Seams to Pit Q_{XY} (ML/d)
Broonie	Carrington Pit	Horizontal	6.00E-03	0.37	1,100	60.00	1.69	0.15
Broonie	Carrington Barrier Wall - South	Horizontal	5.80E-04	1.52	1,100	10.00	0.11	0.01

Vertical Leakage from Alluvium to Target Coal Seam

Vertical Leakage from Alluvium to Coal Seam Location	Vertical Leakage from Alluvium to Broonie Coal Seam at..	Flow Direction	Vertical Hydraulic of PCM Layer 2 in MER (March 2010) K_Z (m/d)	Vertical Hydraulic Gradient (i_z)	Pit Wall Length (m)	Width of Alluvium (m)	Vertical Discharge from Alluvium to Broonie Coal Seams Q_Z (L/s)	Vertical Discharge from Alluvium to Broonie Coal Seams Q_Z (ML/d)	Percentage of Pit Inflow from Alluvium Q_Z/Q_{XY} (%)
Broonie	Palaeochannel east limb	Vertical	2.60E-04	1.31	1,100	300	1.30	0.11	77%

Notes

i_{XY}	Horizontal hydraulic gradient
i_Z	Vertical hydraulic gradient. Head difference between nested bores
K_{XY}	Horizontal hydraulic conductivity (m/d)
K_Z	Vertical hydraulic conductivity (m/d)
Q_{XY}	Estimated leakage of groundwater from target coal seams into pits (ML/d)
Q_Z	Estimated leakage groundwater from alluvium, through the interburden and into target coal seams (ML/d)
Q_z/Q_{xy}	Pit inflow sourced from alluvium groundwater (%)
*	Estimated depth to base of Permian overburden from CFW59 lithological log & geological cross-sections in MER (2005)

Groundwater Flow

Q=KiA

Q	Discharge (m^3/d)
K	Hydraulic Conductivity (m/d)
i	Hydraulic Gradient
A	Area Intersected (m^2)

Australasian
Groundwater
and Environmental
Consultants Pty Ltd
(AGE)

Report on

HVO South and Lemington

2014 Groundwater Impacts Report

Prepared for
Coal and Allied Pty Ltd

Project No. G1593H January 2015
www.ageconsultants.com.au ABN 64 080 238 642

Document details and history

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Report on

HVO South and Lemington 2014 Groundwater Impacts Report

1. Introduction

The Hunter Valley Operations (HVO) mining complex is located approximately 20 km north-west of Singleton, NSW. The complex is divided into its HVO North and HVO South components by the Hunter River (refer Figure 1). This report focuses on HVO South (the Project area), located south of the Hunter River. The mine is owned by Rio Tinto Coal Australia (RTCA) and operated by Coal and Allied Operations Pty Ltd (Coal & Allied).

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) have been engaged by Coal and Allied to address the Special Environmental Conditions in Schedule 3 of the Project Approval, issued by the Minister for Planning (March, 2009). This report supports the Annual Environmental Management Report (AEMR) for 2014, and addresses Condition No. 28 of the Project Approval. Condition No. 28 requires the report to include:

- "*alluvial and hard rock buffer groundwater levels;*
- *interpreted drawdown levels resulting from existing and/or ongoing mining operations of the project;* and
- *accounting for any drawdown loss of alluvial groundwater or river flows*."

Furthermore, this report presents the findings of an assessment of existing consent comittments for Lemington Underground (LUG) Bore 20BL17392, specifically conditions 13 and 14. The majority of the requirments are assessed as part of the annual Groundwater Impact Report; however, there are several new assessment criteria for the LUG Bore, including:

- *"review actual impacts of the extractions on any aquifers, groundwater dependant ecosystems and streams in the area";*
- *"make comparisons between actual and predicted impacts (modelled results)";*
- *"provide statistics for the monitoring data collated for each bore for the previous year"; and*
- *"assess compliance with the licence terms and conditions".*

The New South Wales Office of Water (NOW) has identified alluvial and hard rock buffer zones for mines located along surface water systems, such as rivers and streams. The HVO South buffer zones are located between the Hunter River and three open cut coal mine pits in the Cheshunt area (Cheshunt Pit, Money Box Pit and Barry's Void), as well as between Wollombi Brook alluvial system and Lemington South Pit 1. Active mining occurred in the Cheshunt Pit and Riverview Pit during 2014.

2. Project setting

2.1 Location

This report focuses on HVO South, which is located to the south of the Hunter River and comprises of the Cheshunt and Lemington South Pit areas. HVO South is bound by the Golden Highway to the west, and the New England Highway to the east. Several mines are located around HVO South, including Warkworth Mine and Wambo Mine, which are located within 2 km of Lemington South Pit 1. Refer to Figure 1.

LEGEND

- ◆ NOW Stream Gauges
- ▲ HVO Surface Water Monitoring Site
- — Watercourse
- — Barrier Wall

HVO South & LUG (G1593H)
2014 Groundwater Impacts Report

Project Area

DATE: 28/1/2015

FIGURE No: 1

2.2 Climate

The climate of the HVO area is mostly temperate, and characterised by hot, wet summers and mild, dry winters. Climate monitoring data collected by Coal and Allied at the HVO Corp Meteorological Weather Station during 2014 is summarised in Table 1.

Table 1 Climate Averages: HVO Corp. Meteorological Data 2014

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean max temp (°C)	33.1	30.0	27.4	24.6	21.6	18.0	17.1	18.2	22.5	18.4	32.6	30.8
Mean min temp (°C)	17.6	17.7	16.4	13.8	10.4	8.4	6.2	7.2	8.8	12.8	15.8	17.2
Total monthly rainfall 2014 (mm)	6	85.2	133	48.4	8.6	22	33.4	75.8	24.4	11.2	18.2	136.6

The total annual rainfall for 2014 was 602.8 mm, with December being the wettest month with 136.6 mm.

Monthly Cumulative Rainfall Departure (CRD) using all available rainfall data has been calculated separately for the period January 1900 to December 2014 using rainfall data from the Jerry's Plains monitoring station, and the period 2007 to 2014 using the HVO Corp. Meteorological data. The CRD calculated using the Jerry's Plains data is considered to be more representative of the long term trends in rainfall for the area, and as such has been used on all further analysis presented herein.

The CRD method is a summation of the monthly departure of rainfall from the long-term average monthly rainfall. A rising trend in the CRD plot indicates periods of above average rainfall, whilst a falling slope indicates periods when rainfall is below average. Assessment of the Jerry's Plains CRD for the period from January 2007 to December 2014 shows the area has experienced a general period of above average rainfall for the reporting period.

The CRD graph for the period 2007 to 2014 is shown in Figure 2. The CRD indicates that the site experienced intermittent periods of above average rainfalls between March and April, July and August, and in December 2014.

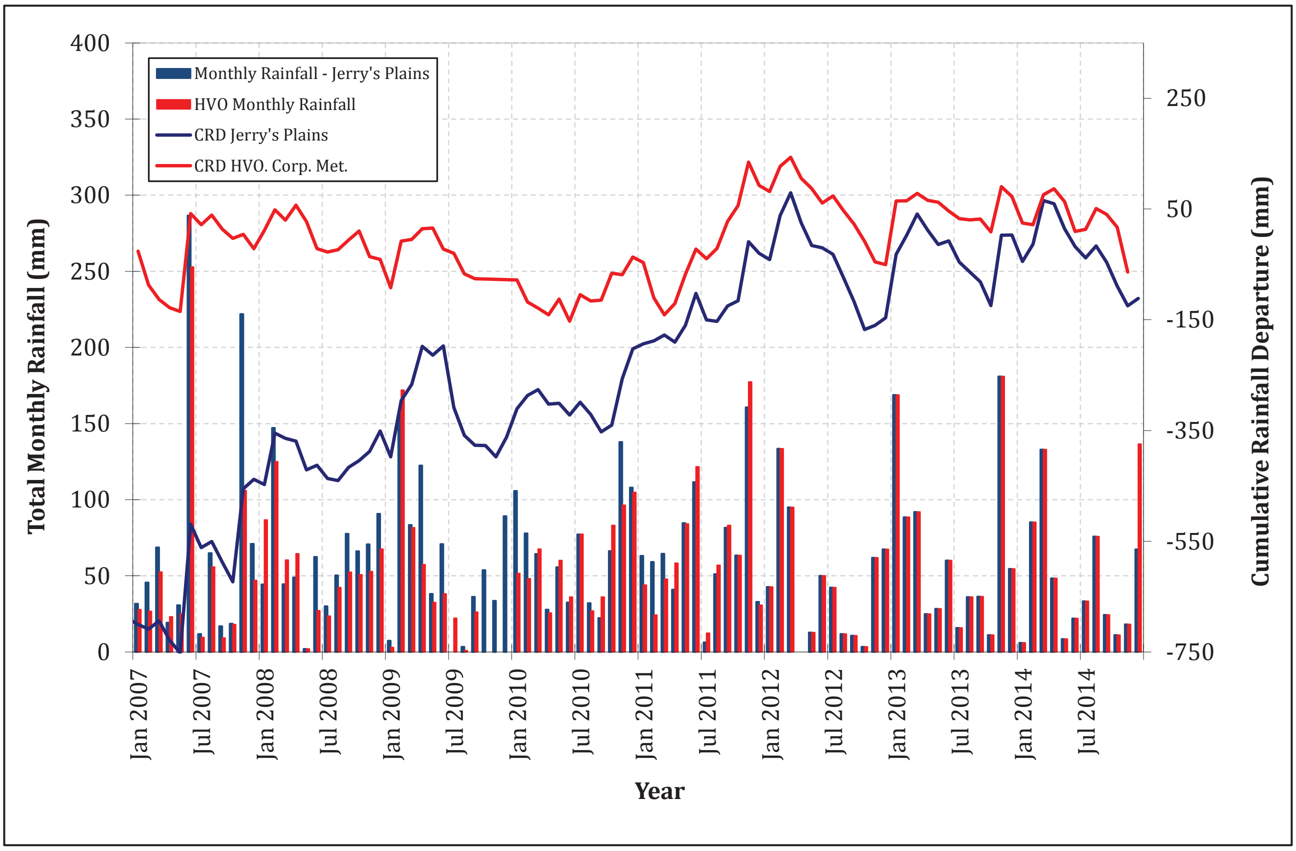


Figure 2 Cumulative rainfall departure graph – HVO Corp meteorological data

2.3 Stream flow

The New South Wales Office of Water (NOW) collects real time river flow data via the Hunter Integrated Telemetry System (HITS), which is installed at gauges along the Hunter River and the Wollombi Brook, both upstream and downstream of the mine pits (Figure 1), the stream gauge stations used include:

- Hunter River Station 210083 – Hunter River stream gauge located approximately 12 km upstream of the Cheshunt Pit area (60.96 mRL at zero gauge);
- Hunter River Station 210125 – Hunter River stream gauge located approximately 3 km downstream of Barry's Void (50.33 mRL at zero gauge); and
- Wollombi Brook Station 210004 – Wollombi Brook stream gauge located approximately 1 km upstream of the Lemington South Pit 1 – North Void (47.76 mRL at zero gauge).

HVO also collects monthly river elevation data from four stations along the Hunter River as shown in Figure 1 (reduced from 15 in previous years). The two closest HVO monitoring stations to HVO South are:

- Hunter River HVO Station WLP3 – Hunter River survey point located approximately 800 m north of Barry's Void; and
- Hunter River HVO Station WLP5 – Hunter River survey point located approximately 200 m north of Cheshunt Pit.

Long term stream level data for the four mentioned HVO survey points and NOW stream gauge stations are shown in Appendix A. The 2014 Hunter River level data, collected from the HVO survey points are also tabulated in Appendix A. The stream level data indicates that the Hunter River and Wollombi Brook levels remained stable in the 2014 monitoring period.

2.4 Geology

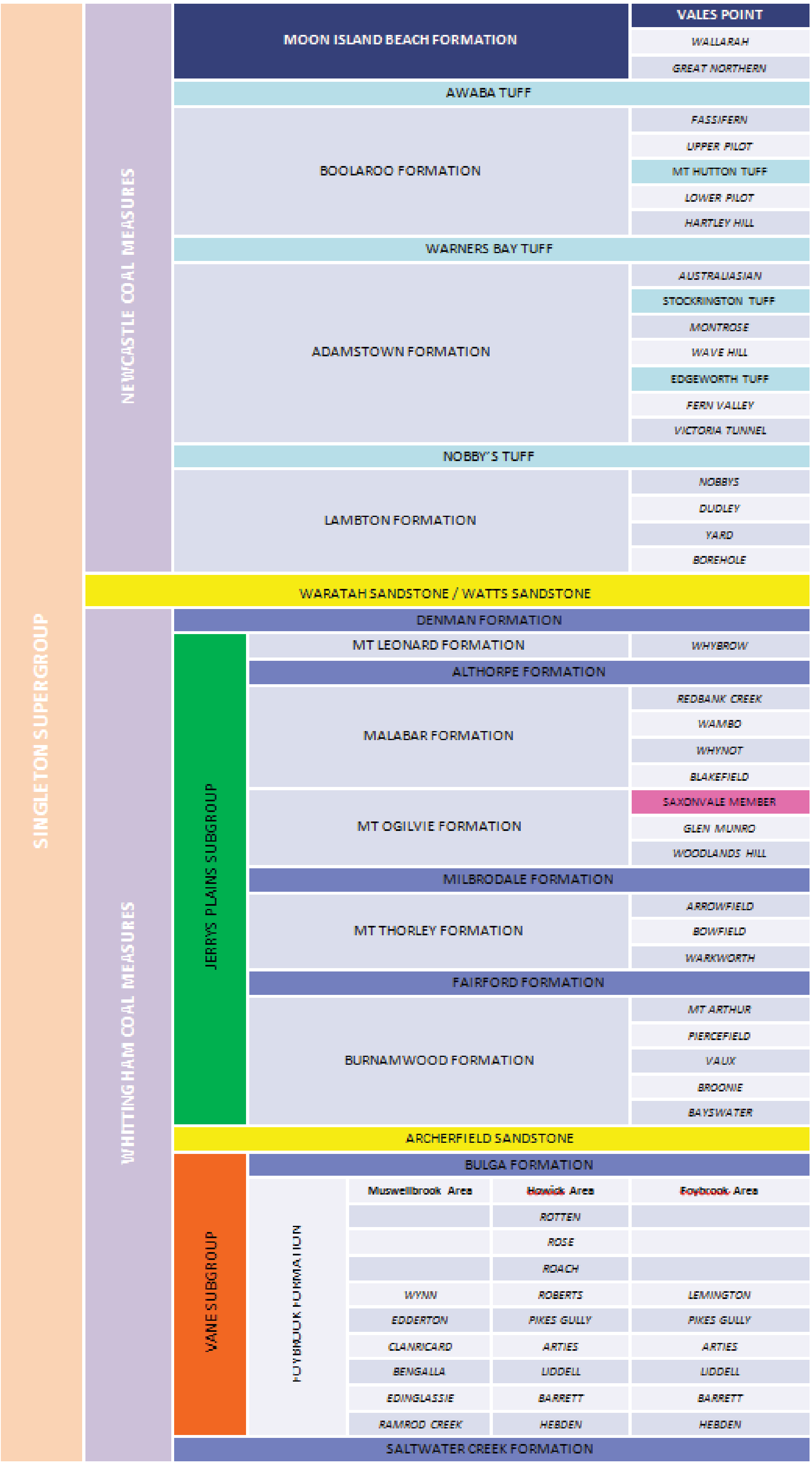
The stratigraphic sequence of the Permian coal measures is shown in Figure 3, regional geology map was sourced from the 1:100,000 scale geological map, published by the Department of Mineral Resources (Glen & Beckett, 1993) and reproduced in Figure 4.

The Quaternary alluvium in Figure 4 has been digitised based on the 1:25,000 Geology Maps of Singleton (McIlveen, 1984), Muswellbrook (Summerhayes, 1983), Jerrys Plains (Sniffin & Summerhayes, 1987) and Doyles Creek (Sniffin et al, 1988). It is important to note that the mapping does not accurately define the extent of alluvium, as large-scale mapping often incorporates desktop assessment with limited ground truthing. AGE (2011) show mapping over-estimates the extent of the alluvium, which compares resistivity investigation results from Groundsearch Australia (2006) to the mapped extent from the 1:25,000 Singleton Geological Map (McIlveen, 1984).

2.4.1 Stratigraphy

The stratigraphic sequence in the region comprises two distinct units, Quaternary alluvium and Permian sediments. The Quaternary alluvium consists of silt, sand and gravel in the alluvial floodplains of the Hunter River and Wollombi Brook. The alluvium unconformably overlies the Permian sediments, which comprise of coal seam sequences with overburden and interburden consisting of sandstone, siltstone, tuffaceous mudstone, and conglomerate.

The Middle Permian rocks form a regular layered sedimentary sequence, with the Wittingham Coal Measures containing the main economic coal seams. The Wittingham Coal Measures include the Jerrys Plains Subgroup, which is the sequence being mined at HVO South (Figure 3). Coal seams mined in the Lemington South Pit 1 include the Bowfield Seam (BFS), Arrowfield Seam (AFS), Woodlands Hill Seam (WDH) and Glen Munro Seam (GM). Coal seams mined in the Cheshunt Pit include the Mt Arthur Coal Seam (MTA), Piercefield Coal Seam, Vaux Coal Seam and Broonie Coal Seam. The Archerfield Sandstone and the Vane Subgroup underlie the Jerrys Plains Subgroup.



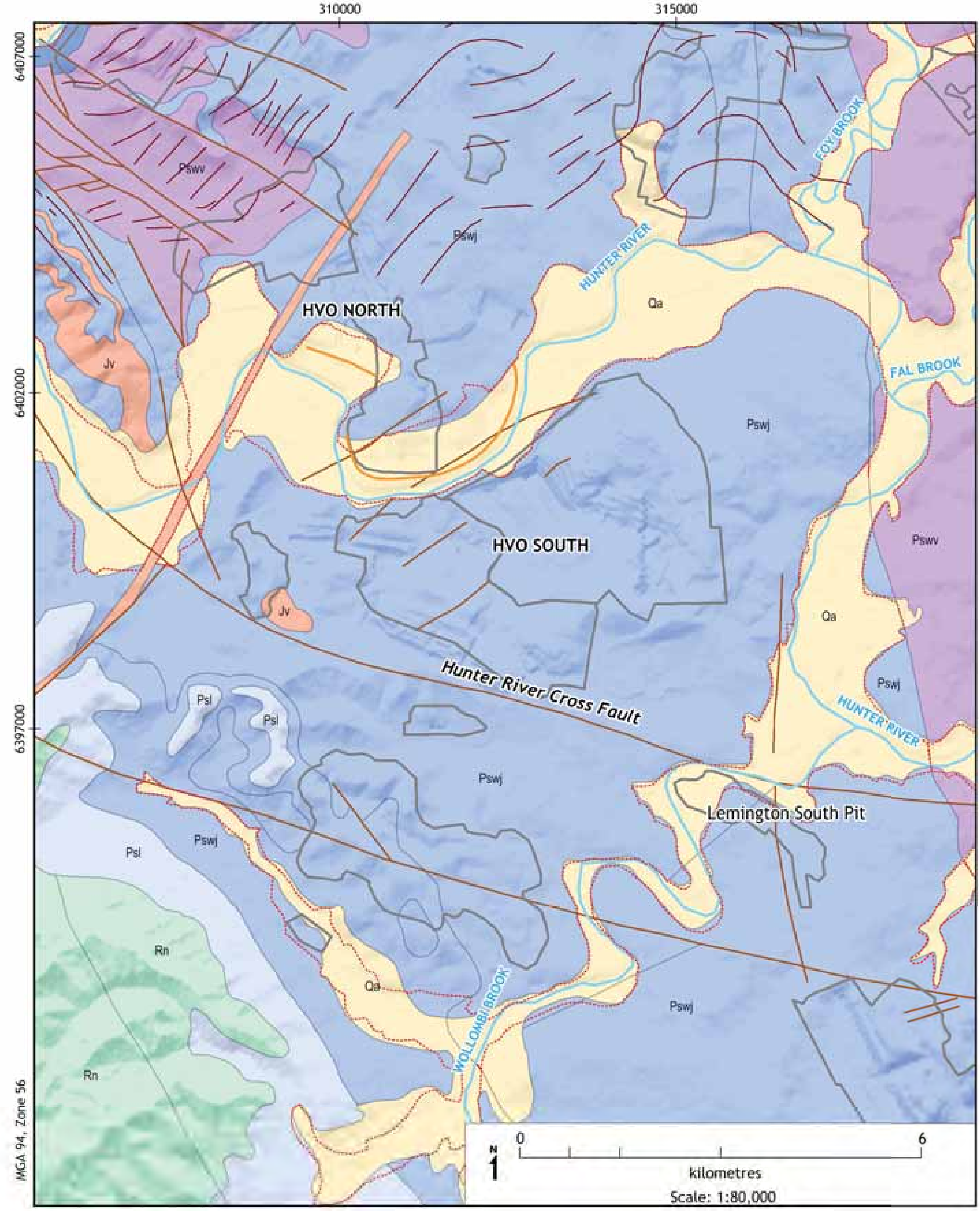
SINGLETON SUPER GROUP

- NEWCASTLE COAL MEASURES
  - MOON ISLAND BEACH FORMATION
    - VALES POINT
    - WALLARAH
    - GREAT NORTHERN
  - AWABA TUFF
  - BOOLAROO FORMATION
    - FASSIFERN
    - UPPER PILOT
    - MT HUTTON TUFF
    - LOWER PILOT
    - HARTLEY HILL
  - WARNERS BAY TUFF
  - ADAMSTOWN FORMATION
    - AUSTRALASIAN
    - STOCKRINGTON TUFF
    - MONTROSE
    - WAVE HILL
    - EDGEWORTH TUFF
    - FERN VALLEY
    - VICTORIA TUNNEL
  - NOBBY'S TUFF
  - LAMBTON FORMATION
    - NOBBYS
    - DUDLEY
    - YARD
    - BOREHOLE
- WARATAH SANDSTONE / WATTS SANDSTONE
- WHITTINGHAM COAL MEASURES
  - DENMAN FORMATION
  - JERRYS PLAINS SUBGROUP
    - MT LEONARD FORMATION
      - WHYBROW
    - ALTHORPE FORMATION
    - MALABAR FORMATION
      - REDBANK CREEK
      - WAMBO
      - WHYNOT
      - BLAKEFIELD
    - MT OGILVIE FORMATION
      - SAXONVALE MEMBER
      - GLEN MUNRO
      - WOODLANDS HILL
    - MILBRODALE FORMATION
    - MT THORLEY FORMATION
      - ARROWFIELD
      - BOWFIELD
      - WARKWORTH
    - FAIRFORD FORMATION
    - BURNAMWOOD FORMATION
      - MT ARTHUR
      - PIERCEFIELD
      - VAUX
      - BROONIE
      - BAYSWATER
  - ARCHERFIELD SANDSTONE
  - VANE SUBGROUP
    - BULGA FORMATION
    - FOYBROOK FORMATION

Muswellbrook Area	Howick Area	Foybrook Area
	ROTTEN	
	ROSE	
	ROACH	
WYNN	ROBERTS	LEMINGTON
EDDERTON	PIKES GULLY	PIKES GULLY
CLANRICARD	ARTIES	ARTIES
BENGALLA	LIDDELL	LIDDELL
EDINGLASSIE	BARRETT	BARRETT
RAMROD CREEK	HEBDEN	HEBDEN

- SALTWATER CREEK FORMATION

Figure 3 Singleton super group sequence stratigraphy



LEGEND

Singleton Geological Map (1:25,000).

▭ Qa - Quaternary - Alluvium

Hunter Coalfields Geological Map (1:100,000)

▨ Qa - Quaternary - Alluvium

▨ Jv - Jurassic - Basalt

▨ Rn - Triassic - Undifferentiated sediments

▨ Psl - Late Permian - Wollombi Coal Measures

▨ Pswj - Late Permian - Jerrys Plains Subgroup

▨ Pswv - Late Permian - Vane Subgroup

— Watercourse

— Barrier Wall

☐ Mine Area

— Fault

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Regional Geology

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2.4.2 *Structural geology*

The major structural feature at HVO South is the Bayswater Syncline that strikes north-south. The Bayswater Syncline is located to the east of Cheshunt Pit and west of Lemington South Pit 1. On the western limb of the Bayswater Syncline is the "*Western Graben*", which trends in a north-south direction (NTEC, 2010). The 1:100,000 Hunter Valley Coalfields mapping shows several faults trending south-west to north-east in the Cheshunt area, and trending north to south and north-west to south-east near Lemington South Pit 1.

Resistivity studies by Groundsearch Australia (2008) have also identified two possible faults across Barry's Flat, which is located north-east of Barrys Void. AGE (2010a) indicated that these two faults may have caused a stratigraphic discontinuities and over-thrusting of seams.

An anticline structure is also present within the northern highwall of Cheshunt Pit. Figure 5 highlights the anticline structure (in red), and shows minor displacement of the coal measures along minor faults (in yellow). Along the crest of the anticline, the MTA appears to sub-crop beneath the alluvium (Appendix B).

Figure 5 Cheshunt Pit anticline

2.5 Hydrogeology

The hydrogeological setting at HVO South is comprised of shallow Quaternary alluvial aquifers, and deeper Permian coal measures. Sections 2.5.1 and 2.5.2 below detail the hydrogeological characteristics of the alluvium and Permian coal measures.

2.5.1 *Alluvial aquifer*

Figure 4 shows the mapped extent of Quaternary alluvium. AGE (2010b) assessed that the alluvium along the Wollombi Brook and Hunter River are generally 10 m to 15 m thick, with the alluvium, thinning to 0 m to 5 m towards the edges of the alluvial plain. This is consistent with the Groundsearch Australia (2006) report findings of alluvium to 6.4 m depth, approximately 100 m from Wollombi Brook.

Recharge to the alluvium occurs via direct rainfall infiltration and localised recharge via lateral seepage from the Hunter River and Wollombi Brook during periods of high flows. Resistivity studies by Groundsearch Australia (2006 and 2008) suggest a moderate to high hydraulic conductivity for the alluvium. Falling head tests on bores within the Wollombi Brook alluvium indicate a hydraulic conductivity of 0.2 m/day to 1.6 m/day (AGE, 2010b).

2.5.2 Permian coal measures

The Permian coal measures can be categorised into the following hydrogeological units:

- the majority of the Permian comprises interburden/overburden, consisting of very low to low permeability and very low yielding sandstone, siltstone and conglomerate units; and
- low to moderately permeable coal seams, each typically ranging in thickness from 2.5 m to 10 m, which are the prime water bearing strata within the Permian sequence.

The Permian coal measures occur as a regular layered south westerly dipping sedimentary sequence. In most areas around HVO South, low permeability interburden separates the alluvium and coal measures; however, MER (2005) and Groundsearch Australia (2006) reported that the coal seams may subcrop below the alluvium intermittently near Cheshunt Pit and Barry's Void as shown in the geological cross-sections in Appendix B.

The low to moderately permeable coal seams have recorded horizontal hydraulic conductivity (Kxy) values of between 4.0 x 10^{-3} m/day and 0.6 m/day (Rust PPK, 1997 and MER, 2005). The hydraulic conductivity of the low yielding interburden/overburden has been recorded between 1.0 x 10^{-4} m/day and 1.0 x 10^{-5} m/day (Rust PPK, 1997, MER, 2005 and AGE, 2010b).

3. Groundwater monitoring program

3.1 Monitoring bore network

The groundwater monitoring network at HVO South comprises of 85 monitoring bores (consisting of both single screened bores and multiple piezometer installations).

Bores are screened into the alluvium, interburden and coal measures as detailed in Table 2 below. Further bore construction details are included within Appendix C. The monitoring bore locations for the Cheshunt, Barry's Void and Lemington South areas are shown in Figure 6 to Figure 8.

Table 2 Monitoring bore screened lithology

Location	Screened lithology	No. of bores	Totals
Cheshunt Area	Alluvium	6	25
	Mount Arthur Coal Seam (MTA)	9	
	Interburden	10	
Barry's Void	Alluvium	16	27
	Mount Arthur Coal Seam (MTA)	8	
	Other undifferentiated	3	
Lemington South Pit 1	Alluvium	4	33
	Interburden	1	
	Arrowfield Coal Seam (AFS)	4	
	Bowfield Seam	15	
	Glen Munro Coal Seam (GM)	1	
	Woodland Hill Coal Seam	8	

3.2 Water level monitoring

All 85 bores were monitored over 2014, at frequencies ranging from monthly to six-monthly intervals, as described in the HVO Water Management Plan. Groundwater levels were measured by manual dipping. Of the 85 bores monitored, 17 are fitted with Solinst data-loggers to record groundwater levels on a four or six-hourly basis; refer to Appendix C (final column) for specific bores.

LEGEND:

Bore by Monitored Strata:

- 🟡 Alluvium
- 🔵 Permian Interburden
- ● Mt Arthur Seam
- 🔴 Permian Coal Seam

▲ Stream Gauge Location

- - MER Palaeochannel

HVO South Mine Lease

River / Water Area

Quaternary Alluvium - Digitised from 1:25K Coalfields Map

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Monitoring Bores - Cheshunt Area

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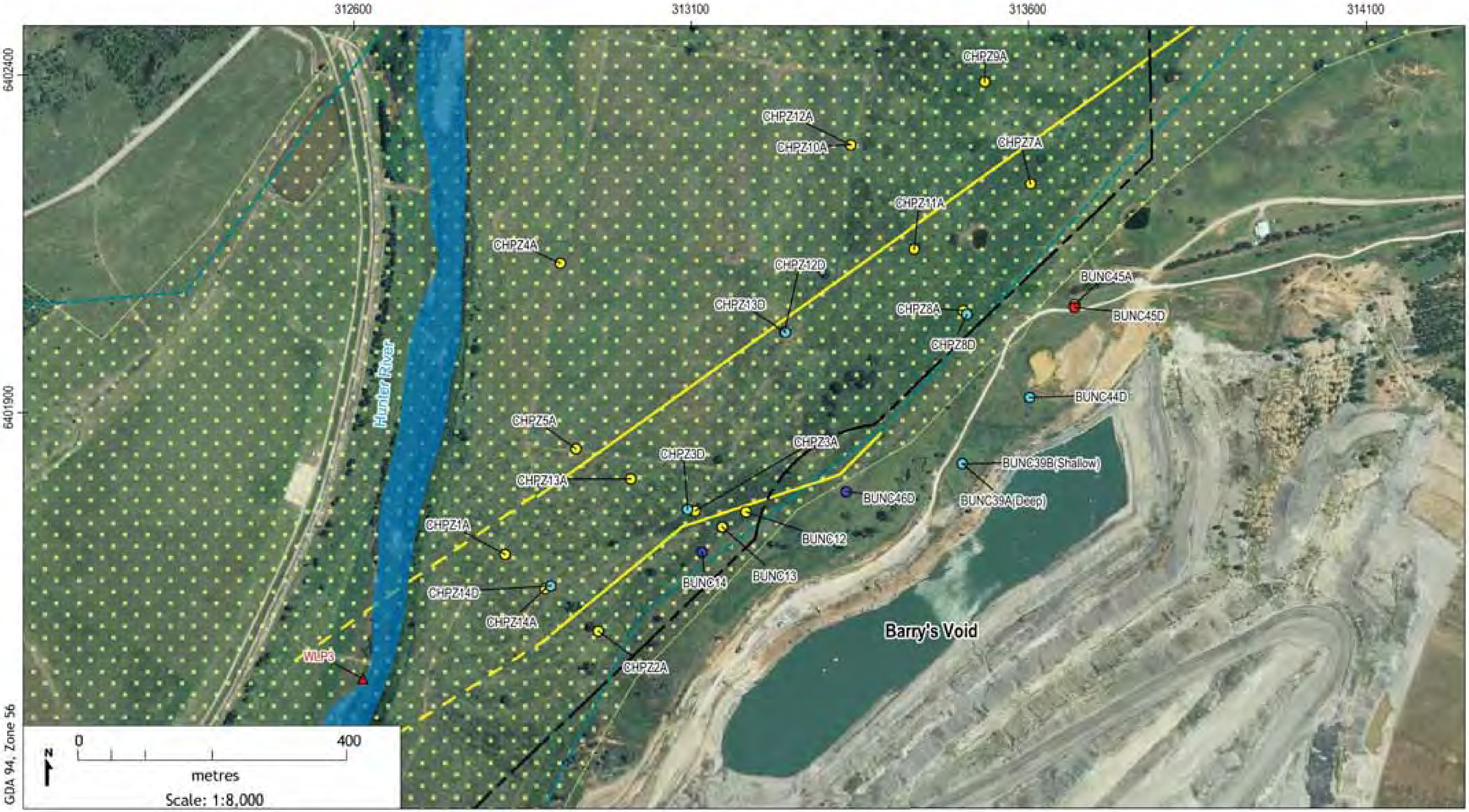

LEGEND:

Bore by Monitored Strata:
- 🟡 Alluvium
- 🔵 Permian Interburden
- ● Mt Arthur Seam
- 🔴 Permian Coal Seam

- ▲ Stream Gauge Location
- — MER Palaeochannel
- ▭ HVO South Mine Lease

- 🟦 River
- — Fault (Groundsearch Australia 2008)
- - - Inferred Fault (Groundsearch Australia 2008)
- Quaternary Alluvium - Digitised from 1:25K Coalfields Map

HVO South & LUG (G1593H)
2014 Groundwater Impacts Report

Monitoring Bores - Barry's Void

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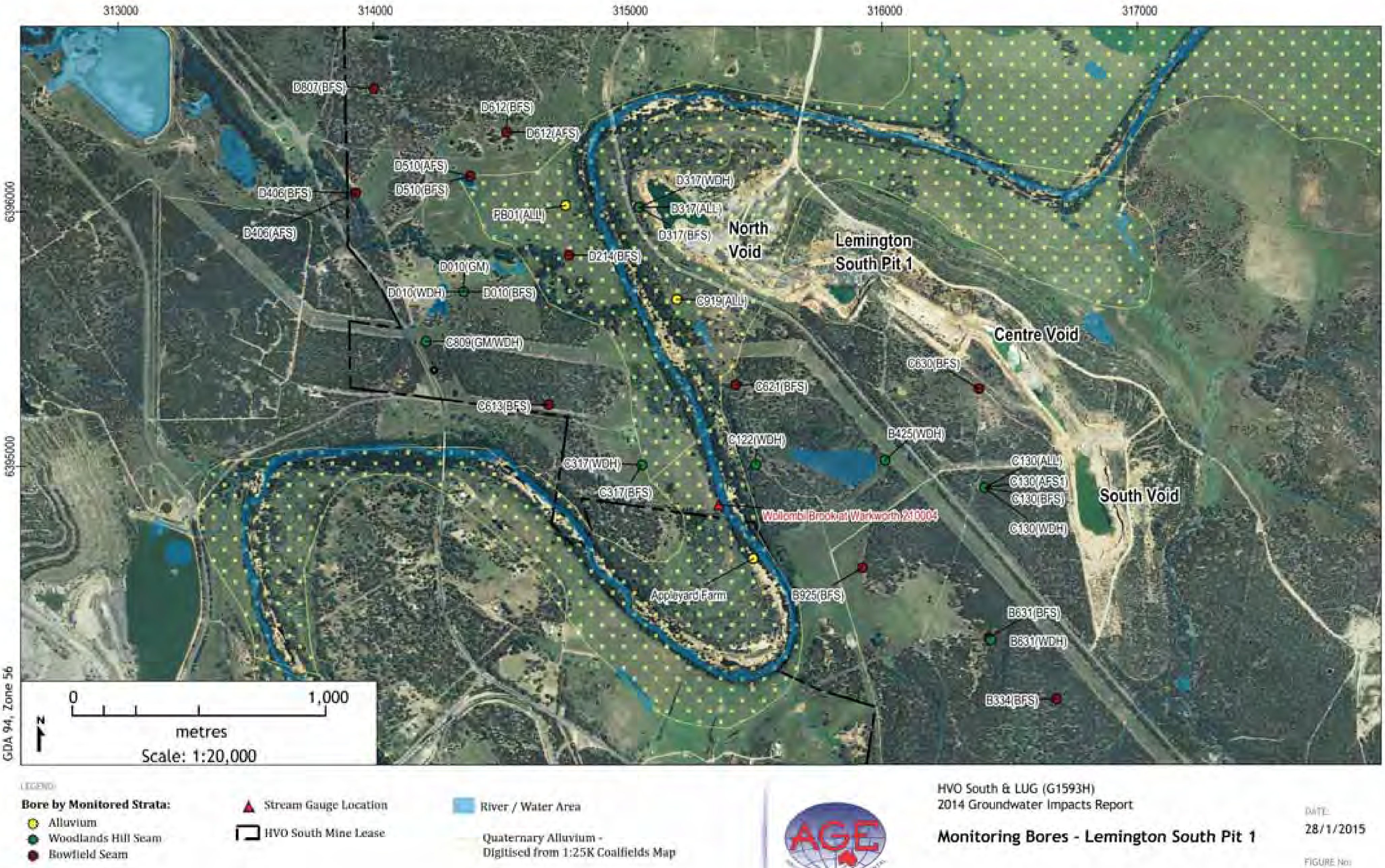

HVO South & LUG (G1593H)
2014 Groundwater Impacts Report

Monitoring Bores - Lemington South Pit 1

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8

4. Groundwater quality

Electrical conductivity (EC) and pH was measured in 85 bores in 2014. These measurements were undertaken either quarterly or every six months.

In addition, 35 bores were sampled for laboratory analysis of major ions and selected metals. Two sampling rounds were undertaken in March and September on Cheshunt Pit and Barry's Pit bores. One sampling round was undertaken in November at Lemington South.

4.1 Field chemistry

EC and pH field measurements are attached in Appendix D. A summary of 2014 EC data is summarised in Table 3. Field EC has also been graphed to help identify potential changes throughout the year (refer Appendix D). It is noted that of the 85 monitoring bores in the greater groundwater monitoring network 62 bores were sampled for groundwater quality analysis.

Table 3 Electrical conductivity data summary

Location	Lithology	Mean Ec (µS/cm)	Min Ec (µS/cm)	Max Ec (µS/cm)	Total Bores Sampled	Number of Measurements
Barry's Pit	Alluvium	1031	418	2530	14	46
Barry's Pit	Mount Arthur Seam	1236	836	3580	8	18
Barry's Pit	Piercefield Seam	2368	1910	2610	1	4
Cheshunt	Alluvium	876	870	880	6	3
Cheshunt	Mount Arthur Seam	2466	800	7100	9	18
Lemington	Alluvium	5348	390	9240	4	12
Lemington	Bowfield Seam	7726	2820	15320	15	30
Lemington	Glen Munro Seam	18537	10700	23100	2	6
Lemington	Woodlands Hill Seam	10810	6040	13570	3	6

The graphs of field EC (Appendix D) identify that EC showed very little change throughout the year. There were a few exceptions, viz:

- bore CHP45A (Barry's Pit - alluvium) between February and May 2014 field measurements ranged from 1896 to 2530 µS/cm; however, measurements stabilised over the later part of the year in line with the February reading;
- bore BUNC45D (Barry's Pit - Mount Arthur seam) between February and May 2014 field measurements ranged from 2490 to 1910 µS/cm; however, measurements stabilised over the later part of the year in line with the February reading;
- bore BZ1-3 (Cheshunt Pit - Mount Arthur seam) during the 2013 reporting period, the bore showed an increase of 5405 µS/cm (1355 to 6760 µS/cm). A watching brief was in put in place for the bore. During the 2014 reporting period, the elevated field EC readings were sustained, ranging from 6820 to 7100 µS/cm. This is posibly due to depresurisation caused by mining the Mt Arthur Seam; and
- bore BZ2A(1) (Cheshunt Pit - Mount Arthur seam) during the 2013 reporting period, a subdued increase as per bore BZ1-3 was observed; however, this was not noted in the 2014 reporting period results.

4.2 Laboratory analysis

Schoeller plots have been created in order to compare major ion chemistry of groundwater samples. Groundwater type comparison using this technique is possible even if some of the major ions were not analysed; as is the case at HVO South, where total alkalinity was not included in as many (40%) of the sample analyses.

The Schoeller plots compare the normalised concentration of ions (in milliequivalents/litre) on a vertical logarithmic axis with the analytes identified on the horizontal axis. Points for each ion are then connected to form a line. Similar shaped lines from multiple samples indicate a similarity in origin and vertical displacement of similar line lines indicates dilution with fresh water (resulting in downward shift in the line) or concentration/evaporation (resulting in an upward shift).

Schoeller plots have been prepared for:

- Barry's Pit Alluvium, Mount Arthur Seam and interburden; and
- Lemington South – Alluvium, interburden and various seams.

Figure 9 shows representative Schoeller plots for the main lithological units. The detailed plots for all the bores are in included in Appendix D.

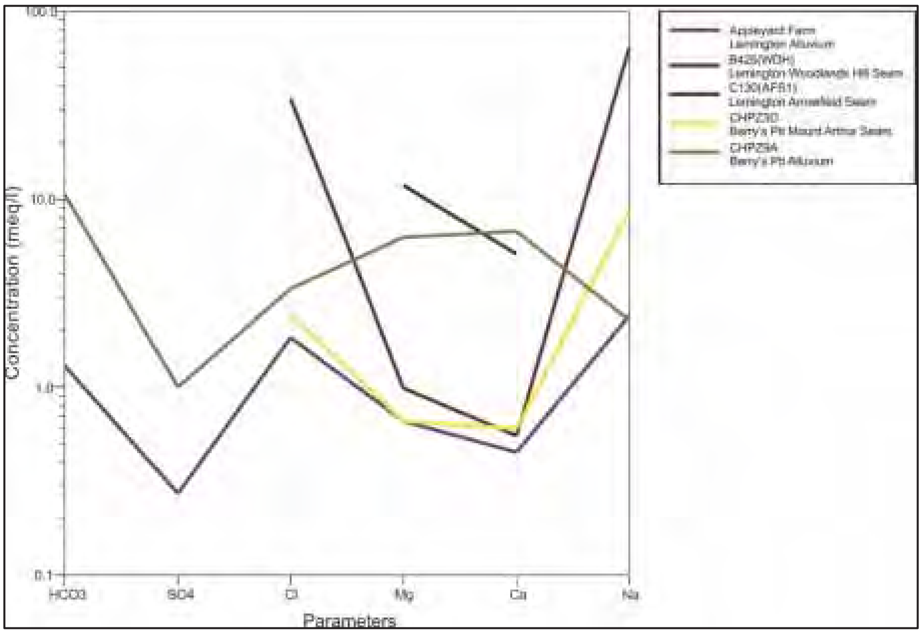

Figure 9 Schoeller plot of typical alluvium or seam chemistry

The results of this analysis are that the major ion chemistry appears similar in most samples; however, samples obtained from groundwater in Barry's Pit alluvium generally have Mg as the dominant cation with the concentration of [Mg]>[Ca]>[Na]. For the Mount Arthur Seam, various Lemington Seams, Barry's Pit interburden and Lemington Alluvium, Na is the dominant cation and [Na]>[Mg]>[Ca].

One exception of note is:

- BUNC45A (Barry's Pit - previous categorised as an alluvium bore) the water type trace is unlike other Barry's Pit alluvium samples. As noted in the 2013 monitoring period, it is thought that this bore screened across the regolith.

5. Groundwater levels

Manual measurements of groundwater levels have been collected at HVO South since 2007 and data-loggers were installed in a number of bores from 2009. This report specifically assesses groundwater trends over the 2014 calendar year; however, all available data has been used to assess potential changes in long-term trends. Manually measured groundwater level data for the 2014 monitoring period are included in Appendix E, and long-term hydrographs are shown in Appendix F. Groundwater levels at each mine pit area are discussed below, in Section 5.1 to 5.3. The hydrographs are contrasted with the CRD curve as well as river levels recorded at the aforementioned NOW and HVO river level measuring stations. Comparison of groundwater levels against rainfall and river levels assists in assessing the degree of connectivity between surface water and groundwater and fluctuations due to infiltration of rainfall through the unsaturated zone.

The most complete groundwater data sets are from the February and November monitoring events. These months were used for the Groundwater flow interpretation and the contoured data (the alluvium [Hunter River and Wollombi Brook], Mt Arthur Seam and Bowfield Seam) is presented in Appendix G.

5.1 Cheshunt Pit

Hydrographs of long-term Cheshunt Pit alluvium and Mount Arthur Seam groundwater levels are included in Appendix F.

5.1.1 Alluvium

Groundwater contours (m AHD) for February 2014 (Appendix G) indicate groundwater levels are between 55 m and 56 m AHD, with groundwater flow in a north-easterly direction following the course of the Hunter River.

In 2012, the groundwater elevation recorded in Hobden's Well showed a declining trend. In 2013 and 2014, this level had stabilised around a very similar elevation to that recorded in the Hunter River at the downstream river level monitoring station WLP3. This would suggest a small groundwater gradient existed between the river and the alluvium and that the river was losing water to the alluvium over this stretch.

5.1.2 Mount Arthur Seam (MTA)

Groundwater contours for November 2014 (Appendix G) indicate that groundwater within the Mount Arthur Seam flows generally towards the south and toward the actively mined Cheshunt Pit (where the Mt Arthur seam is mined). This is the result of localised depressurisation due to active mining. The direction of groundwater flow remains the same as in 2013.

There is no obvious correlation between CRD and groundwater levels recorded in the Mount Arthur Seam.

Declining groundwater levels in BZ1-3, BZ2A(1) and BZ3-3 all show a clear response to mining of the active Cheshunt Pit. BZ1-3 shows the greatest response and this is assumed to be due to its proximity to the active mining face in 2014. A significant loss in pressure head in BZ1-3 is noted over a relatively short period of time; a phenomenon noted in other bores in previous years. BZ2A(1) and BZ3-3 show a very similar pressure response during 2014, with heads continuing to decline by approximately 1 m since 2013.

In common with 2013 observations, the groundwater levels in BC1a, HG2A and BZ4A-2 show little or no response to pit depressurisation operations (observed in other nearby bores) and no clear response to rainfall (CRD). In fact, all three of these bores indicate nearly static groundwater elevations in Mount Arthur Seam between 5 m and 20 m above BZ1-3, BZ2A(1) and BZ3-3 (that do show a response to mining). This may be a reflection of the distance between the bores and the active mining areas at Cheshunt Pit. Alternative or additional reasons for the lack of response in these bores could be:

- The presence of a fault or faults isolating these bores from the effects of depressurisation; and
- Recharge occurring to the north-east masking the effects of depressurisation. It is notable that the EC in the bores that do not show a response to mining are significantly lower than those that do (refer to Appendix D). This may be indicative of recharge or interconnection from the overlying alluvium.

5.2 Barry's Void

Hydrographs of long-term Barry's Void alluvium and Mount Arthur Seam groundwater levels are included in Appendix F.

5.2.1 Alluvium

Groundwater contours (m AHD) for February 2014 (Appendix G) show a subdued groundwater gradient across Barry's Flat, with groundwater flowing in a general north-easterly direction, following the Hunter River.

Groundwater hydrographs for the alluvial bores show groundwater levels in 2014 responding to changes in rainfall and river level (Appendix F). The overall groundwater level trend correlates well with variations in the CRD with a peak river and groundwater level observed in late February and a steady recession seen for the remainder of the year. A very similar response was observed in 2013. This provides a good indication of connection between the alluvial aquifer and the Hunter River.

Comparison of river levels (recorded at WLP3) and the groundwater levels indicate that groundwater levels were both above and below river levels during the year. Groundwater levels rose above the river level in early 2014 (March-April), as a consequence, there would have been a groundwater flow gradient from the alluvium to the river. For the rest of the year the groundwater levels generally fell below river level, causing the groundwater gradient to reverse and flow from the river to the alluvium. In contrast, groundwater levels within borehole CHPZ4A remained above river water levels for much of the second part of the year (May-Nov).

Groundwater levels for the alluvium indicate no impact from mining for the year.

5.2.2 Mount Arthur Seam (MTA)

Groundwater contours for November 2014 (Appendix G) indicates groundwater within the Mt Arthur seam to flow towards Barry's Void.

Continuous groundwater monitoring results for the bores CHPZ3D, CHPZ8D and CHPZ12D show a clear response of groundwater level to rainfall/river level. The peaks in the groundwater hydrographs following rainfall generally last 10-15 days. This is consistent with peaks in the river level. As the manual measurement are monthly these peaks are noted in the bores with automated measuring equipment and not in the manually measured bores.

Bores CHPZ3D, CHPZ13D and CHPZ14D all show a decline in groundwater level of up to 1m at the end of May, which is likely due to recommencement of mining nearby.

The elevation of water in Barry's Void is 5 m to 10 m lower than the observed elevation of groundwater in the Mount Arthur Seam outside of the pit to the north. It is understood that Barry's Void was dewatered in early 2014 to allow for the continuation of mining towards the Hunter River. Hence, the water in the pit area is not likely to be the source of the pressure changes. The likely source of the pressure change is rainfall and surface water infiltration; therefore, these results are indicative of a connection between the Mount Arthur Seam and the river at this location, and/or posible repressurisation of coal seams due to backfilling of the North Void. Any interaction likely to occur where the Mt Arthur Seam subcrops beneath both the River and the alluvium to the north–west of Barry's Pit.

5.3 Lemington South Pit 1

Groundwater hydrographs for the alluvium and key coal seams (Woodland, Glen Munro, Arrowfield and Bowfield) near to Lemington South Pit 1 are included in Appendix F. Comments are included in the following sections.

5.3.1 Alluvium

Groundwater levels in the alluvium were monitored at five locations, viz:

- C130(ALL);
- C919(ALL);
- D317(ALL);
- PB01(ALL); and
- Appleyard Farm

The field data is summarised in Appendix E.

The frequency of monitoring in Bores C130(ALL), C919(ALL), D317(ALL) and PB01(ALL) was increased from 6-monthly to monthly in 2014; a review of the monitoring program was undertaken in late 2013 following the receipt of a licence to abstractwater from the disused Lemington Underground mine workings (LUG Bore). A bore at Appleyard Farm, has been monitored monthly since 2012. Hydrographs from these bores are included in Appendix E.

Bores C130(ALL), C919(ALL), D317(ALL) and PB01(ALL) all show very little variation in 2014. A slight rise in recorded groundwater levels in February coincides with high rainfall (as indicated by CRD). This rise was not seen in D317. The hydrograph at Appleyard Farm is the most informative of these bores: (a) because it has a continuous record from 2013; and (b) because this shows a very close correlation with the adjacent river water level in Wollombi Brook (Station 210004). The hydrograph shows that the elevation, timing and magnitude of the groundwater response in Appleyard Farm bore almost exactly matches the river level, which in turn indicates an intimate connection between the alluvium and the river at this location.

Based on this observation, it appears that Wollombi Brook loses water to the alluvium at or near Appleyard Farm. It is not possible to determine whether the water is regained by the Brook further downstream, as there is insufficient data.

5.3.2 Woodland Hill Seam (WDH) and Glen Munro Seam (GM)

The groundwater levels in six bores constructed to the Woodland Hill, one bore constructed to the Glen Munro Seam, and one bore screened across both these seams, were recorded in May and November 2014. The hydrographs for these Woodland hill and Glen Munro Seam bores including the 2014 and historical data are shown in Appendix F.

In all of these bores, very little observed change was noted in groundwater levels in 2014. Bore B425 (WDH) shows a declining groundwater level in line with a drier period as evidenced by the contrasted CRD plot.

5.3.3 *Arrowfield Seam (AFS)*

The groundwater levels in four bores constructed to the Arrowfield Seam were recorded in May and November 2014. The hydrographs for the Arrowfield Seam bores including the 2014 and historical data are shown in Appendix F.

Bores D510(AFS) and D406(AFS) show very slight declines in groundwater level, while bores C130(AFS1) and D612(AFS) show groundwater levels which have increased in line with 2011 levels.

The recovery of groundwater levels in bores D612(AFS) and C130(AFS1) suggests a recording error in 2012, as noted in the 2013 AEMR.

5.3.4 *Bowfield Seam (BFS)*

The groundwater levels in 15 bores constructed to the Bowfield Seam, with seven north of the Wollombi Brook and eight to the south, were recorded in quarterly or six-monthly during the review period. The hydrographs for the Bowfield Seam bores including the 2014 and historical data are shown in Appendix F. Groundwater level contours for November 2014 (Appendix G) indicate that groundwater within the Bowfield Seam generally flows in a west-south westerly direction and away from Lemington South Pit.

South of the Wollombi Brook, groundwater levels in the Bowfield Seam record a slight rise and subsequent fall which coincides with rainfall (CRD). The long-term recovery in groundwater levels observed in previous years is not seen in the 2014 data, and the general decline in groundwater levels seen in the 2013 data continues. This is possibly due to the use of the disused pit for water storage, and the subesequent abstraction of water from the Lemington Underground Bore (LUG Bore). Further discussion of the impacts (if any) of water abstraction from the LUG Bore are given in Section 7.

North of the Wollombi Brook, an increase in groundwater level was noted in all bores, with the exception of bore D406(BFS).

6. Loss of alluvial groundwater

The following section details the estimated loss of alluvial groundwater due to mining operations at HVO South. Groundwater leakage from coal seams into the mine pits (Q_{XY}), and vertical leakage of alluvial groundwater into the underlying Permian coal measures (Q_z), were calculated by applying Darcy's Law (*Equation 1*). Several assumptions were made in order to calculate flow loss, which are detailed in Appendix H. Flow loss calculation results are shown and discussed in further calculation details presented in Appendix I.

Equation 1 – Darcy's Law

$$Q = KiA \qquad (Equation\ 1)$$

where:

Q	is the amount of water discharged (m^3/day)
K	is the hydraulic conductivity (m/day)
i	is the hydraulic gradient (dimensionless)
A	is the area (e.g. exposed coal seam) (m^2)

6.1 Flow loss calculation results

6.1.1 Horizontal discharge (Q_{xy})

Leakage of groundwater from the target coal seams, namely Mt Arthur (MTA) and Bowfield Seams (BFS) into the pits (Q_{xy}) has been calculated using Darcy's Law (see Appendix H for the assumptions appliaed and Appendix I for the calculations) with the results shown in Table 4. The results indicate that approximately 0.12 ML/day of groundwater from the BFS enters the Lemington South Pit 1. The results also indicate that groundwater inflow from the MTA enters the pits at a rate of between 0.14 ML/day to 1.7 ML/day for the Cheshunt Pit area (including Cheshunt anticline). The highest inflows are predicted to occur at the anticline structure observed on the northern highwall of Cheshunt Pit, with predicted seepage rates of between 0.42 ML/day to 1.66 ML/day. These estimates are based on field observations of structural features on the highwall (JP Environmental 2013), and pump rate estimates by JP Environmental in 2011. Further testing and investigation of the hydraulic properties at the anticline structure and observations of pit water inflows and pumping rates are recommended to improve data confidence.

Detailed groundwater models have been undertaken at HVO South by MER (2005), ERM (2008) and NTEC (2009). Modelled leakage estimates for Cheshunt Pit and Barry's Void range between 0.22 ML/day/km (MER, 2005 and NTEC, 2010) and 2.2 ML/day (ERM, 2008). Leakage into Lemington South Pit 1 (North Void) is modelled to reach between 0.08 ML/day (NTEC, 2009) and 0.8 ML/day (ERM, 2008). The calculated estimates of groundwater leakage show a good agreement with previously modelled leakage estimates reported by MER (2005), ERM (2008) and NTEC (2009).

6.1.1 Vertical discharge (Q_z)

The vertical leakage of water from the alluvium into the underlying coal measures (Q_Z) was calculated and the results are summarised in Table 5. The results indicate a combined alluvial groundwater loss of approximately 2.3 ML/day for the Cheshunt Pit area (Money Box Pit, Cheshunt Pit, Cheshunt Pit anticline and Barry's Void) and an estimated groundwater loss of approximately 0.01 ML/day for Lemington South Pit. The largest loss of alluvial groundwater relates to the Cheshunt Pit anticline, with a predicted loss of around 1.94 ML/day. Estimates for Cheshunt Pit are considered conservative, with the Kz value used based on coal seam parameters in Rust PPK (1997), in order to account for potential sub-cropping of the Mount Arthur Seam beneath the alluvium.

The vertical leakage rates (Q_Z) defining the downward flow of groundwater from the alluvium to the coal seams were divided by the rate of groundwater leakage from target coal seams into the pits (Q_{XY}). The results (% Q_Z/Q_{XY}) indicate that:

- approximately 10% of groundwater seepage is likely to be sourced from the alluvium at Barry's Void;
- approximately 99% of groundwater seepage is likely to be sourced from the alluvium at Cheshunt Pit;
- approximately 8% of groundwater seepage is likely to be sourced from the alluvium at Lemington South Pit; and
- approximately 99% of water discharging from the anticline structure at Cheshunt Pit is likely to be sourced from alluvial groundwater.

Real time river flow data and Hunter Integrated Telemetry System (HITS) data collected by NOW indicates that baseflow for the Hunter River is 151 ML/day at Station 210083 (approximately 12 km upstream of Cheshunt Pit). The time weighted discharge rate duration curve, which is based on historical streamflow data since 1969, shows that the Hunter River flows at a rate of around 150 ML/day, approximately 75 % of the time, and flows at a rate of around 60 ML/day, approximately 95% of the time. The total leakage of alluvial groundwater (Q_Z) into the coal seams for Money Box Pit, Cheshunt Pit and Barry's Void is estimated at approximately 2.28 ML/day and would equate to an approximate flow loss of 1.5% to 3.8% from the Hunter River adjacent to these pits.

NOW data from Wollombi Brook at Station 210004 (approximately 1 km upstream of Lemington South Pit 1) shows that the flow rate is approximately 4 ML/day, 75 % of the time, no flow occurs at the 95th percentile. The total leakage of alluvial groundwater (Q_Z) from the Lemington South Pit 1 – North Void is estimated at 0.01 ML/day, and indicates an approximate stream flow loss of 0.2% from Wollombi Brook.

It is anticipated that the 1.5% and 0.2% flow loss, based on the 75th percentile, is a more realistic estimate, as the reduction in flow will correspondingly reduce the hydraulic gradient and rate of recharge into the surrounding aquifers. These flow loss estimates are considered conservative due to the assumptions made in the calculations (i.e. high K_Z for Cheshunt and Money Box Pits).

In addition, the loss from the Hunter River is potentially lower than calculated. Seepage into the Money Box Pit anticline structure is still a possibility, with recharge being primarily from spoil in mined-out pits located north of the Hunter River. In addition, the river flow loss calculations assume that all alluvial groundwater is sourced from the Hunter River or Wollombi Brook; however, groundwater level hydrographs suggest some recharge to the alluvial aquifers is sourced from rainfall.

The leakage values calculatd above are well beneath those as documented in the Hunter Valley Operations South Coal Project Environmental Assessment Report (ERM, 2008), suggesting a maximum predicted seepage volume of 7.3 ML/day.

Table 4 Estimated leakage of groundwater from coal seams into pits

Horizontal leakage from alluvium to coal seam location	Location	Flow direction	Horizontal hydraulic conductivity (MER, 2010) K_{XY} (m/d)	Horizontal hydraulic gradient (i_{XY})	Pit wall length (m)	Exposed face (m)	Horizontal discharge to Pit Q_{XY} (L/s)	Horizontal discharge from coal seams to Pit Q_{XY} (ML/d)	Percentage of pit inflow from alluvium Q_Z/Q_{XY} (%)
Mt Arthur	Cheshunt - Money Box Pit	Horizontal	0.05	0.44	650	10	1.6	0.14	0.94%
Mt Arthur	Cheshunt Pit Anticline	Horizontal	2.3 - 9.1	0.46	10	40	4.8 - 19.2	0.4 - 1.7	~ 99%
Mt Arthur	Cheshunt Pit	Horizontal	0.05	0.33	1,010	10	1.9	0.16	~ 99%
Mt Arthur	Cheshunt - Barry's Void	Horizontal	0.05	0.27	1,100	10	1.7	0.15	10%
						Cheshunt Area Total	**10.1 - 24.5**	**0.9 - 2.1**	-
Bowfield	Lemington South Pit 1	Horizontal	0.05	0.98	350	7	1.4	0.12	8 %

Notes: K_{xy} *Derived from NTEC (2010) and Rust PPK (1997) (m/day)*

i_{xy} *Horizontal hydraulic gradient*

Q_{xy} *Volume of groundwater discharging into mine pit*

Table 5 Estimated leakage of alluvial groundwater into coal seams

Vertical leakage from alluvium to coal seam location	Location	Flow direction	Vertical hydraulic of PCM Layer 2 in MER (March 2010) KZ (m/d)	Vertical hydraulic gradient (iz)	Pit wall length (m)	Width of alluvium (m)	Vertical discharge from alluvium to coal seams QZ (L/s)	Vertical discharge from alluvium to coal seams QZ (ML/d)
Mt Arthur	Cheshunt - Money Box Pit	Vertical	0.001	0.82	650	250	1.5	0.13
Mt Arthur	Cheshunt Pit Anticline	Vertical	1.00	0.78	10	250	22.5	*1.94*
Mt Arthur	Cheshunt Pit	Vertical	0.001	0.82	1,010	250	2.4	0.21
Mt Arthur	Cheshunt - Barry's Void	Vertical	0.0001	0.53	1,100	250	0.2	0.01
Cheshunt Area Total							**26.6**	***2.3***
Bowfield	Lemington South Pit 1	Vertical	0.0001	0.75	350	360	0.1	0.01

Notes:

Kz	*Derived from Rust PPK Pty Ltd (1997) Groundwater and Mine Water Management Study, South Lemington Mine (m/day)*
iz	*Vertical hydraulic gradient*
Qz	*Is the amount of water discharged (L/s)*

7. Lemington Underground (LUG) Bore Compliance

Lemington Underground (LUG) bore licence (20BL173392) was granted on 23rd September 2013 and is intended to regulate the abstraction of up to 1,800 ML/annum between 1 July and 30 June. The LUG bore abstracts water from the abandoned LUG mine void to supply water to both Hunter Valley Operations (HVO) and Mount Thorley Warkworth (MTW) mine sites (Rio Tinto, 2014). The following sections address the key criteria / licence conditions for LUG Bore licence 20BL173392, not covered in the other report sections.

7.1 Abstraction data

Table 6 shows the groundwater abstraction data for the licence reporting period (July 2013 to June 2014). The total abstraction for the licence reporting period was 332.37 ML, which is 18% of the annual allocation.

Table 6 Summary Groundwater Abstraction Data

Month / Year	Groundwater Extracted (ML)
September 2013	0
October 2013	25.3
November 2013	75.46
December 2013	103.22
January 2014	109.08
February 2014	1.8
March 2014	0
April 2014	0.02
May 2014	9.53
June 2014	7.96
Total	**332.37**

7.2 LUG Bore monitoring bore data

Table 8 (Appendix J) summarises details of the LUG bore monitoring network. This network monitors LUG bore abstraction impacts (if any) upon alluvium and coal seam aquifers. Groundwater level data from the monitoring network was used to create groundwater hydrographs in Appendix F, and to assess potential abstraction induced drawdown in the alluvium and coal seam aquifers near the LUG bore.

7.2.1 Alluvial Groundwater level near LUG Bore

Over the 2013/2014 LUG bore licence reporting period, groundwater level in alluvial bores C130(ALL), PBO1(ALL), C919(ALL), Appleyard Farm and D317 (ALL) declined by between 0.11 m (C130 (ALL)) and 0.51m (PB01 (ALL)). It is noted that the stream gauge data for the Wollombi Brook (NOW Station 21004) measured a decline of 0.22m over the same period.

As previously mentioned, alluvial groundwater levels appear to be correlated with changes in stream level and rainfall. Therefore it is more likely that the decline in alluvial groundwater levels in the monitoring bores is related to a decline in stream level, rather than extraction from LUG Bore.

7.2.2 Coal Seam groundwater levels near LUG Bore

The following findings can be observed from the data collected over the 2013/2014 LUG bore licence reporting period:

- groundwater levels within the Woodlands Hill Seam and Glen Munro Seam bores declined by between 0.11 m (C130 (WDH)) and 1.35 m (B425 (WDH)). Groundwater levels within these bore in the monitoring period preceding this one were at above average levels, likely due to elevated rainfall. It is likely that the decline in groundwater levels in the Woodlands Hill and Glen Munro seams were due to a return to long-term average rainfall levels; also, it is likely that there is recharge to these shallow seams from rainfall. This data suggests that the groundwater level within these shallow seams is not impacted by groundwater abstraction from the LUG Bore.
- groundwater levels within the Arrowfield Seam bores declined by between 0.35m D510 (AFS) and 1.02m D612 (AFS). Hydrograph analysis of these bores suggests little change in groundwater levels due to changing rainfall conditions. The hydrographs also show that there is little change due to abstraction from the LUG Bore.
- groundwater levels in the Bowfield Seam to the east of the Wollombi Brook declined by up to 2.76m, while those to the west of Wollombi Brook varied (i.e. some declined, and others rose). Hydrograph analysis combined with water level data from South Lemington South Void suggest that changes in the groundwater level within these bores is likely due to changes in the water level within the South Lemington South Void, and not directly impacted by abstraction from the LUG Bore.

7.3 Summary & Recommendations

Based on available data, LUG Bore (20BL173392) complies with licence conditions and there has been little impact (if any) on surrounding aquifers. Although groundwater dependent ecosystems and streams were not specifically assessed in this review, the sources of groundwater and recharge for these systems do not appear to have been affected.

Given the above, ongoing monitoring of the LUG Bore monitoring network bores is recommended as to assess long term impacts (if any) of on-going abstraction from the LUG Bore.

8. Conclusions

The following conclusions HVO South area are drawn from the data presented in the previous sections.

Hunter River Alluvium

- Flow and gradient: groundwater in the Hunter River alluvium flows in a north-easterly direction. The hydraulic gradient beneath Barry's Flat is low, which is likely related to a high hydraulic conductivity of the alluvium and topography of the land surface. Wollombi Brook alluvial groundwater flows towards the North Void of Lemington South Pit 1.
- Levels vs CRD: Alluvium groundwater levels near Barry's Void and Lemington South Pits correlate closely to the CRD curve for 2014. The groundwater levels around Barry's Void appear to respond to peak flow events at Hunter River gauging stations. This indicates that the alluvium north-west of Barry's Void may be an area where the river is the predominant source of recharge.
- The alluvium groundwater levels in the area between Cheshunt Pit and the Hunter River is below the base of the existing alluvial monitoring network. Further investigation is required to confirm the construction details of existing Cheshunt Pit alluvial bores. Bores, which are screened above the saturated thickness of the alluvium, should be replaced.

Mt Arthur Seam

- Groundwater levels in Mount Arthur Seam bores (adjacent Cheshunt Pit) declined by up to 1 m during the 2014 monitoring period. This decrease is likely due to depressurisation from mining of the Mount Arthur Seam in the Cheshunt area.
- Mount Arthur Seam bores close to Barry's Void exhibited stable groundwater levels over 2014.
- Mount Arthur Seam bores on Barry's Flat showed a response to peak flow events at Hunter River stream gauging stations. Faulting and displacement of stratigraphy or the subcrop of the coal seams within this region may have resulted in hydraulic connection between the coal measures and the overlying alluvium.
- Higher groundwater elevations in the alluvium compared to the underlying coal seams indicate the potential for downward seepage from the alluvium to the Permian coal seams at each of the pits.

Alluvial Groundwater Loss

- Darcy's Law calculations indicate that approximately 0.14 ML/day to 1.7 ML/day of groundwater from the Mount Arthur Seam enters Cheshunt Pit area. This volume is less than that estimated for 2013 and includes inflows into Cheshunt Pit, Money Box Pit, Barry's Void and the Cheshunt Pit anticline.
- The results from the calculations also indicate that approximately 0.12 ML/day of groundwater from the BFS enters Lemington South Pit 1 - North Void. This volume is similar to that estimated in 2013.
- Calculation of potential inflows involved several assumptions, as detailed in Appendix H. Further investigation and testing of hydraulic parameters is recommended, in order to refine the groundwater inflow estimates and collection of in-pit pump data.
- The inflow calculations suggest the alluvium is the likely groundwater source for approximately 10%, 8% and 99% of groundwater inflows for Barry's Void, Lemington South Pit 1 and Cheshunt Pit (excluding the anticline structure), respectively. The results also show that up to approximately 99% of groundwater inflow at the Cheshunt Pit anticline structure could be alluvium sourced.

- The total leakage of alluvial groundwater into the coal seams for the Cheshunt area is in the order of 2.28 ML/day and would equate to an approximate flow loss of 1.5% from the Hunter River in areas adjacent to the pits (based on assumptions and November 2014 groundwater data). The total leakage of alluvial groundwater to the Lemington South Pit 1 – North Void is 0.01 ML/day and indicates an approximate stream flow loss.
- The source of water inflows into the Cheshunt Pit may be a combination of the Permian coal measures, Hunter River, rainfall and potentially the backfilled North Void (located north of the Hunter River). The identified anticline structure along with other structural features may act as conduits for groundwater flow between HVO North and HVO South mine areas. It is recommended that on-going sampling and geochemical analysis be undertaken in order to assist in understanding the temporal and spatial variability in seepage.

9. References

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Appendix A Surface water flow graphs

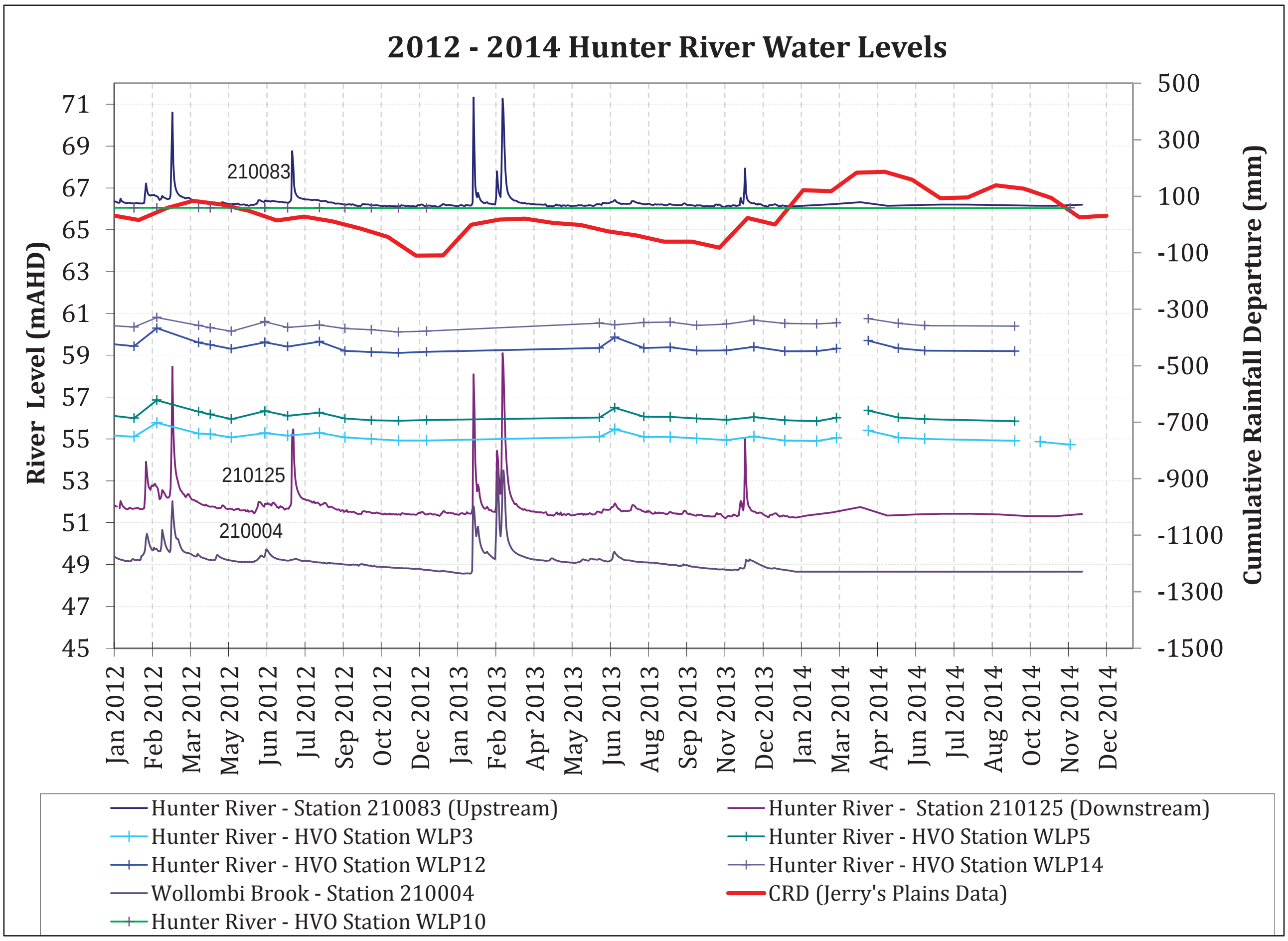


Figure 10 Hunter river levels

Table 7 2014 HVO Hunter River stream level (mRL) data

Station ID	Easting	Northing	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
WLP3	312612.6	6401505.3	54.9	54.9	55.1	55.4	55.1	55.0	n/a	n/a	54.9	54.9	54.7	n/a
WLP5	311655.1	6400647.0	55.9	55.9	56.0	56.4	56.0	55.9	n/a	n/a	55.9	55.8	55.7	n/a
WLP10	310079.7	6401633.6	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	58.47	n/a
WLP12	309346.1	6402293.6	59.2	59.2	59.3	59.7	59.3	59.2	n/a	n/a	59.2	59.1	n/a	n/a
WLP14	308597.7	6402452.9	60.5	60.5	60.6	60.7	60.5	60.4	n/a	n/a	60.4	60.4	60.3	n/a

Appendix B Cheshunt Mine Area Geological Cross Section (MER, 2005)

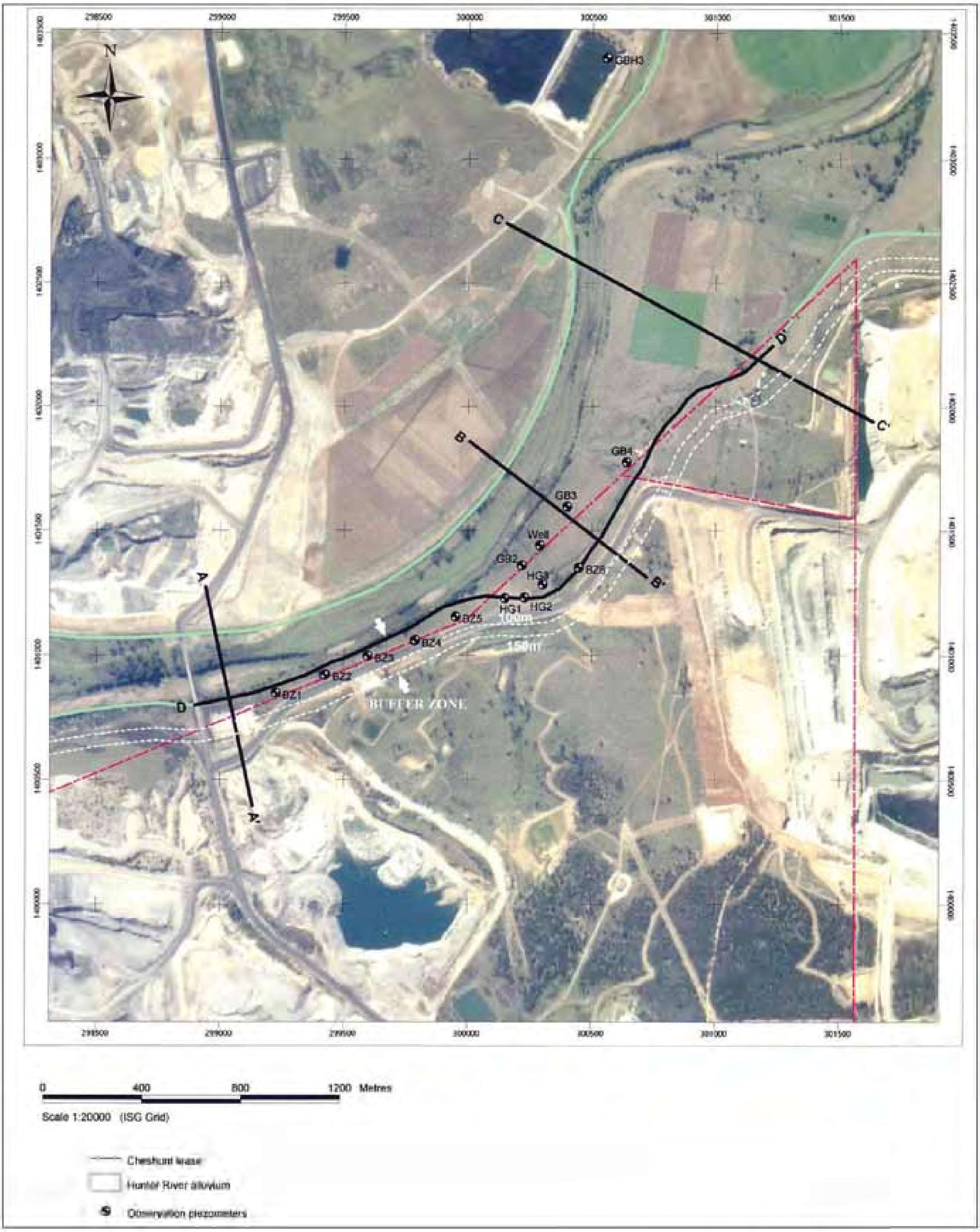


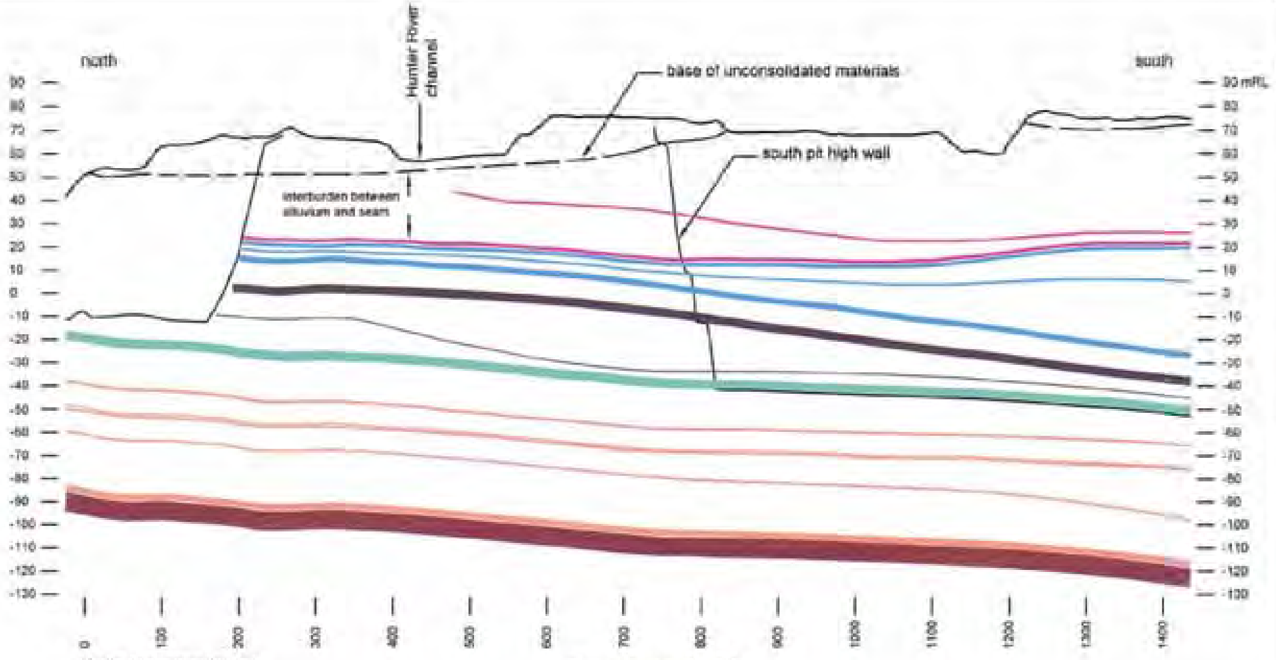
Image Source: MER, 2005

HVO South & LUG (G1593H)
2014 Groundwater Impacts Report

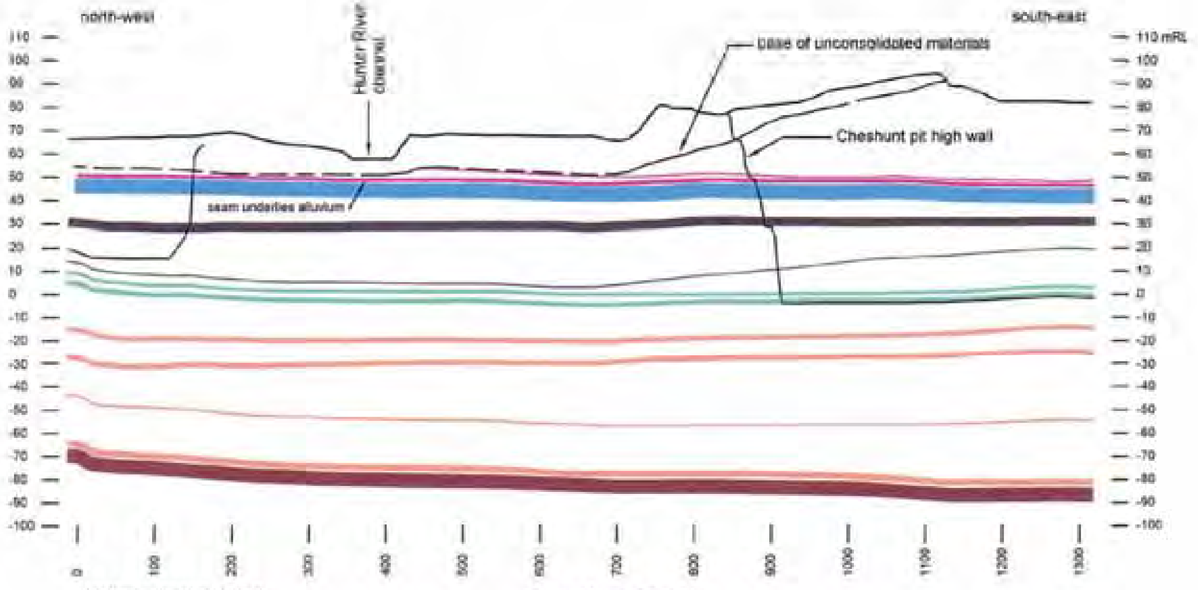
Geological Sections (Source: MER 2005)

DATE: 28/1/2015

FIGURE No: 11



Section A-A'



Section B-B'

🟥 WARKWORTH SEAMS	🟩 VAUX SEAMS
🟦 MT ARTHUR SEAMS	🟧 BROONIE SEAMS
⬛ PIERCEFIELD SEAMS	🟫 BAYSWATER SEAM

Image Source: MER, 2005

HVO South & LUG (G1593H)
2014 Groundwater Impacts Report

Stratigraphic Sections A-A' and B-B' (Source: MER 2005)

DATE: 28/1/2015

FIGURE No: 12

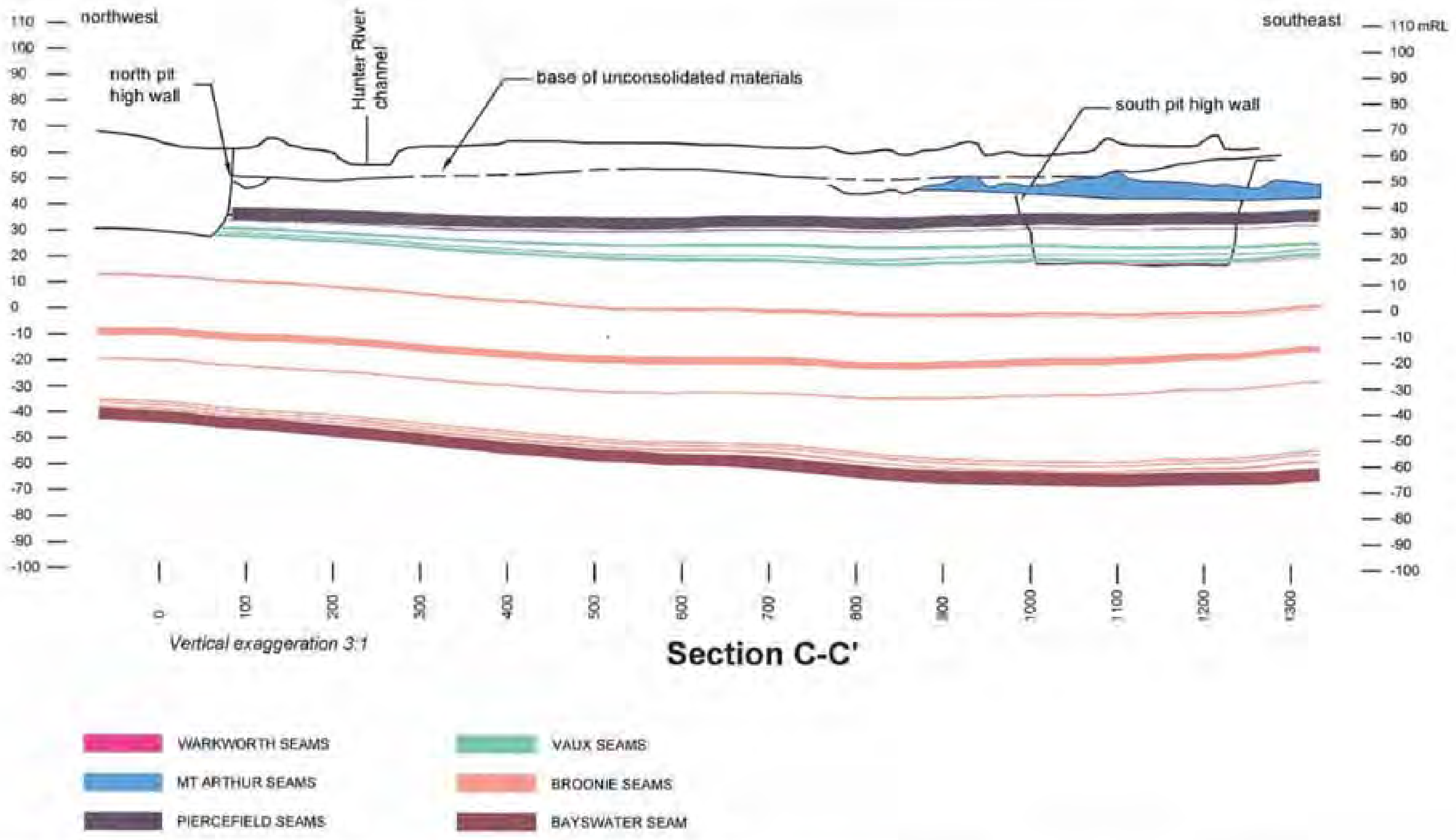


Image Source: MER, 2005

HVO South & LUG (G1593H)
2014 Groundwater Impacts Report

Stratigraphic Section C-C'
(Source: MER 2005)

DATE:
28/1/2015

FIGURE No:
13

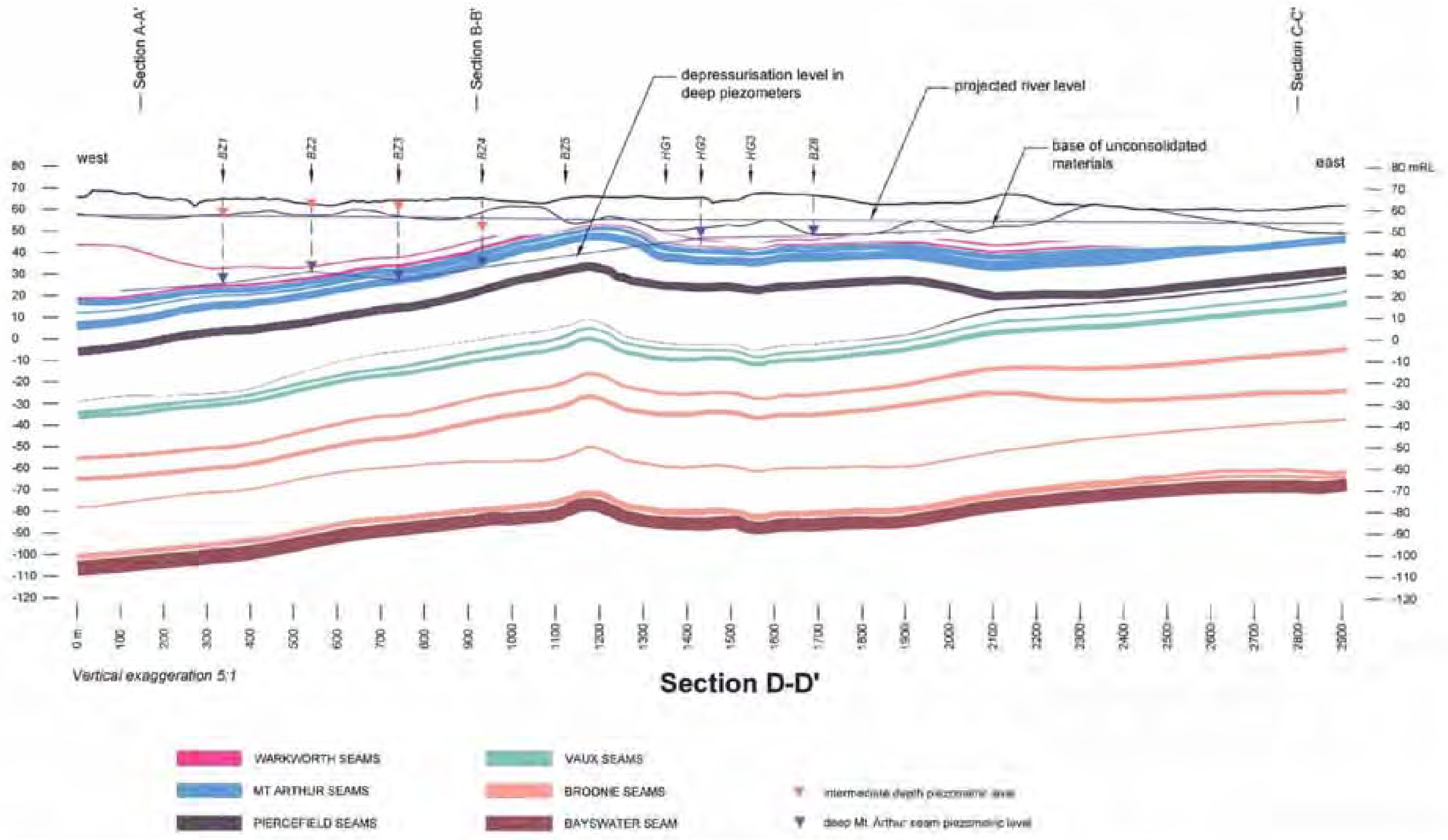


Image Source: MER, 2005

HVO South & LUG (G1593H)
2014 Groundwater Impacts Report

Stratigraphic Section D-D'
(Source: MER 2005)

DATE:
28/1/2015

FIGURE No:
14

Appendix C Monitoring Bore Construction Details

Bore	Install date	Easting	Northing	Ground level (mAHD)	Collar height	Collar RL (mAHD)	Install depth (mBGL)	Install depth (mAHD)	SWL (mAHD) Dec '15	Depth to screen (mBGL)	Target lithology	Location	Logger
BC1		312421	6401010	66.36	0.3	66.66	8.51	57.85			Alluvium	Cheshunt Pit	
BZ1-1		311472.1	6400483	71.77	0.4	72.17	20.99	50.78	55.57	21 - 24	Interburden	Cheshunt Pit	
BZ2B		311668	6400560	71.26					63.86		Alluvium	Cheshunt Pit	
BZ8-1		312685.2	6401010	67.76					57.59		Alluvium	Cheshunt Pit	
Hobdens Well		312540	6401093	66.52	0.68	67.2	13.93	52.59	54.93		Alluvium	Cheshunt Pit	
S6		312394	6400896	69	0.45	66.51	10.25	58.75	58.29		Alluvium	Cheshunt Pit	
BZ1-2		311472.1	6400483	71.77	0.41	72.18	9.73	62.04	61.56	7 - 10	Alluvium	Cheshunt Pit	
BZ2A(2)		311670.9	6400561	71.72	0.55	72.27	20.9	50.82	50.26		Interburden	Cheshunt Pit	
BZ3-1		311840.2	6400640	70.25	0.32	70.57	26.18	44.07	56.23		Interburden	Cheshunt Pit	
BZ3-2		311840.2	6400640	70.25	0.29	70.54	11.71	58.54	58.26		Interburden	Cheshunt Pit	
BZ4A(1)		312029.1	6400705	74.36					49.74		Interburden	Cheshunt Pit	
BZ4B		312029.1	6400705	74.11					65.1		Interburden	Cheshunt Pit	
BZ8-2		312685.2	6401010	67.76					49.16		Interburden	Cheshunt Pit	
HG1		312390	6400882	66.1	0.69	66.79	14.65	51.45	54.74		Interburden	Cheshunt Pit	
HG2		312468.7	6400886	67.45	0.63	68.08	15.49	51.96	55.3		Interburden	Cheshunt Pit	
HG3		312541.4	6400940	66.83					55.46		Interburden	Cheshunt Pit	
BC1a	1/05/2009	312421	6401010	66.08	0.28	66.36	21.1	44.98	48.84		Mt Arthur?	Cheshunt Pit	
BZ1-3	1/05/2009	311472.1	6400483	71.77	0.4	71.77	35	36.77	39.19	56	Mt Arthur	Cheshunt Pit	Y
BZ2A(1)	1/05/2009	311670.9	6400561	71.72	0.44	71.72	39	32.72	31.64	52.1	Mt Arthur	Cheshunt Pit	Y
BZ3-3	1/05/2009	311840.2	6400640	70.25	0.38	70.25	38	32.25	31.24	44.5	Mt Arthur	Cheshunt Pit	Y
BZ4A(2)		312029.1	6400705	73.77	0.59	74.36	41.41	32.36	33.58	41	Mt Arthur	Cheshunt Pit	Y

Bore	Install Date	Easting	Northing	Ground Level (mAHD)	Collar Height	Collar RL (mAHD)	Install Depth (mBGL)	Install Depth (mAHD)	SWL (mAHD)	Depth to Screen (mBGL)	Target Lithology	Location	Logger
BZ5-1		312192.2	6400804	66.85					48.59		Mt Arthur	Cheshunt Pit	
BZ5-2		312192.2	6400804	66.85					54.2		Mt Arthur	Cheshunt Pit	
BZ8-3		312685.2	6401010	67.76					39.88		Mt Arthur	Cheshunt Pit	
HG2a	1/05/2009	312468.7	6400886	66.71	0.58	67.35	27.84	38.87	41.18	41.24	Mt Arthur	Cheshunt Pit	
S4		312614	6401065	67.423	1.1	66.32	11.74	55.68	59.07		Rock/Coal	Barry's Pit	
BUNC12		313180	6401753	75.89					56.33		Alluvium	Barry's Pit	
BUNC13		313145	6401730	78.63					64.12		Alluvium	Barry's Pit	
BUNC39B (Shallow)	1/05/2009	313500.9	6401824	66.99	0.5	66.74	16.08	50.91	52.02	18.8	MTA?	Barry's Pit	
BUNC45A		313667.2	6402060	73.08	0.3	66.74	21.2	51.88	53.23	17.3 - 20.3	Alluvium	Barry's Pit	
CHPZ10A	24/05/2007	313335	6402297	63.24	0.74	63.24	12.55	50.69	54.56	9.5	Alluvium	Barry's Pit	
CHPZ11A	30/05/2007	313430	6402142	61.84	1.07	61.83	10.6	51.24	54.72	7.15	Alluvium	Barry's Pit	Y
CHPZ12A	31/05/2007	313335	6402297	63.31	0.21	63.31	11.5	51.81	54.68	9.5	Alluvium	Barry's Pit	Y
CHPZ13A	5/06/2007	313009.2	6401802	65.37	0.8	65.36	14.3	51.07	54.84	11.17	Alluvium	Barry's Pit	Y
CHPZ14A		312882.8	6401639	65.95	0.46	66.41	15.14	50.81	54.89	13 - 16	Alluvium	Barry's Pit	
CHPZ1A		312823	6401690	65.62					54.67		Alluvium	Barry's Pit	
CHPZ2A	13/06/2007	312961	6401576	65.79	0.58	65.78	15.2	50.59	54.93	12.6	Alluvium	Barry's Pit	Y
CHPZ3A	5/06/2007	313105	6401754	63.89	0.78	63.89	13.8	50.09	54.89	10.9	Alluvium	Barry's Pit	Y
CHPZ4A	22/05/2007	312905	6402121	66.24	0.84	66.24	12.8	53.44	54.87	9.5	Alluvium	Barry's Pit	Y
CHPZ5A	23/05/2007	312928	6401846	65.4	0.44	65.39	13.33	52.07		12	Alluvium	Barry's Pit	Y
CHPZ7A		313602	6402239	60.14	0.15	60.29	11.23	48.91	54.4	8 - 11	Alluvium	Barry's Pit	
CHPZ9A		313534	6402390	62.05					54.53		Alluvium	Barry's Pit	

Bore	Install Date	Easting	Northing	Ground Level (mAHD)	Collar Height	Collar RL (mAHD)	Install Depth (mBGL)	Install Depth (mAHD)	SWL (mAHD)	Depth to Screen (mBGL)	Target Lithology	Location	Logger
BUNC45D		313667.2	6402055	73.08	0.36	73.44	30.73	42.35	48.97	25.9 - 28.9	Coal	Barry's Pit	
BUNC39A (Deep)		313500.9	6401824	66.74					50.94		Mt Arthur?	Barry's Pit	
BUNC44D	14/05/2007	313600.5	6401922	64.49	0.72	64.49	16.4	48.09	50.915	13	Mt Arthur	Barry's Pit	
BUNC46D - Barrys	1/05/2009	313328.3	6401783	65.71	0.18	65.89	25.12	40.59	55.07	21 - 24	Interburden	Barry's Pit	
CHPZ12D	16/05/2007	313236.9	6402020	63.57	0.33	63.57	14.3	49.27	54.64	15	Mt Arthur	Barry's Pit	Y
CHPZ13D	16/05/2007	313238	6402019	65.05	0.36	65.05	17.31	47.74	53.19	19.9	Mt Arthur	Barry's Pit	Y
CHPZ14D	15/05/2007	312891	6401643	65.91	0.38	65.91	18.84	47.07	52.58	24.3	Mt Arthur	Barry's Pit	Y
CHPZ3D	15/05/2007	313093.2	6401756	63.63	0.66	63.63	15.95	47.68	53.15	19.2	Mt Arthur	Barry's Pit	Y
CHPZ8D	25/05/2007	313508	6402045	60.97	1.05	60.97	9.5	51.47	54.57	6	Mt Arthur	Barry's Pit	Y
BUNC14		313115	6401693	80.82					70.48		Sandstone	Barry's Pit	
CHPZ8A		313502.2	6402051	60.05	0.8	60.35	6.25	53.8	54.38	4 - 6	Alluvium	Barry's Pit	
C130(ALL)		316399.6	6394916	63.424	0.32	63.10	16.98	46.44	47.58		Interburden?	Lemington South Pit 1	
C919(ALL)		315191.7	6395655	58.236	0.3	57.93	11.46	46.77	46.71		Alluvium	Lemington South Pit 1	
D317(ALL)		315044	6396018	59.5	0.29	59.79	14.65	44.85	44.44	9.2 - 12.2	Alluvium	Lemington South Pit 1	
PB01(ALL)		314754	6396026	55					47.45		Alluvium	Lemington South Pit 1	
Appleyard Farm		315491	6394639	43.44	0.75	43.44	8.77	34.67	36.6	-	Alluvium	Lemington South Pit 1	
D406(AFS)		313931	6396074	57.731	0.32				41.96		Arrowfield	Lemington South Pit 1	
D612(AFS)		314524	6396314	62.548	0.39						Arrowfield	Lemington South Pit 1	
B334(BFS)		316683.5	6394088	73.668	0.27	73	51.8	21.86	28.22	58.5	Bowfield	Lemington South Pit 1	Y

Bore	Install Date	Easting	Northing	Ground Level (mAHD)	Collar Height	Collar RL (mAHD)	Install Depth (mBGL)	Install Depth (mAHD)	SWL (mAHD)	Depth to Screen (mBGL)	Target Lithology	Location	Logger
C130(BFS)		316399.6	6394916	63.31	0.01	63	36.7	26.617	32.62	55	Bowfield	Lemington South Pit 1	Y
C317(BFS)		315054.4	6395007	60.74	0.36	61.10	76.16	-15.41			Bowfield	Lemington South Pit 1	
C613(BFS)		314688.2	6395243	63.94	0.31	64.25	85.49	-21.54			Bowfield	Lemington South Pit 1	
C621(BFS)		315421.3	6395321	58.68	0.32	59.00	57.45	1.23	32.53		Bowfield	Lemington South Pit 1	
C630(BFS)		316377.5	6395306	69.15	0.34	69.49	49.1	20.05	32.56		Bowfield	Lemington South Pit 1	
D010(BFS)		314354.8	6395687	56.33	0.39	56.72	68.05	-11.71	30.48		Bowfield	Lemington South Pit 1	
D214(BFS)		314768	6395831	56.99	0.33	57.32	53.47	3.52	31.88		Bowfield	Lemington South Pit 1	
D317(BFS)		315042.6	6396018	59.97	0.31	60.28	35.42	24.55	31.3	39	Bowfield	Lemington South Pit 1	Y
D406(BFS)		313931	6396074	57.67	0.32	57.99	61.33	-3.65	25.64		Bowfield	Lemington South Pit 1	
D510(BFS)		314380.1	6396141	55.30	0.32	55.62	30.35	24.95	28.36		Bowfield	Lemington South Pit 1	
D612(BFS)		314524	6396314	62.43	0.34	62.77	35.06	27.37	28.81		Bowfield	Lemington South Pit 1	
D807(BFS)		314002	6396484	60.29	0.35	60.64	41.37	18.92	24.99		Bowfield	Lemington South Pit 1	
B631(BFS)		316415	6394327	72.43	0.3	72.73	36.09	36.34	42.39	78	Bowfield Seam	Lemington South Pit 1	Y
B925(BFS)		315920.6	6394604	62.81	0.36	63.17	41.21	21.60	30.09	81	Bowfield Seam	Lemington South Pit 1	Y
C130(AFS1)		316399.6	6394916	63.55	0.33	63.88	42.16	21.39	45.15		Arrowfield	Lemington South Pit 1	
D010(GM)		314354.8	6395687	56					48.55		Glen Munro	Lemington South Pit 1	
D510(AFS)		314380.1	6396141	55.27	0.3	55.57	38.78	16.49	32.44		Arrowfield	Lemington South Pit 1	
B425(WDH)		316010.3	6395024	58.19	0.31	58.50	36.19	22.00	31.99		Woodlands Hill	Lemington South Pit 1	
B631(WDH)		316424.4	6394319	72.24	0.27	72.51	30.73	41.51	46.8		Woodlands Hill	Lemington South Pit 1	

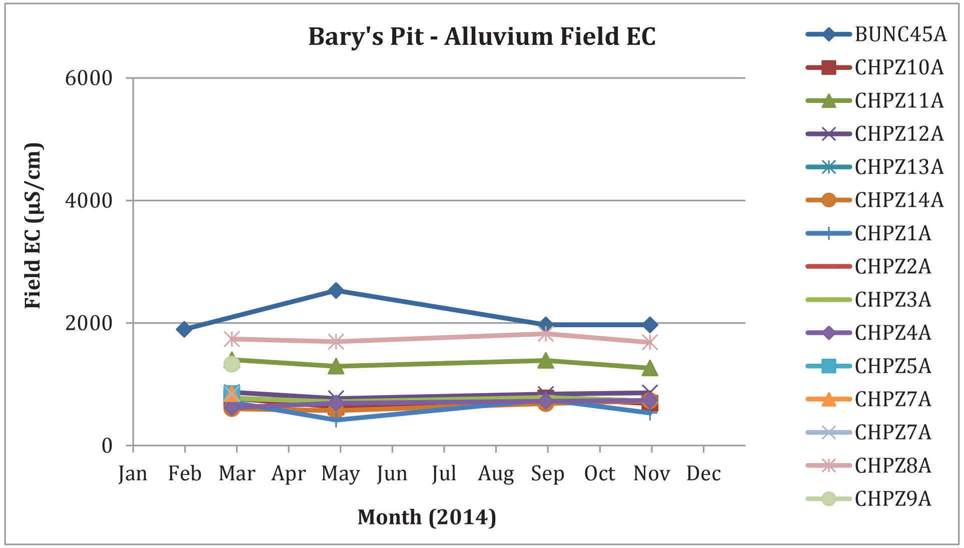
Bore	Install Date	Easting	Northing	Ground Level (mAHD)	Collar Height	Collar RL (mAHD)	Install Depth (mBGL)	Install Depth (mAHD)	SWL (mAHD)	Depth to Screen (mBGL)	Target Lithology	Location	Logger
C122(WDH)		315501.2	6395007	58.73	0.29	59.02	22.69	36.04	46.1		Woodlands Hill	Lemington South Pit 1	
C130(WDH)		316399.6	6394916	63.51	0.38	63.89	21.55	41.96	47.47		Woodlands Hill	Lemington South Pit 1	
C317(WDH)		315054.4	6395007	60.33	0.21	60.54	33.89	26.44			Woodlands Hill	Lemington South Pit 1	
C809 (GM/WDH)		314206.7	6395493	59.12	0.31	59.43	28.69	30.43	47.57	28 - 38	Woodlands Hill	Lemington South Pit 1	
D010(WDH)		314354.8	6395687	56.26	0.33	56.59	16.97	39.29	47.12		Woodlands Hill	Lemington South Pit 1	
D317WDH		315044	6396018	59.5					59.5		Woodlands Hill	Lemington South Pit 1	

Appendix D Groundwater Quality

Bore ID	Target lithology	Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
BUNC45D	Coal	Barry's Pit	-	2490	-	-	1910	-	-	-	2610	-	2460	-
BUNC46D	Interburden	Barry's Pit	-	2120	-	-	-	-	-	-	-	-	-	-
BUNC44D	Mt Arthur	Barry's Pit	-	3580	-	-	-	-	-	-	-	-	-	-
BUNC39A(Deep)	Mt Arthur	Barry's Pit	-	1578	-	-	-	-	-	-	-	-	-	-
BUNC39B(Shallow)	MTA	Barry's Pit	-	-	-	-	-	-	-	-	-	-	-	-
BUNC14	Sandstone	Barry's Pit	-	-	-	-	-	-	-	-	-	-	-	-
BC1	Alluvium	Cheshunt Pit	-	-	-	-	-	-	-	-	-	-	-	-
BZ1-2	Alluvium	Cheshunt Pit	-	-	-	-	-	-	-	-	-	-	-	-
BZ2B	Alluvium	Cheshunt Pit	-	-	-	-	-	-	-	-	-	-	-	-
BZ8-1	Alluvium	Cheshunt Pit	-	-	-	-	-	-	-	-	-	-	-	-
Hobden's Well	Alluvium	Cheshunt Pit	-	-	2110	-	-	-	-	-	-	-	-	-
S6	Alluvium	Cheshunt Pit	-	-	-	-	-	-	-	-	-	-	-	-
BZ1-1	Interburden	Cheshunt Pit	-	-	9100	-	8700	-	-	-	8580	-	8500	-
BZ2A(2)	Interburden	Cheshunt Pit	-	-	-	-	-	-	-	-	-	-	-	-
BZ3-1	Interburden	Cheshunt Pit	-	-	2430	-	2570	-	-	-	2440	-	2480	-
BZ3-2	Interburden	Cheshunt Pit	-	-	-	-	-	-	-	-	-	-	-	-
BZ4B	Interburden	Cheshunt Pit	-	-	-	-	-	-	-	-	-	-	-	-
BZ8-2	Interburden	Cheshunt Pit	-	-	1314	-	1310	-	-	-	1266	-	1311	-
Fpbo	Interburden	Cheshunt Pit	-	-	-	-	-	-	-	-	-	-	-	-
HG1	Interburden	Cheshunt Pit	-	-	-	6830	-	-	-	-	-	-	-	-
HG2	Interburden	Cheshunt Pit	-	-	4120	-	-	-	-	-	-	-	-	-

Bore ID	Target Lithology	Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
HG3	Interburden	Cheshunt Pit	-	-	1389	-	1391	-	-	-	1460	-	1498	-
BZ1-3	Mt Arthur	Cheshunt Pit	-	-	6980	-	7080	-	-	-	6820	-	7100	-
BZ2A(1)	Mt Arthur	Cheshunt Pit	-	-	1619	-	1758	-	-	-	1658	-	1742	-
BZ3-3	Mt Arthur	Cheshunt Pit	-	-	1768	-	1353	-	-	-	1263	-	1930	-
BZ4A(2)	Mt Arthur	Cheshunt Pit	-	-	-	-	-	-	-	-	2340	-	1860	-
BZ5-1	Mt Arthur	Cheshunt Pit	-	-	-	-	-	-	-	-	-	-	-	-
BZ5-2	Mt Arthur	Cheshunt Pit	-	-	-	-	-	-	-	-	-	-	-	-
BZ8-3	Mt Arthur	Cheshunt Pit	-	-	-	-	-	-	-	-	-	-	-	-
HG2A	Mt Arthur	Cheshunt Pit	-	-	5180	-	5260	-	-	-	5180	-	5350	-
BC1a	Mt Arthur?	Cheshunt Pit	-	-	828	-	800	-	-	-	809	-	810	-
Appleyard Farm	Alluvium	Lemington South Pit 1	-	525	-	-	485	-	-	445	-	-	390	-
C919(ALL)	Alluvium	Lemington South Pit 1	-	-	-	-	9240	-	-	-	-	-	9080	-
D317(ALL)	Alluvium	Lemington South Pit 1	-	-	-	-	7230	-	-	-	-	-	7270	-
PB01(ALL)	Alluvium	Lemington South Pit 1	-	-	-	7340	-	-	7460	-	-	7490	-	7230
C130(AFS1)	Arrowfield	Lemington South Pit 1	-	-	-	-	13210	-	-	-	-	-	13060	-
D406(AFS)	Arrowfield	Lemington South Pit 1	-	-	-	-	2820	-	-	-	-	-	2860	-
D510(AFS)	Arrowfield	Lemington South Pit 1	-	-	-	-	6930	-	-	-	-	-	6860	-
D612(AFS)	Arrowfield	Lemington South Pit 1	-	-	-	-	12440	-	-	-	-	-	12300	-
B334(BFS)	Bowfield	Lemington South Pit 1	-	-	-	-	5190	-	-	-	-	-	4900	-
C130(BFS)	Bowfield	Lemington South Pit 1	-	-	-	-	3590	-	-	-	-	-	4000	-
C317(BFS)	Bowfield	Lemington South Pit 1	-	-	-	-	8480	-	-	-	-	-	8430	-

Bore ID	Target Lithology	Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
C613(BFS)	Bowfield	Lemington South Pit 1	-	-	-	-	9080	-	-	-	-	-	9000	-
C621(BFS)	Bowfield	Lemington South Pit 1	-	-	-	-	3240	-	-	-	-	-	3230	-
C630(BFS)	Bowfield	Lemington South Pit 1	-	-	-	-	2830	-	-	-	-	-	2830	-
D010(BFS)	Bowfield	Lemington South Pit 1	-	-	1326	-	-	-	-	-	-	-	-	-
D214(BFS)	Bowfield	Lemington South Pit 1	-	-	-	-	9070	-	-	-	-	-	8900	-
D317(BFS)	Bowfield	Lemington South Pit 1	-	-	-	-	-	-	-	-	-	-	-	-
D406(BFS)	Bowfield	Lemington South Pit 1	-	-	-	-	11210	-	-	-	-	-	10890	-
D510(BFS)	Bowfield	Lemington South Pit 1	-	-	-	-	13550	-	-	-	-	-	13340	-
D612(BFS)	Bowfield	Lemington South Pit 1	-	-	-	-	15320	-	-	-	-	-	14680	-
D807(BFS)	Bowfield	Lemington South Pit 1	-	-	-	-	11630	-	-	-	-	-	11310	-
B631(BFS)	Bowfield Seam	Lemington South Pit 1	-	-	-	-	13200	-	-	-	-	-	-	-
B925(BFS)	Bowfield Seam	Lemington South Pit 1	-	-	-	-	4390	-	-	-	-	-	4840	-
D010(GM)	Glen Munro	Lemington South Pit 1	-	-	-	-	10710	-	-	-	-	-	10610	-
C130(ALL)	Interburden?	Lemington South Pit 1	-	23100	-	-	22100	-	-	22700	-	-	21800	-
B425(WDH)	Woodlands Hill	Lemington South Pit 1	-	-	-	-	7800	-	-	-	-	-	6040	-
B631(WDH)	Woodlands Hill	Lemington South Pit 1	-	-	-	-	12440	-	-	-	-	-	11560	-
C122(WDH)	Woodlands Hill	Lemington South Pit 1	-	-	-	-	13450	-	-	-	-	-	13570	-
C130(WDH)	Woodlands Hill	Lemington South Pit 1	-	-	-	-	20700	-	-	-	-	-	20010	-
C317(WDH)	Woodlands Hill	Lemington South Pit 1	-	-	-	-	8370	-	-	-	-	-	8570	-
C809(GM/WDH)	Woodlands Hill	Lemington South Pit 1	-	-	-	10150	-	-	15760	-	-	11560	-	15800
D010(WDH)	Woodlands Hill	Lemington South Pit 1	-	-	-	-	10700	-	-	-	-	-	10820	-


Bary's Pit - Alluvium Field EC
Field EC (µS/cm)
6000
4000
2000
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month (2014)
BUNC45A
CHPZ10A
CHPZ11A
CHPZ12A
CHPZ13A
CHPZ14A
CHPZ1A
CHPZ2A
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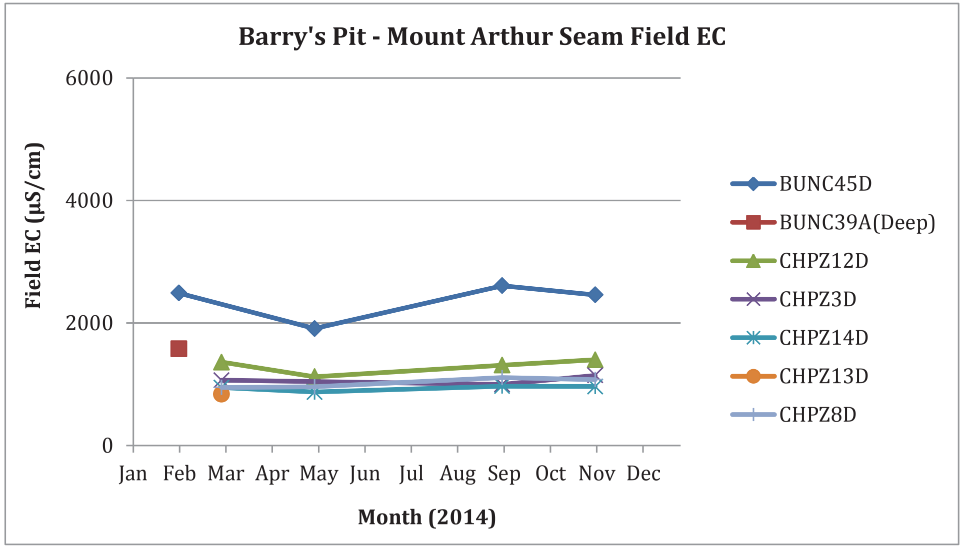
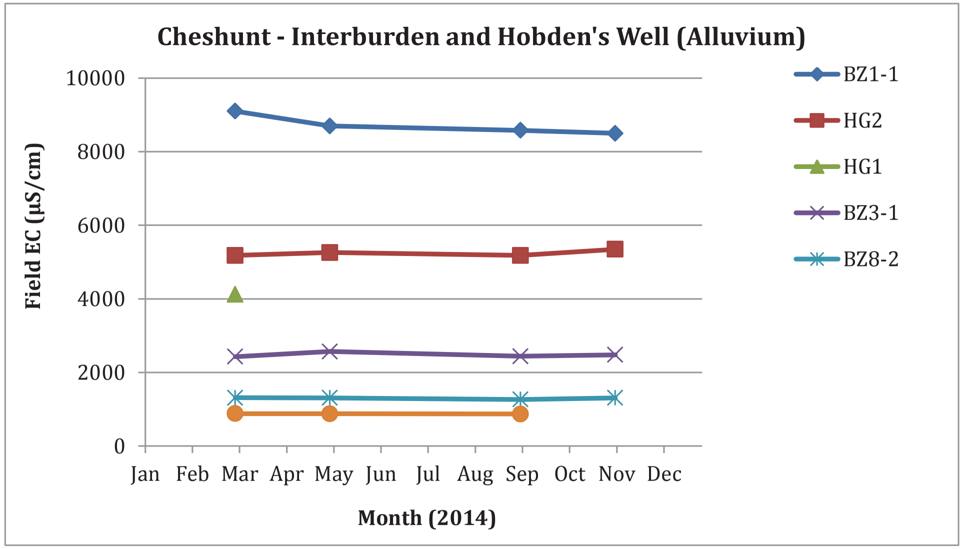
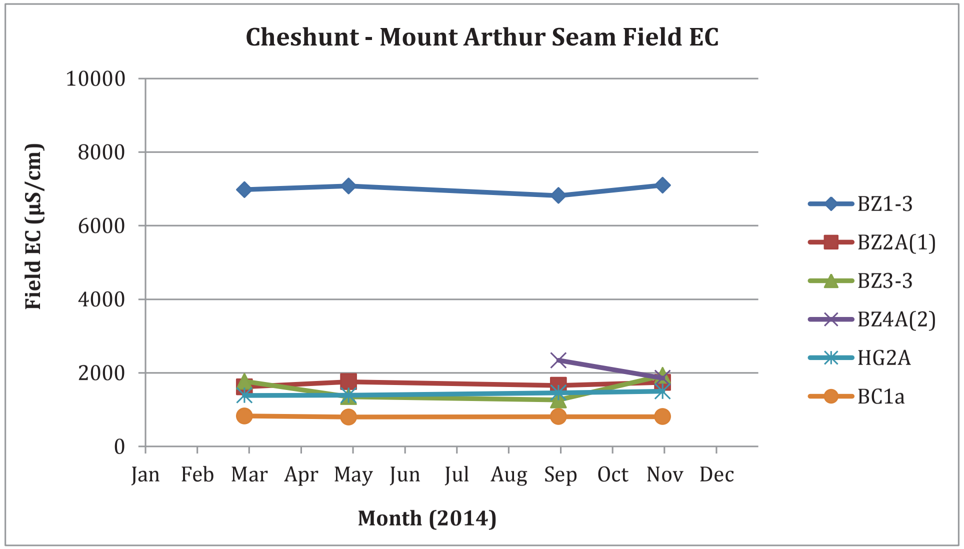
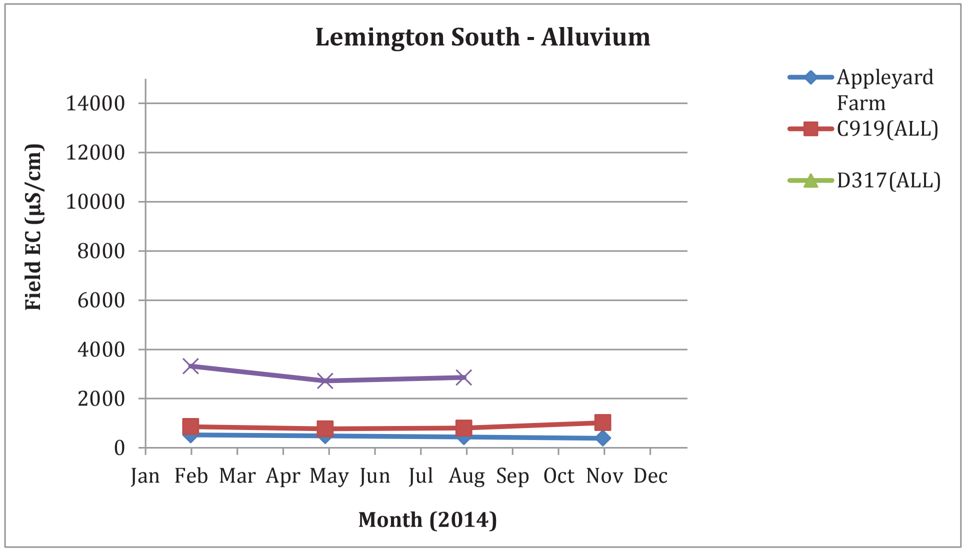
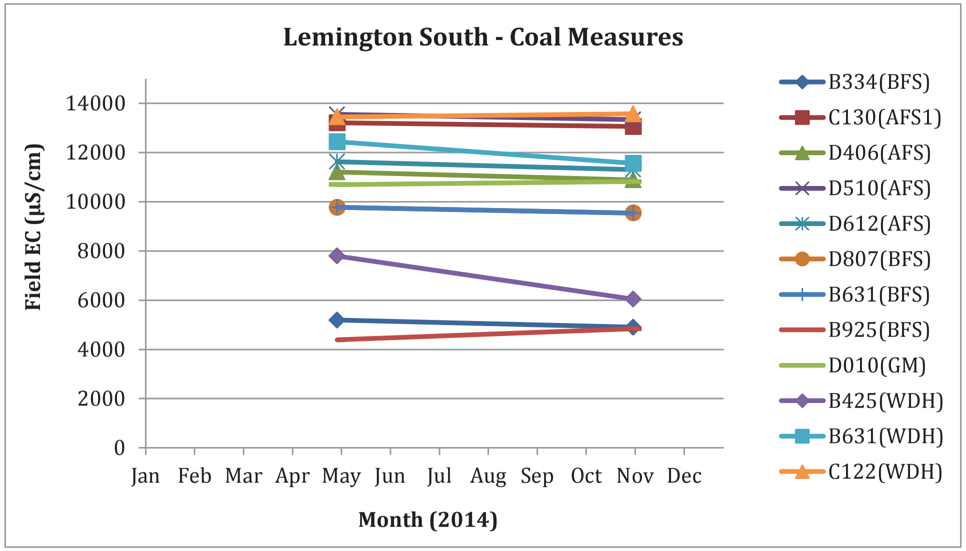
CHPZ7A
CHPZ8A
CHPZ9A


Barry's Pit - Mount Arthur Seam Field EC
Field EC (µS/cm)
6000
4000
2000
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month (2014)
BUNC45D
BUNC39A(Deep)
CHPZ12D
CHPZ3D
CHPZ14D
CHPZ13D
CHPZ8D


Cheshunt - Interburden and Hobden's Well (Alluvium)
Field EC (µS/cm)
10000
8000
6000
4000
2000
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month (2014)
BZ1-1
HG2
HG1
BZ3-1
BZ8-2


Cheshunt - Mount Arthur Seam Field EC
Field EC (µS/cm)
10000
8000
6000
4000
2000
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month (2014)
BZ1-3
BZ2A(1)
BZ3-3
BZ4A(2)
HG2A
BC1a


Lemington South - Alluvium
Field EC (µS/cm)
14000
12000
10000
8000
6000
4000
2000
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month (2014)
Appleyard Farm
C919(ALL)
D317(ALL)

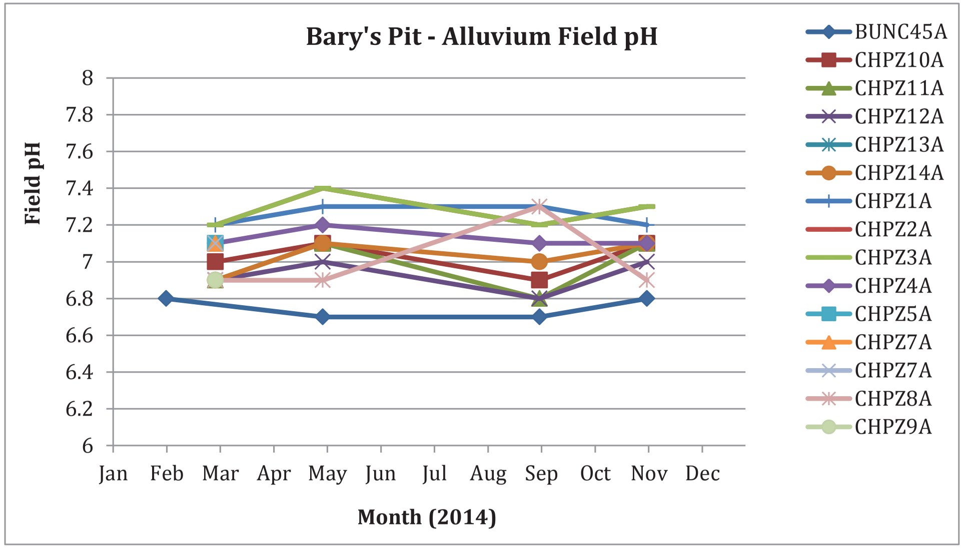

Lemington South - Coal Measures
Field EC (µS/cm)
14000
12000
10000
8000
6000
4000
2000
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month (2014)
B334(BFS)
C130(AFS1)
D406(AFS)
D510(AFS)
D612(AFS)
D807(BFS)
B631(BFS)
B925(BFS)
D010(GM)
B425(WDH)
B631(WDH)
C122(WDH)

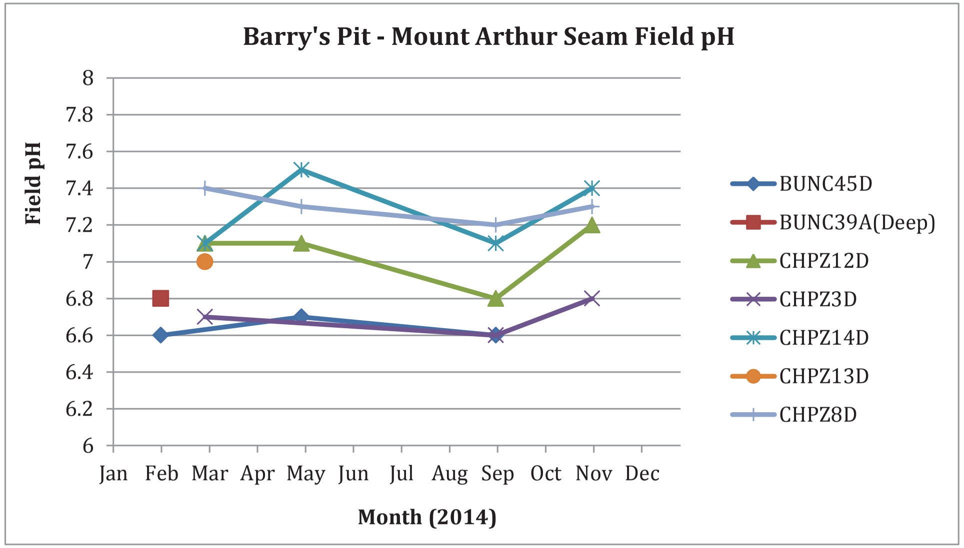
Bore ID	Target lithology	Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
BUNC12	Alluvium	Barry's Pit	-	-	-	-	-	-	-	-	-	-	-	-
BUNC13	Alluvium	Barry's Pit	-	-	-	-	-	-	-	-	-	-	-	-
BUNC45A	Alluvium	Barry's Pit	-	6.8	-	-	6.7	-	-	-	6.7	-	6.8	-
CHPZ10A	Alluvium	Barry's Pit	-	-	7	-	7.1	-	-	-	6.9	-	7.1	-
CHPZ11A	Alluvium	Barry's Pit	-	-	6.9	-	7.1	-	-	-	6.8	-	7.1	-
CHPZ12A	Alluvium	Barry's Pit	-	-	6.9	-	7	-	-	-	6.8	-	7	-
CHPZ13A	Alluvium	Barry's Pit	-	-	7.1	-	-	-	-	-	-	-	-	-
CHPZ14A	Alluvium	Barry's Pit	-	-	6.9	-	7.1	-	-	-	7	-	7.1	-
CHPZ1A	Alluvium	Barry's Pit	-	-	7.2	-	7.3	-	-	-	7.3	-	7.2	-
CHPZ2A	Alluvium	Barry's Pit	-	-	7.2	-	7.4	-	-	-	7.2	-	7.3	-
CHPZ3A	Alluvium	Barry's Pit	-	-	7	-	7	-	-	-	7.1	-	7.1	-
CHPZ4A	Alluvium	Barry's Pit	-	-	7.1	-	7.2	-	-	-	7.1	-	7.1	-
CHPZ5A	Alluvium	Barry's Pit	-	-	7.1	-	-	-	-	-	-	-	-	-
CHPZ7A	Alluvium	Barry's Pit	-	-	7	-	-	-	-	-	-	-	-	-
CHPZ8A	Alluvium	Barry's Pit	-	-	6.9	-	6.9	-	-	-	7.3	-	6.9	-
CHPZ9A	Alluvium	Barry's Pit	-	-	6.9	-	-	-	-	-	-	-	-	-
BUNC45D	Coal	Barry's Pit	-	6.6	-	-	6.7	-	-	-	6.6	-	6.6	-
BUNC46D	Interburden	Barry's Pit	-	7.1	-	-	-	-	-	-	-	-	-	-
BUNC44D	Mt Arthur	Barry's Pit	-	6.4	-	-	-	-	-	-	-	-	-	-
CHPZ12D	Mt Arthur	Barry's Pit	-	-	7.1	-	7.1	-	-	-	6.8	-	7.2	-

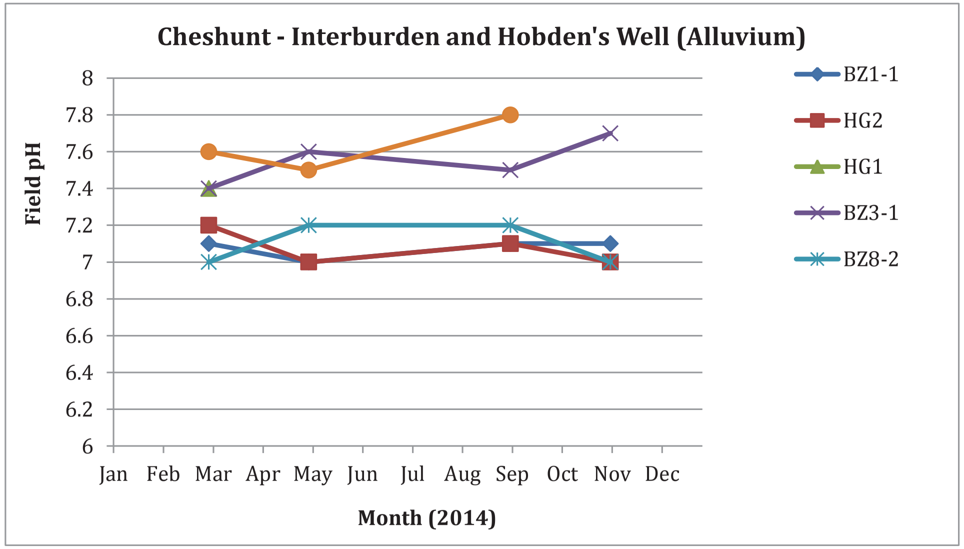
Bore ID	Target Lithology	Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CHPZ13D	Mt Arthur	Barry's Pit	-	-	7	-	-	-	-	-	-	-	-	-
CHPZ14D	Mt Arthur	Barry's Pit	-	-	7.1	-	7.5	-	-	-	7.1	-	7.4	-
CHPZ3D	Mt Arthur	Barry's Pit	-	-	6.7	-	-	-	-	-	6.6	-	6.8	-
CHPZ8D	Mt Arthur	Barry's Pit	-	-	7.4	-	7.3	-	-	-	7.2	-	7.3	-
BUNC39A(Deep)	Mt Arthur?	Barry's Pit	-	6.8	-	-	-	-	-	-	-	-	-	-
BUNC39B(Shallow)	MTA?	Barry's Pit	-	-	-	-	-	-	-	-	-	-	-	-
S4	Rock/Coal	Barry's Pit	-	-	-	-	-	-	-	-	-	-	-	-
BUNC14	Sandstone	Barry's Pit	-	-	-	-	-	-	-	-	-	-	-	-
BC1	Alluvium	Cheshunt Pit	-	-	-	-	-	-	-	-	-	-	-	-
BZ1-2	Alluvium	Cheshunt Pit	-	-	-	-	-	-	-	-	-	-	-	-
BZ2B	Alluvium	Cheshunt Pit	-	-	-	-	-	-	-	-	-	-	-	-
BZ8-1	Alluvium	Cheshunt Pit	-	-	-	-	-	-	-	-	-	-	-	-
Hobden's Well	Alluvium	Cheshunt Pit	-	-	7.6	-	7.5	-	-	-	7.8	-	-	-
S6	Alluvium	Cheshunt Pit	-	-	-	-	-	-	-	-	-	-	-	-
BZ1-1	Interburden	Cheshunt Pit	-	-	7.1	-	7	-	-	-	7.1	-	7.1	-
BZ2A(2)	Interburden	Cheshunt Pit	-	-	-	-	-	-	-	-	-	-	-	-
BZ3-1	Interburden	Cheshunt Pit	-	-	7.4	-	7.6	-	-	-	7.5	-	7.7	-
BZ3-2	Interburden	Cheshunt Pit	-	-	-	-	-	-	-	-	-	-	-	-
BZ4A(1)	Interburden	Cheshunt Pit	-	-	-	-	-	-	-	-	-	-	-	-
BZ4B	Interburden	Cheshunt Pit	-	-	-	-	-	-	-	-	-	-	-	-
BZ8-2	Interburden	Cheshunt Pit	-	-	7	-	7.2	-	-	-	7.2	-	7	-

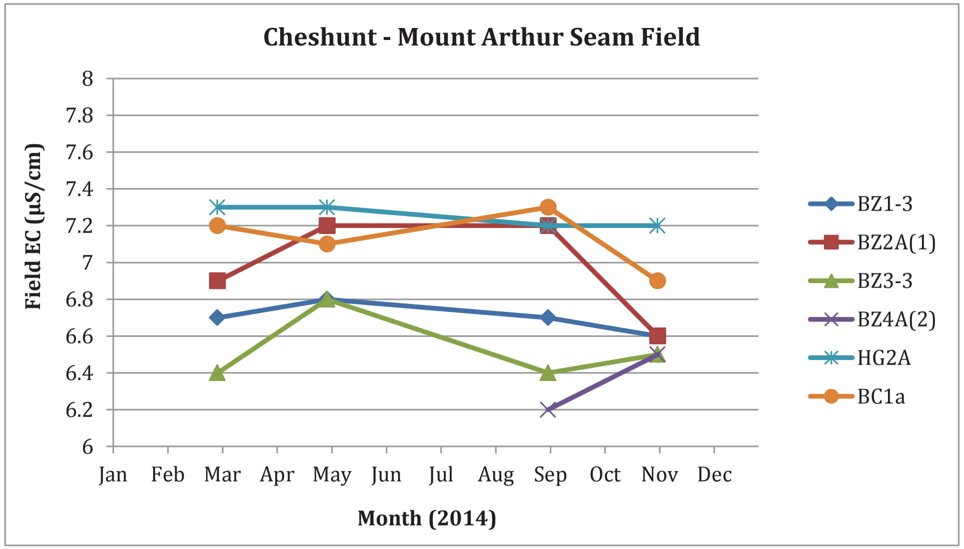
Bore ID	Target Lithology	Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
HG1	Interburden	Cheshunt Pit	-	-	7.4	-	-	-	-	-	-	-	-	-
HG2	Interburden	Cheshunt Pit	-	-	7.2	-	7	-	-	-	7.1	-	7	-
HG3	Interburden	Cheshunt Pit	-	-	7.4	-	-	-	-	-	-	-	-	-
BZ1-3	Mt Arthur	Cheshunt Pit	-	-	6.7	-	6.8	-	-	-	6.7	-	6.6	-
BZ2A(1)	Mt Arthur	Cheshunt Pit	-	-	6.9	-	7.2	-	-	-	7.2	-	6.6	-
BZ3-3	Mt Arthur	Cheshunt Pit	-	-	6.4	-	6.8	-	-	-	6.4	-	6.5	-
BZ4A(2)	Mt Arthur	Cheshunt Pit	-	-	-	-	-	-	-	-	6.2	-	6.5	-
BZ5-1	Mt Arthur	Cheshunt Pit	-	-	-	-	-	-	-	-	-	-	-	-
BZ5-2	Mt Arthur	Cheshunt Pit	-	-	-	-	-	-	-	-	-	-	-	-
BZ8-3	Mt Arthur	Cheshunt Pit	-	-	-	-	-	-	-	-	-	-	-	-
HG2A	Mt Arthur	Cheshunt Pit	-	-	7.3	-	7.3	-	-	-	7.2	-	7.2	-
BC1a	Mt Arthur?	Cheshunt Pit	-	-	7.2	-	7.1	-	-	-	7.3	-	6.9	-
Appleyard Farm	Alluvium	Lemington South Pit 1	-	6.9	-	-	7	-	-	7.2	-	-	6.5	-
C919(ALL)	Alluvium	Lemington South Pit 1	-	7.7	-	-	7.6	-	-	7.5	-	-	7.6	-
D317(ALL)	Alluvium	Lemington South Pit 1	-	-	-	-	-	-	-	-	-	-	-	-
PB01(ALL)	Alluvium	Lemington South Pit 1	-	7.3	-	-	7.2	-	-	7	-	-	-	-
C130(AFS1)	Arrowfield	Lemington South Pit 1	-	-	-	-	7.4	-	-	-	-	-	7.4	-
D406(AFS)	Arrowfield	Lemington South Pit 1	-	-	-	-	7	-	-	-	-	-	6.9	-
D510(AFS)	Arrowfield	Lemington South Pit 1	-	-	-	-	7.1	-	-	-	-	-	7	-
D612(AFS)	Arrowfield	Lemington South Pit 1	-	-	-	-	6.9	-	-	-	-	-	7	-
B334(BFS)	Bowfield	Lemington South Pit 1	-	-	-	-	7.3	-	-	-	-	-	7.3	-

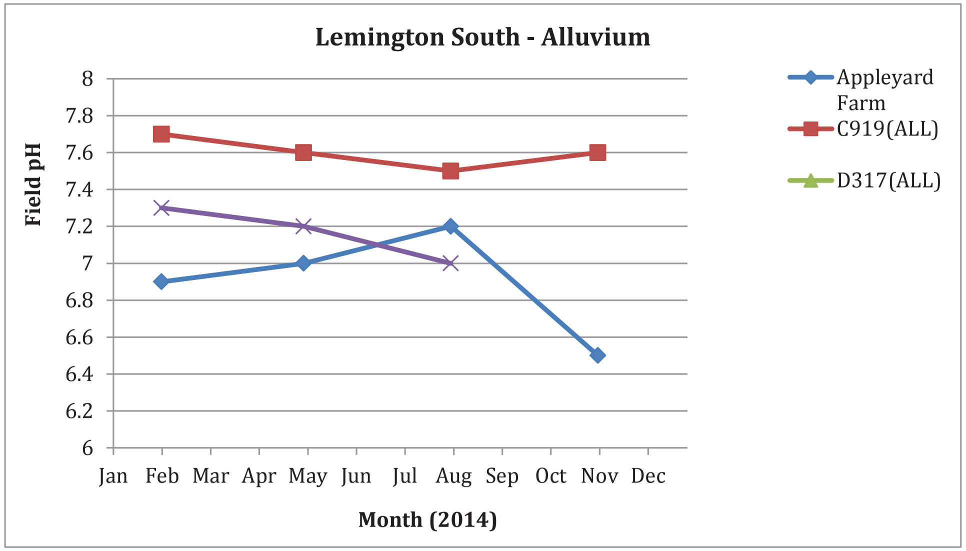
Bore ID	Target Lithology	Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
C130(BFS)	Bowfield	Lemington South Pit 1	-	-	-	-	7.5	-	-	-	-	-	7.4	-
C317(BFS)	Bowfield	Lemington South Pit 1	-	-	-	-	7.1	-	-	-	-	-	7.2	-
C613(BFS)	Bowfield	Lemington South Pit 1	-	-	-	-	7.2	-	-	-	-	-	7.2	-
C621(BFS)	Bowfield	Lemington South Pit 1	-	-	-	-	7.4	-	-	-	-	-	7.5	-
C630(BFS)	Bowfield	Lemington South Pit 1	-	-	-	-	7.7	-	-	-	-	-	7.6	-
D010(BFS)	Bowfield	Lemington South Pit 1	-	-	-	-	7.3	-	-	-	-	-	7.2	-
D214(BFS)	Bowfield	Lemington South Pit 1	-	-	-	-	7.6	-	-	-	-	-	7.6	-
D317(BFS)	Bowfield	Lemington South Pit 1	-	-	-	-	7.2	-	-	-	-	-	7.5	-
D406(BFS)	Bowfield	Lemington South Pit 1	-	-	-	-	7.3	-	-	-	-	-	7.4	-
D510(BFS)	Bowfield	Lemington South Pit 1	-	-	-	-	7.6	-	-	-	-	-	7.6	-
D612(BFS)	Bowfield	Lemington South Pit 1	-	-	-	-	7	-	-	-	-	-	7.1	-
D807(BFS)	Bowfield	Lemington South Pit 1	-	-	-	-	7	-	-	-	-	-	7	-
B631(BFS)	Bowfield Seam	Lemington South Pit 1	-	-	-	-	6.8	-	-	-	-	-	-	-
B925(BFS)	Bowfield Seam	Lemington South Pit 1	-	-	-	-	7	-	-	-	-	-	7.2	-
D010(GM)	Glen Munro	Lemington South Pit 1	-	-	-	-	7.1	-	-	-	-	-	6.9	-
C130(ALL)	Interburden?	Lemington South Pit 1	-	6.9	-	-	7	-	-	6.8	-	-	6.9	-
B425(WDH)	Woodlands Hill	Lemington South Pit 1	-	-	-	-	7.4	-	-	-	-	-	7.5	-
B631(WDH)	Woodlands Hill	Lemington South Pit 1	-	-	-	-	6.9	-	-	-	-	-	6.9	-
C122(WDH)	Woodlands Hill	Lemington South Pit 1	-	-	-	-	7.7	-	-	-	-	-	7.3	-

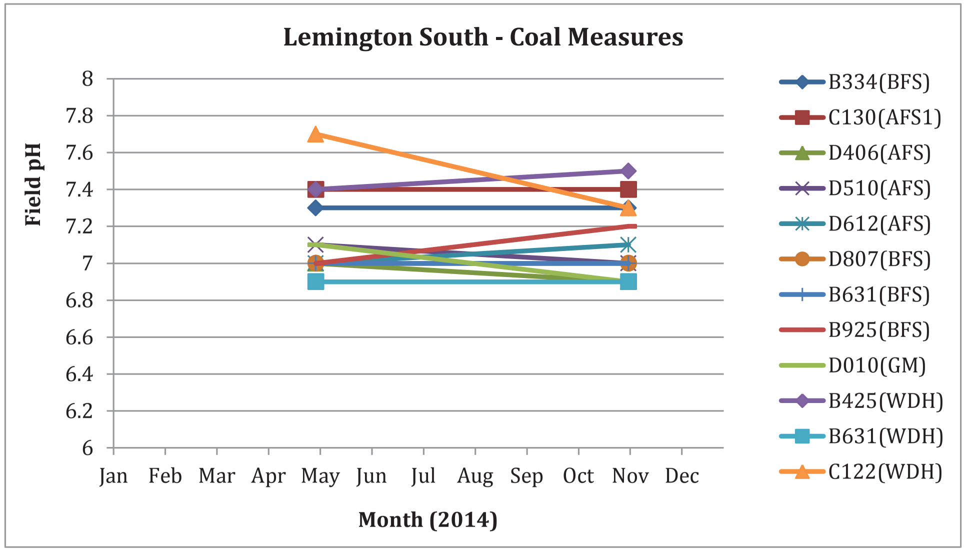

Bary's Pit - Alluvium Field pH


Barry's Pit - Mount Arthur Seam Field pH


Cheshunt - Interburden and Hobden's Well (Alluvium)


Cheshunt - Mount Arthur Seam Field

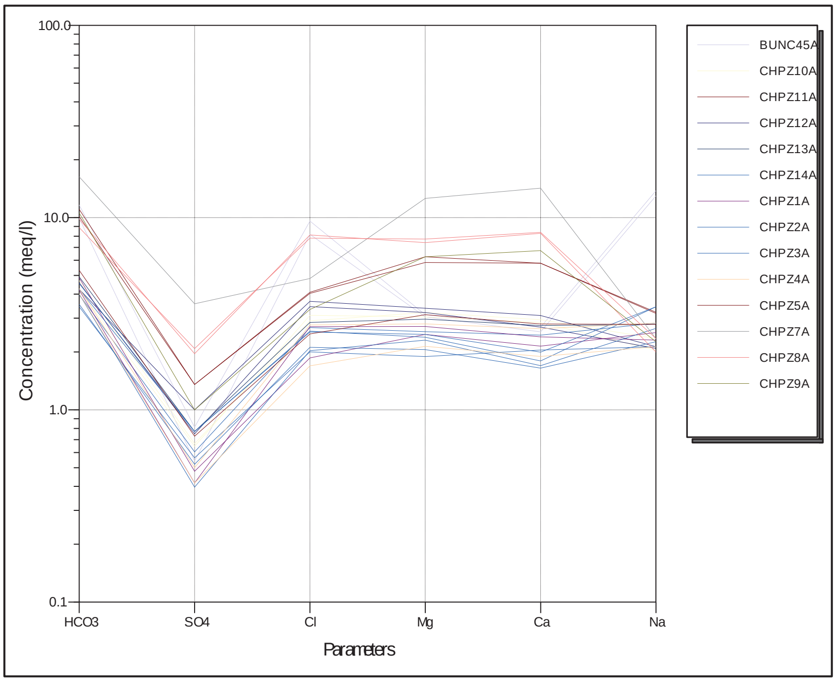

Lemington South - Alluvium
Field pH
8
7.8
7.6
7.4
7.2
7
6.8
6.6
6.4
6.2
6
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month (2014)
Appleyard Farm
C919(ALL)
D317(ALL)


Lemington South - Coal Measures
Field pH
8
7.8
7.6
7.4
7.2
7
6.8
6.6
6.4
6.2
6
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month (2014)
B334(BFS)
C130(AFS1)
D406(AFS)
D510(AFS)
D612(AFS)
D807(BFS)
B631(BFS)
B925(BFS)
D010(GM)
B425(WDH)
B631(WDH)
C122(WDH)

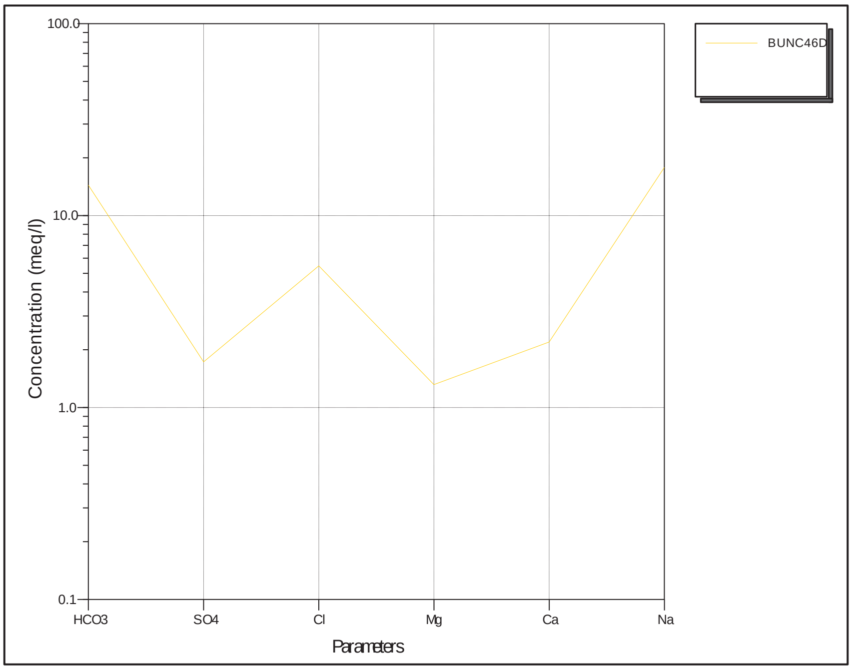
Station	Geology	Site	Date	Al - Total (mg/l)	Alk - Total (mg/l)	As - Total (mg/l)	B (mg/l)	Ba (mg/l)	Ca - Total (mg/l)	CaCO3 - Total Hard (mg/l)	Cl- (mg/l)	Fe - Filtered (mg/L)	Hydroxide Alk (mg/l)	K - Total (mg/l)	Li (mg/l)	Mg - Total (mg/l)	Mn - Total (mg/l)	Na - Total (mg/l)	P - Total (mg/l)	Se (mg/l)	Si (mg/l)	SO4 - Total (mg/l)	Sr - Total (mg/l)	TDS - Total (mg/l)	Zn - Total (mg/l)
BUNC45A	Alluvium	Barry's Pit	Feb	-	497	0.001	-	-	51	-	290	-	1	8	-	37	-	298	-	-	-	26	-	-	-
BUNC45A	Alluvium	Barry's Pit	Sep	0.32	582	<0.001	0.09	-	54	-	340	-	<1	7	-	38	-	317	-	<0.01	-	39	-	1060	0.008
CHPZ10A	Alluvium	Barry's Pit	Mar	-	211	0.001	-	-	57	-	110	-	1	1	-	37	-	47	-	-	-	31	-	-	0.005
CHPZ10A	Alluvium	Barry's Pit	Sep	<0.01	235	<0.001	<0.05	-	59	-	103	-	<1	<1	-	39	-	54	-	<0.01	-	32	-	430	<0.005
CHPZ11A	Alluvium	Barry's Pit	Mar	-	507	0.002	-	-	116	-	145	-	1	4	-	76	-	74	-	-	-	65	-	-	0.007
CHPZ11A	Alluvium	Barry's Pit	Sep	0.31	552	<0.001	0.05	-	116	-	143	-	<1	3	-	71	-	73	-	<0.01	-	65	-	762	<0.005
CHPZ12A	Alluvium	Barry's Pit	Mar	-	212	0.001	-	-	62	-	130	-	1	1	-	41	-	49	-	-	-	48	-	-	0.005
CHPZ12A	Alluvium	Barry's Pit	Sep	<0.01	229	<0.001	<0.05	-	54	-	122	-	<1	<1	-	39	-	48	-	<0.01	-	36	-	484	0.009
CHPZ13A	Alluvium	Barry's Pit	Mar	-	246	0.001	-	-	55	-	101	-	1	2	-	36	-	64	-	-	-	37	-	-	0.005
CHPZ14A	Alluvium	Barry's Pit	Mar	-	172	0.001	-	-	41	-	71	-	1	1	-	23	-	49	-	-	-	27	-	-	0.005
CHPZ14A	Alluvium	Barry's Pit	Sep	0.11	199	<0.001	<0.05	-	49	-	95	-	<1	1	-	31	-	65	-	<0.01	-	29	-	364	<0.005
CHPZ1A	Alluvium	Barry's Pit	Mar	-	243	0.001	-	-	43	-	66	-	1	3	-	30	-	58	-	-	-	23	-	-	0.005
CHPZ1A	Alluvium	Barry's Pit	Sep	0.06	210	<0.001	<0.05	-	48	-	96	-	<1	2	<0.001	33	0.009	53	0.04	<0.01	19.2	20	0.447	366	<0.005
CHPZ2A	Alluvium	Barry's Pit	Mar	-	227	0.001	-	-	40	-	90	-	1	1	-	30	-	79	-	-	-	37	-	-	0.005
CHPZ2A	Alluvium	Barry's Pit	Sep	<0.01	212	<0.001	<0.05	-	36	-	91	-	<1	<1	-	29	-	79	-	<0.01	-	37	-	384	<0.005
CHPZ3A	Alluvium	Barry's Pit	Mar	-	177	0.001	-	-	33	-	75	-	1	1	-	25	-	52	-	-	-	25	-	-	0.005
CHPZ3A	Alluvium	Barry's Pit	Sep	<0.01	200	<0.001	<0.05	-	34	-	72	-	<1	<1	-	28	-	61	-	<0.01	-	19	-	290	<0.005
CHPZ4A	Alluvium	Barry's Pit	Mar	-	201	0.001	-	-	38	-	60	-	1	2	-	26	-	49	-	-	-	20	-	-	0.005

Station	Geology	Site	Date	Al - Total (mg/l)	Alk - Total (mg/l)	As - Total (mg/l)	B (mg/l)	Ba (mg/l)	Ca - Total (mg/l)	CaCO3 - Total Hard (mg/l)	Cl- (mg/l)	Fe - Filtered (mg/L)	Hydroxide Alk (mg/l)	K - Total (mg/l)	Li (mg/l)	Mg - Total (mg/l)	Mn - Total (mg/l)	Na - Total (mg/l)	P - Total (mg/l)	Se (mg/l)	Si (mg/l)	SO4 - Total (mg/l)	Sr - Total (mg/l)	TDS - Total (mg/l)	Zn - Total (mg/l)
CHPZ4A	Alluvium	Barry's Pit	Sep	0.04	214	<0.001	<0.05	-	53	-	98	-	<1	2	-	34	-	65	-	<0.01	-	24	-	372	<0.005
CHPZ5A	Alluvium	Barry's Pit	Mar	-	266	0.001	-	-	56	-	88	-	1	2	-	38	-	64	-	-	-	35	-	-	0.005
CHPZ7A	Alluvium	Barry's Pit	Mar	-	815	0.001	-	-	285	-	171	-	1	3	-	153	-	54	-	-	-	171	-	-	0.005
CHPZ8A	Alluvium	Barry's Pit	Mar	-	444	0.009	-	-	168	-	277	-	1	2	-	94	-	54	-	-	-	100	-	-	0.222
CHPZ8A	Alluvium	Barry's Pit	Sep	18.6	491	0.003	0.07	-	166	-	288	-	<1	1	-	90	-	46	-	<0.01	-	94	-	1040	0.051
CHPZ9A	Alluvium	Barry's Pit	Mar	-	529	0.001	-	-	135	-	118	-	1	2	-	76	-	52	-	-	-	48	-	-	0.005
BUNC45D	Coal	Barry's Pit	Feb	-	742	0.002	-	-	72	-	368	-	1	14	-	54	-	388	-	-	-	1	-	-	-
BUNC45D	Coal	Barry's Pit	Sep	1.33	960	0.001	0.16	-	70	-	408	-	<1	13	-	49	-	460	-	<0.01	-	<1	-	1410	0.022
BUNC46D	Interburden	Barry's Pit	Feb	-	721	0.002	-	-	44	-	194	-	1	14	-	16	-	410	-	-	-	83	-	-	-
BUNC44D	Mt Arthur	Barry's Pit	Feb	-	315	0.001	-	-	148	-	836	-	1	11	-	133	-	385	-	-	-	190	-	-	-
CHPZ12D	Mt Arthur	Barry's Pit	Mar	-	550	0.001	-	-	18	-	118	-	1	14	-	13	-	288	-	-	-	1	-	-	0.005
CHPZ12D	Mt Arthur	Barry's Pit	Sep	<0.01	572	<0.001	0.11	-	16	-	121	-	<1	9	-	11	-	272	-	<0.01	-	<1	-	692	<0.005
CHPZ13D	Mt Arthur	Barry's Pit	Mar	-	296	0.001	-	-	20	-	90	-	1	7	-	10	-	150	-	-	-	1	-	-	0.005
CHPZ14D	Mt Arthur	Barry's Pit	Mar	-	391	0.001	-	-	21	-	74	-	1	18	-	8	-	183	-	-	-	1	-	-	0.005
CHPZ14D	Mt Arthur	Barry's Pit	Sep	0.2	364	<0.001	0.09	-	13	-	73	-	<1	15	-	7	-	174	-	<0.01	-	<1	-	530	<0.005
CHPZ3D	Mt Arthur	Barry's Pit	Mar	-	420	0.001	-	-	16	-	91	-	1	8	-	10	-	215	-	-	-	1	-	-	0.005
CHPZ3D	Mt Arthur	Barry's Pit	Sep	<0.01	438	<0.001	0.13	-	12	-	86	-	<1	6	-	8	-	198	-	<0.01	-	<1	-	508	0.006
CHPZ8D	Mt Arthur	Barry's Pit	Mar	-	346	0.001	-	-	87	-	107	-	1	4	-	48	-	40	-	-	-	11	-	-	0.005
CHPZ8D	Mt Arthur	Barry's Pit	Sep	0.56	355	<0.001	0.06	-	99	-	133	-	<1	3	-	50	-	35	-	<0.01	-	16	-	673	<0.005

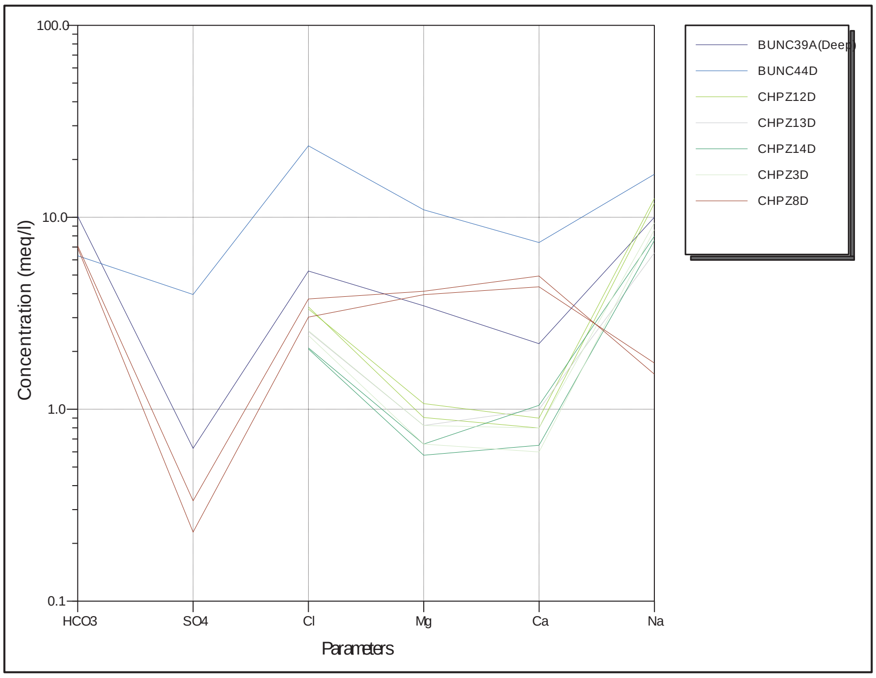
Station	Geology	Site	Date	Al - Total (mg/l)	Alk - Total (mg/l)	As - Total (mg/l)	B (mg/l)	Ba (mg/l)	Ca - Total (mg/l)	CaCO3 - Total Hard (mg/l)	Cl- (mg/l)	Fe - Filtered (mg/L)	Hydroxide Alk (mg/l)	K - Total (mg/l)	Li (mg/l)	Mg - Total (mg/l)	Mn - Total (mg/l)	Na - Total (mg/l)	P - Total (mg/l)	Se (mg/l)	Si (mg/l)	SO4 - Total (mg/l)	Sr - Total (mg/l)	TDS - Total (mg/l)	Zn - Total (mg/l)
BUNC39A(Deep)	Mt Arthur?	Barry's Pit	Feb	-	507	0.001	-	-	44	-	186	-	1	8	-	42	-	230	-	-	-	30	-	-	-
Hobden's Well	Alluvium	Cheshunt Pit	Sep	0.02	250	<0.001	<0.05	-	30	-	106	-	<1	1	-	30	-	98	-	<0.01	-	28	-	435	0.019
BZ1-1	Interburden	Cheshunt Pit	Mar	-	856	0.016	-	-	124	-	2630	-	1	36	-	333	-	1540	-	-	-	215	-	-	0.171
BZ1-1	Interburden	Cheshunt Pit	Sep	4.11	780	0.008	0.09	-	128	-	2540	-	<1	26	-	310	-	1270	-	<0.01	-	233	-	5610	0.216
BZ8-2	Interburden	Cheshunt Pit	Mar	-	316	0.01	-	-	42	-	223	-	1	6	-	57	-	146	-	-	-	46	-	-	0.03
BZ8-2	Interburden	Cheshunt Pit	Sep	3.12	281	0.012	0.06	-	44	-	213	-	<1	4	-	59	-	142	-	<0.01	-	43	-	692	0.038
BZ1-3	Mt Arthur	Cheshunt Pit	Mar	-	1260	0.001	-	-	178	-	1150	-	1	50	-	199	-	1280	-	-	-	900	-	-	0.005
BZ1-3	Mt Arthur	Cheshunt Pit	Sep	0.46	1180	<0.001	0.2	-	188	-	1160	-	<1	43	-	190	-	1030	-	<0.01	-	980	-	4300	0.052
Appleyard Farm	Alluvium	Lemington South Pit 1	Nov	0.02	65	0.001	0.05	-	9	-	65	-	1	4	-	8	-	55	-	0.01	-	13	-	260	0.006
C919(ALL)	Alluvium	Lemington South Pit 1	Nov	58.7	339	0.009	0.05	-	52	-	148	-	1	5	-	32	-	121	-	0.02	-	19	-	1720	0.402
C130(AFS1)	Arrowfield	Lemington South Pit 1	Nov	0.19	706	0.001	0.14	-	102	-	4600	-	1	40	-	144	-	2710	-	0.01	-	1	-	7740	0.079
B925(BFS)	Bowfield Seam	Lemington South Pit 1	Nov	0.04	973	0.001	0.12	-	13	-	1070	-	1	13	-	14	-	1210	-	0.01	-	1	-	2430	0.036
D010(GM)	Glen Munro	Lemington South Pit 1	Nov	0.18	1240	0.001	0.11	-	119	-	3490	-	1	44	-	367	-	2020	-	0.01	-	412	-	7040	0.006
C130(ALL)	Interburden?	Lemington South Pit 1	Nov	6.77	965	0.003	0.05	-	235	-	7740	-	1	53	-	653	-	3760	-	0.01	-	701	-	15100	0.05
B425(WDH)	Woodlands Hill	Lemington South Pit 1	Nov	0.04	1360	0.001	0.16	-	11	-	1210	-	1	15	-	12	-	1460	-	0.02	-	1	-	3730	0.011



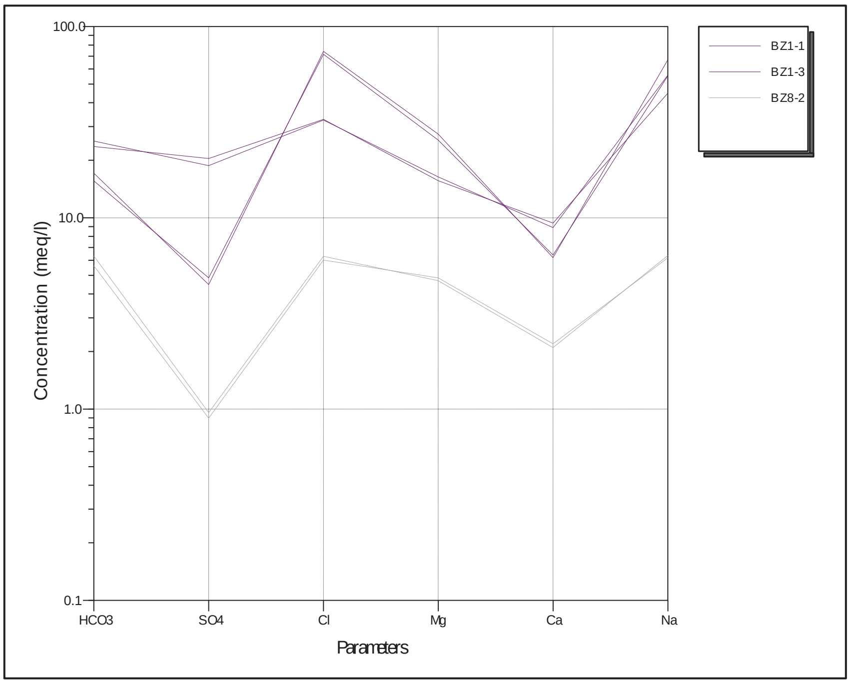
Schoeller Plot - Barry's Pit Alluvium



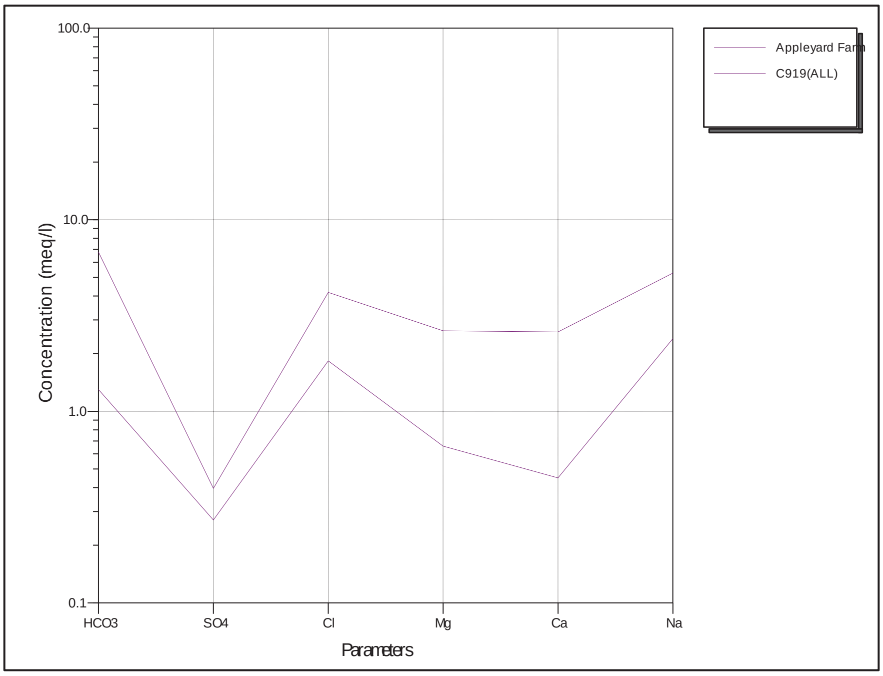
Schoeller Plot - Barry's Pit Interburden



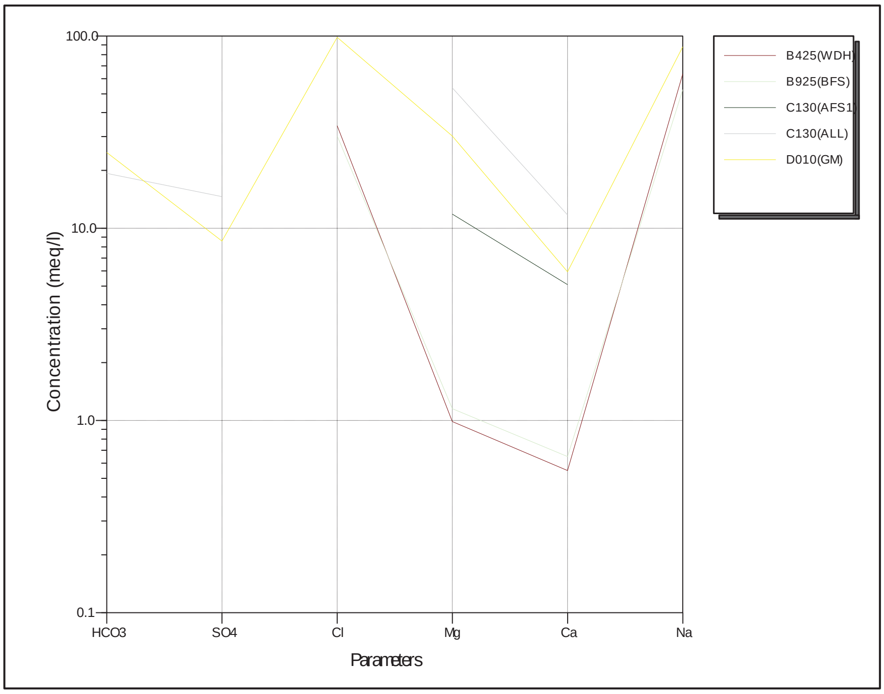
Schoeller Plot - Barry's Pit Mt. Arthur Seam



Schoeller Plot - Cheshunt Coal & Interburden



Schoeller Plot - Lemington Alluvium



Schoeller Plot – Lemington Coal & Interburden

Appendix E Monitoring Bore Groundwater Levels - 2014

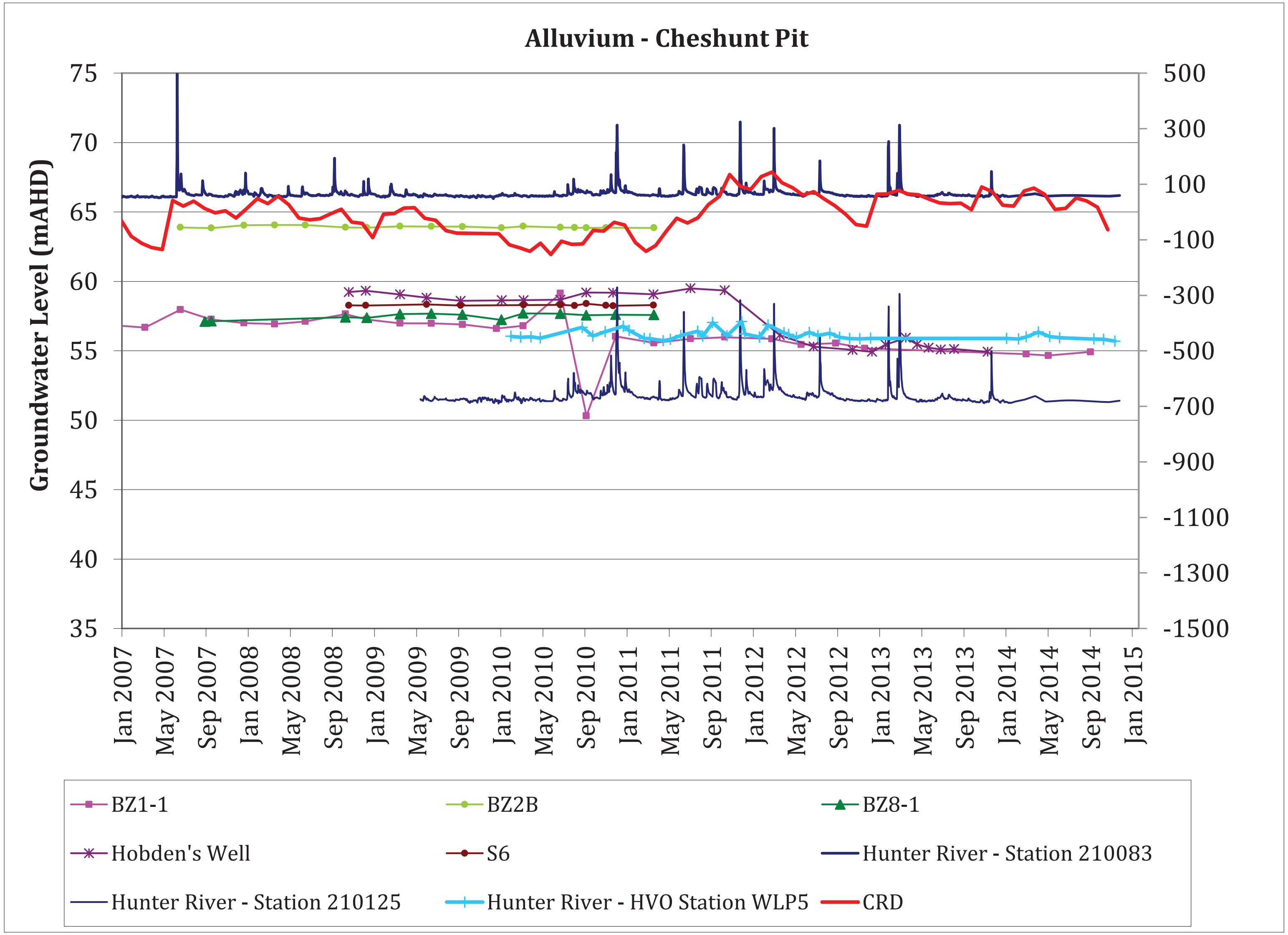
Bore Id	Target lithology	Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
BUNC45A	Alluvium	Barry's Pit	-	53.85	-	-	53.79	-	-	-	53.45	-	53.53	-
CHPZ10A	Alluvium	Barry's Pit	-	-	54.17	-	54.22	-	-	-	54.05	-	54.00	-
CHPZ11A	Alluvium	Barry's Pit	-	-	54.22	-	54.28	-	-	-	54.11	-	54.04	-
CHPZ12A	Alluvium	Barry's Pit	-	-	54.29	-	54.35	-	-	-	54.09	-	54.03	-
CHPZ13A	Alluvium	Barry's Pit	-	-	54.41	-	-	-	-	-	-	-	-	-
CHPZ14A	Alluvium	Barry's Pit	-	-	54.45	-	54.53	-	-	-	54.09	-	54.03	-
CHPZ1A	Alluvium	Barry's Pit	-	-	54.45	-	54.51	-	-	-	54.09	-	54.03	-
CHPZ2A	Alluvium	Barry's Pit	-	-	54.51	-	54.60	-	-	-	54.12	-	54.07	-
CHPZ3A	Alluvium	Barry's Pit	-	-	54.38	-	54.46	-	-	-	54.04	-	54.02	-
CHPZ4A	Alluvium	Barry's Pit	-	-	54.39	-	54.45	-	-	-	54.20	-	54.13	-
CHPZ5A	Alluvium	Barry's Pit	-	-	54.39	-	-	-	-	-	-	-	-	-
CHPZ7A	Alluvium	Barry's Pit	-	-	54.06	-	-	-	-	-	-	-	-	-
CHPZ8A	Alluvium	Barry's Pit	-	-	54.17	-	54.23	-	-	-	54.07	-	54.01	-
CHPZ9A	Alluvium	Barry's Pit	-	-	54.07	-	-	-	-	-	-	-	-	-
BUNC45D	Coal	Barry's Pit	-	49.65	-	-	49.62	-	-	-	48.97	-	49.12	-
BUNC46D	Interburden	Barry's Pit	-	50.84	-	-	-	-	-	-	-	-	-	-
BUNC44D	Mt Arthur	Barry's Pit	-	51.24	-	-	-	-	-	-	-	-	-	-
CHPZ12D	Mt Arthur	Barry's Pit	-	-	54.13	-	54.20	-	-	-	53.71	-	52.73	-
CHPZ13D	Mt Arthur	Barry's Pit	-	-	53.01	-	-	-	-	-	-	-	-	-
CHPZ14D	Mt Arthur	Barry's Pit	-	-	52.59	-	52.62	-	-	-	51.22	-	51.57	-
CHPZ3D	Mt Arthur	Barry's Pit	-	-	53.18	-	53.22	-	-	-	51.98	-	52.28	-
CHPZ8D	Mt Arthur	Barry's Pit	-	-	54.13	-	54.19	-	-	-	54.00	-	53.95	-

Bore Id	Target lithology	Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
BUNC39A(Deep)	Mt Arthur?	Barry's Pit	-	50.82	-	-	-	-	-	-	-	-	-	-
BUNC39B(Shallow)	MTA?	Barry's Pit	-	51.85	-	-	-	-	-	-	-	-	-	-
Hobden's Well	Alluvium	Cheshunt Pit	-	-	54.92	-	55.04	-	-	-	54.84	-	54.73	-
BZ1-1	Interburden	Cheshunt Pit	-	-	54.77	-	54.66	-	-	-	54.92	-	54.50	-
BZ2A(2)	Interburden	Cheshunt Pit	-	-	50.30	-	-	-	-	-	-	-	-	-
BZ3-1	Interburden	Cheshunt Pit	-	-	54.89	-	54.69	-	-	-	54.91	-	54.69	-
BZ4A(1)	Interburden	Cheshunt Pit	-	-	49.69	-	-	-	-	-	-	-	-	-
BZ8-2	Interburden	Cheshunt Pit	-	-	47.71	-	47.81	-	-	-	47.64	-	47.65	-
HG1	Interburden	Cheshunt Pit	-	-	54.89	-	-	-	-	-	-	-	-	-
HG2	Interburden	Cheshunt Pit	-	-	54.75	-	54.89	-	-	-	54.67	-	54.63	-
HG3	Interburden	Cheshunt Pit	-	-	54.98	-	-	-	-	-	-	-	-	-
BZ1-3	Mt Arthur	Cheshunt Pit	-	-	26.94	-	26.89	-	-	-	26.15	-	26.01	-
BZ2A(1)	Mt Arthur	Cheshunt Pit	-	-	26.70	-	26.62	-	-	-	26.60	-	26.41	-
BZ3-3	Mt Arthur	Cheshunt Pit	-	-	27.91	-	29.73	-	-	-	27.73	-	27.56	-
BZ4A(2)	Mt Arthur	Cheshunt Pit	-	-	32.74	-	29.72	-	-	-	33.17	-	33.34	-
HG2A	Mt Arthur	Cheshunt Pit	-	-	41.55	-	41.56	-	-	-	41.52	-	41.49	-
BC1a	Mt Arthur?	Cheshunt Pit	-	-	48.67	-	48.68	-	-	-	48.52	-	48.51	-
Appleyard Farm	Alluvium	Lemington South Pit 1	47.89	47.85	48.16	48.28	48.15	48.12	48.07	48.12	48.24	48.09	47.99	48.24
C919(ALL)	Alluvium	Lemington South Pit 1	47.04	46.93	46.99	47.04	47.14	47.10	47.09	47.02	47.13	47.01	46.88	46.86
D317(ALL)	Alluvium	Lemington South Pit 1	44.45	44.45	44.45	44.43	44.44	44.44	44.44	44.44	44.48	44.46	44.46	44.45

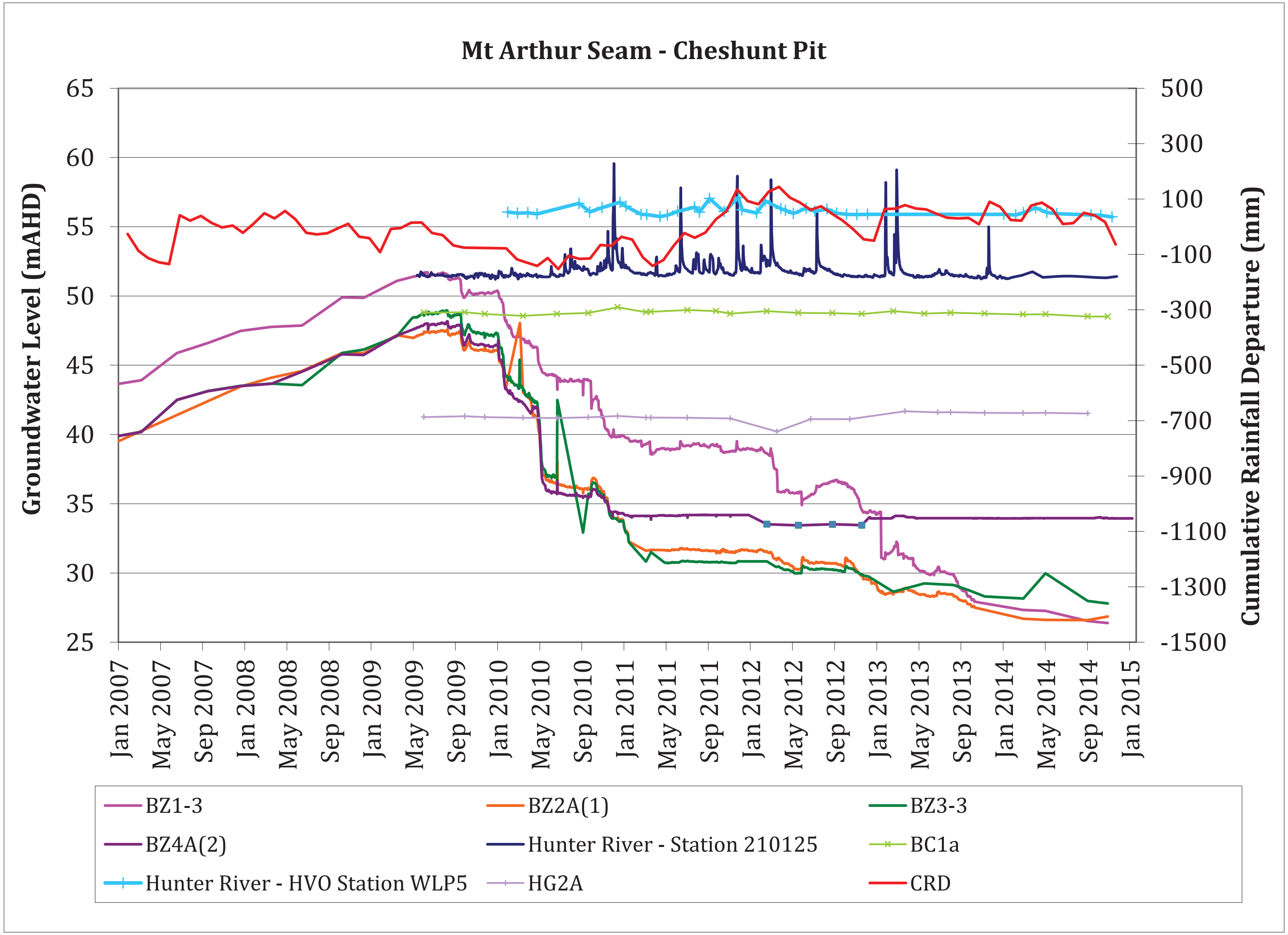
Bore Id	Target lithology	Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PB01(ALL)	Alluvium	Lemington South Pit 1	46.21	46.02	46.02	46.57	46.53	46.49	46.46	46.43	46.58	46.46	46.34	46.41
C130(AFS1)	Arrowfield	Lemington South Pit 1	-	-	-	-	44.64	-	-	-	-	-	45.04	-
D406(AFS)	Arrowfield	Lemington South Pit 1	-	-	-	-	37.73	-	-	-	-	-	37.71	-
D510(AFS)	Arrowfield	Lemington South Pit 1	-	-	-	-	31.68	-	-	-	-	-	31.54	-
D612(AFS)	Arrowfield	Lemington South Pit 1	-	-	-	-	40.57	-	-	-	-	-	40.67	-
B334(BFS)	Bowfield	Lemington South Pit 1	-	27.31	-	-	27.51	-	-	27.28	-	-	26.84	-
C130(BFS)	Bowfield	Lemington South Pit 1	-	30.70	-	-	31.10	-	-	31.02	-	-	30.45	-
C317(BFS)	Bowfield	Lemington South Pit 1	-	30.77	-	-	34.32	-	-	30.59	-	-	29.99	-
C613(BFS)	Bowfield	Lemington South Pit 1	-	36.55	-	-	36.80	-	-	36.98	-	-	37.14	-
C621(BFS)	Bowfield	Lemington South Pit 1	-	31.54	-	-	31.88	-	-	31.36	-	-	30.65	-
C630(BFS)	Bowfield	Lemington South Pit 1	-	-	-	-	34.59	-	-	-	-	-	34.86	-
D010(BFS)	Bowfield	Lemington South Pit 1	-	-	-	-	29.84	-	-	-	-	-	29.80	-
D214(BFS)	Bowfield	Lemington South Pit 1	-	29.83	-	-	30.35	-	-	30.46	-	-	30.46	-
D317(BFS)	Bowfield	Lemington South Pit 1	-	29.02	-	-	29.58	-	-	29.85	-	-	29.89	-
D406(BFS)	Bowfield	Lemington South Pit 1	-	-	-	-	25.76	-	-	-	-	-	26.13	-

Bore Id	Target lithology	Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
D510(BFS)	Bowfield	Lemington South Pit 1	-	-	-	-	27.75	-	-	-	-	-	27.74	-
D612(BFS)	Bowfield	Lemington South Pit 1	-	-	-	-	28.98	-	-	-	-	-	29.13	-
D807(BFS)	Bowfield	Lemington South Pit 1	-	-	-	-	25.52	-	-	-	-	-	26.14	-
B631(BFS)	Bowfield Seam	Lemington South Pit 1	-	42.87	-	-	42.94	-	-	42.86	-	-	42.65	-
B925(BFS)	Bowfield Seam	Lemington South Pit 1	-	28.00	-	-	28.46	-	-	27.95	-	-	27.37	-
D010(GM)	Glen Munro	Lemington South Pit 1	-	-	-	-	49.03	-	-	-	-	-	48.89	-
C130(ALL)	Interburden?	Lemington South Pit 1	47.79	47.77	47.76	47.81	47.78	47.77	47.74	47.74	47.76	47.74	47.71	47.70
B425(WDH)	Woodlands Hill	Lemington South Pit 1	-	31.05	-	-	31.43	-	-	31.13	-	-	30.47	-
B631(WDH)	Woodlands Hill	Lemington South Pit 1	-	-	-	-	46.81	-	-	-	-	-	46.74	-
C122(WDH)	Woodlands Hill	Lemington South Pit 1	-	-	-	-	47.02	-	-	-	-	-	46.96	-
C130(WDH)	Woodlands Hill	Lemington South Pit 1	-	-	-	-	47.75	-	-	-	-	-	47.70	-
C317(WDH)	Woodlands Hill	Lemington South Pit 1	-	-	-	-	46.83	-	-	-	-	46.85	46.79	46.81
D010(WDH)	Woodlands Hill	Lemington South Pit 1	-	-	-	-	47.66	-	-	-	-	-	47.47	-

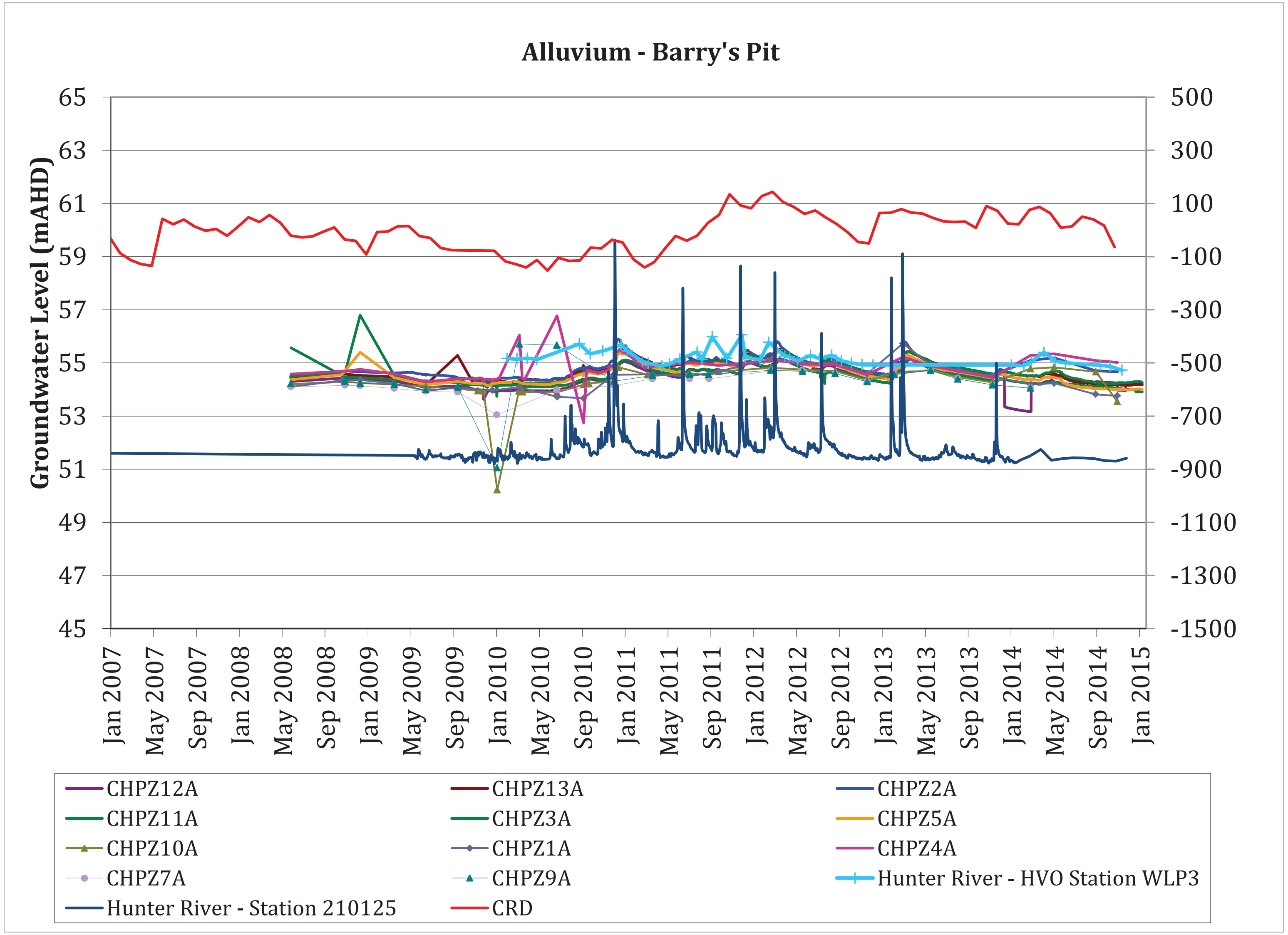
Appendix F Hydrographs



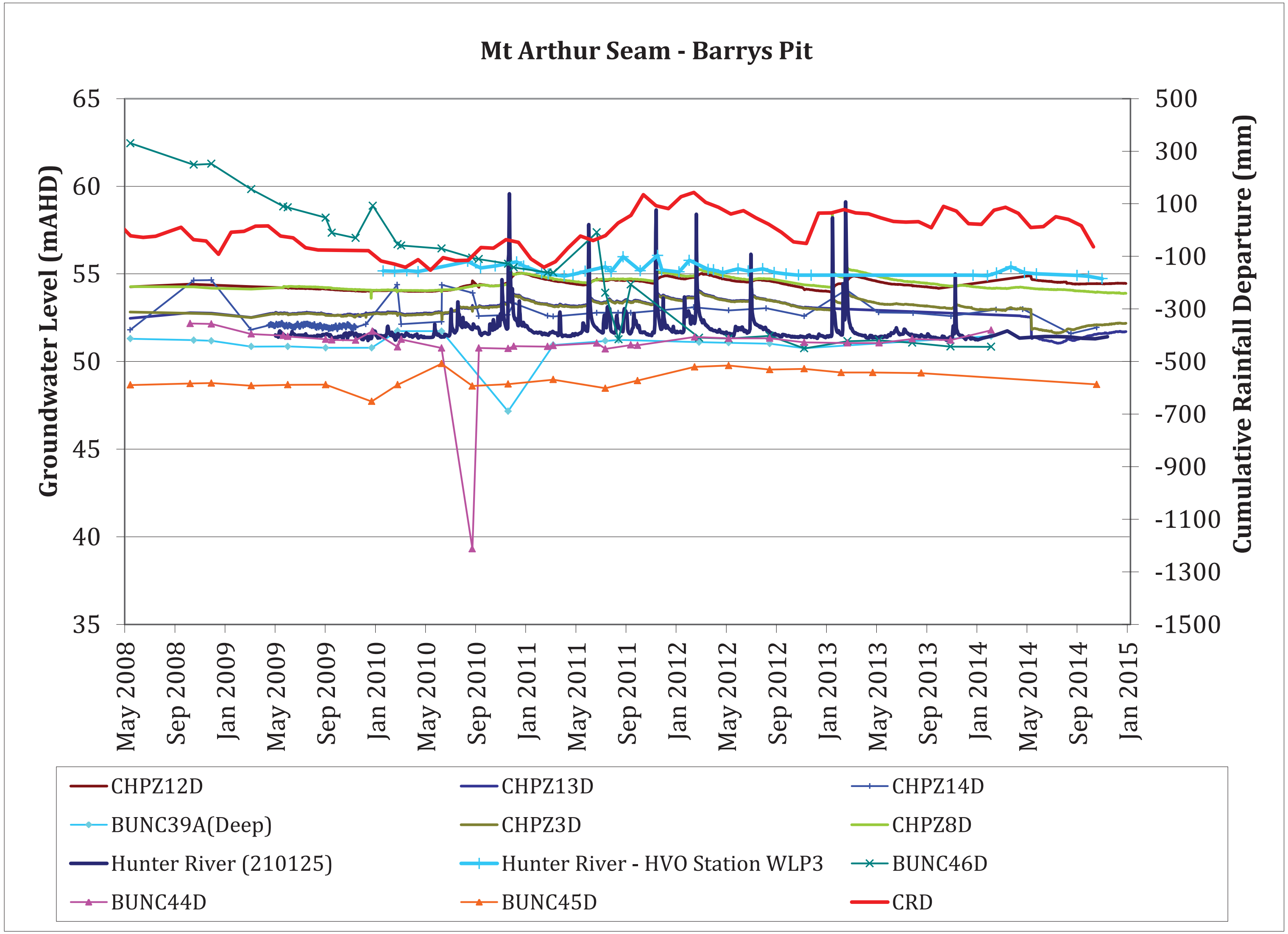
Long term hydrograph for alluvial bores north of Cheshunt Pit



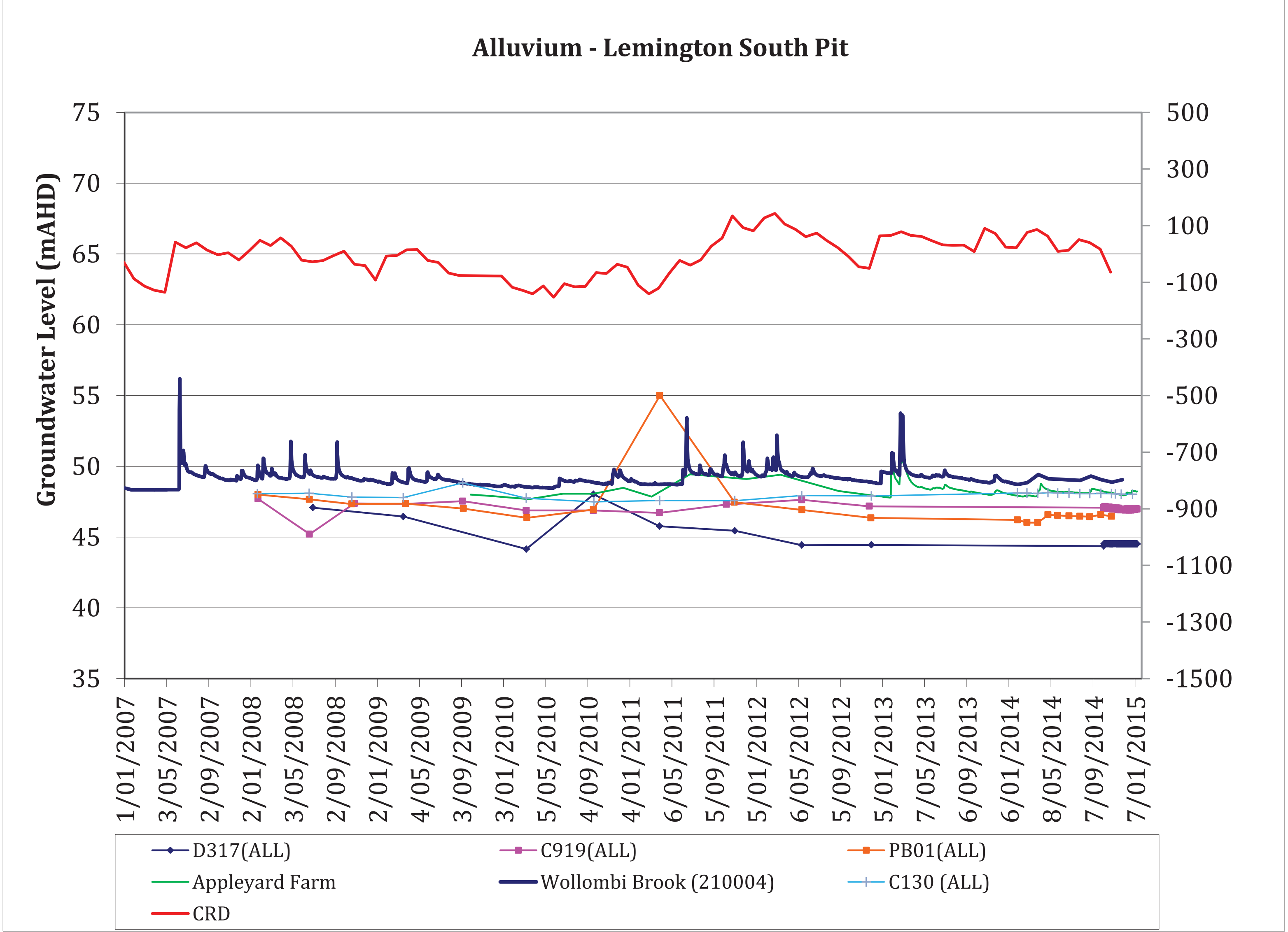
Long term hydrograph for Mount Arthur Seam bores of Cheshunt Pit



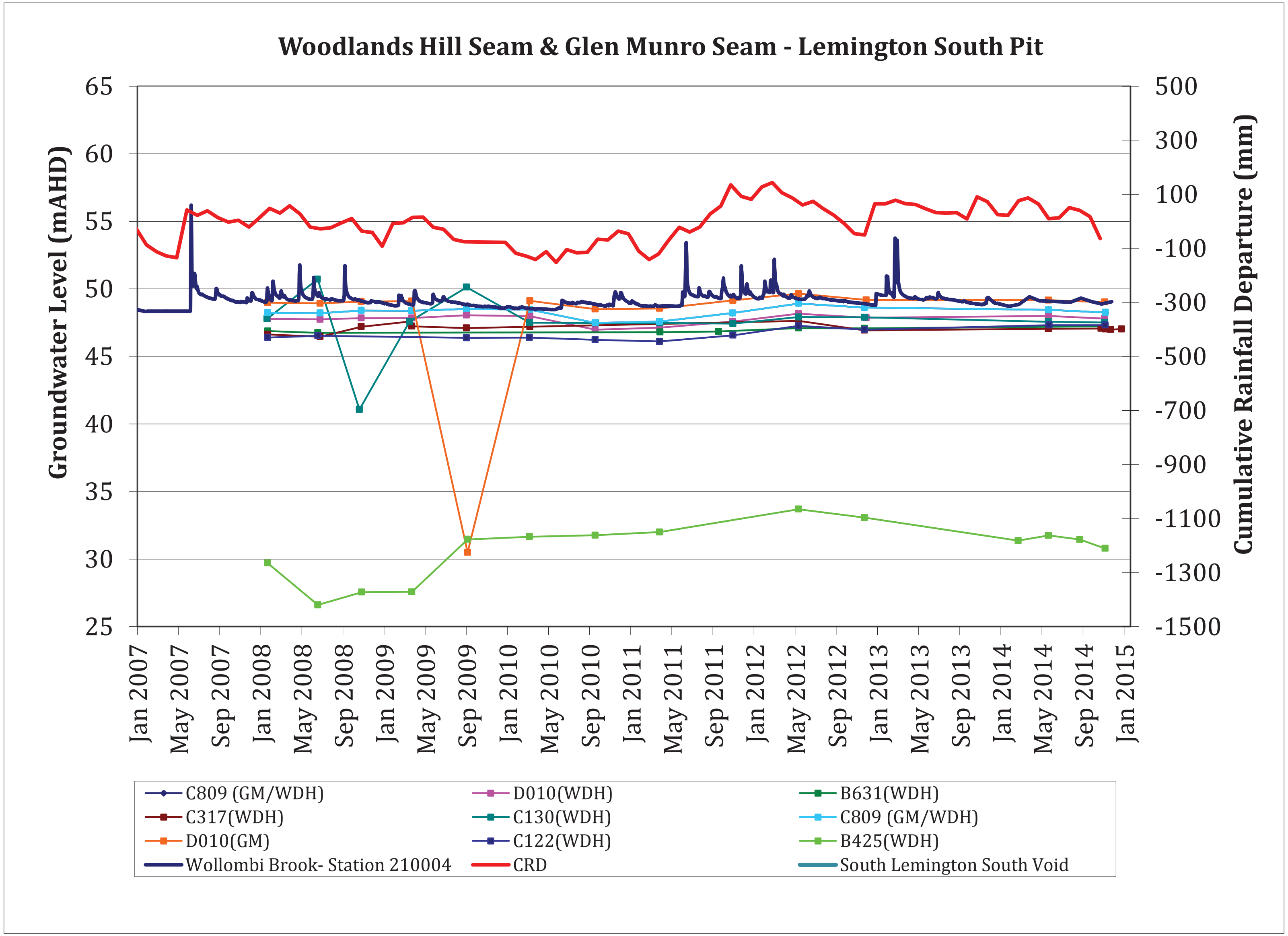
Long term hydrograph for alluvial bores of Barry's Pit



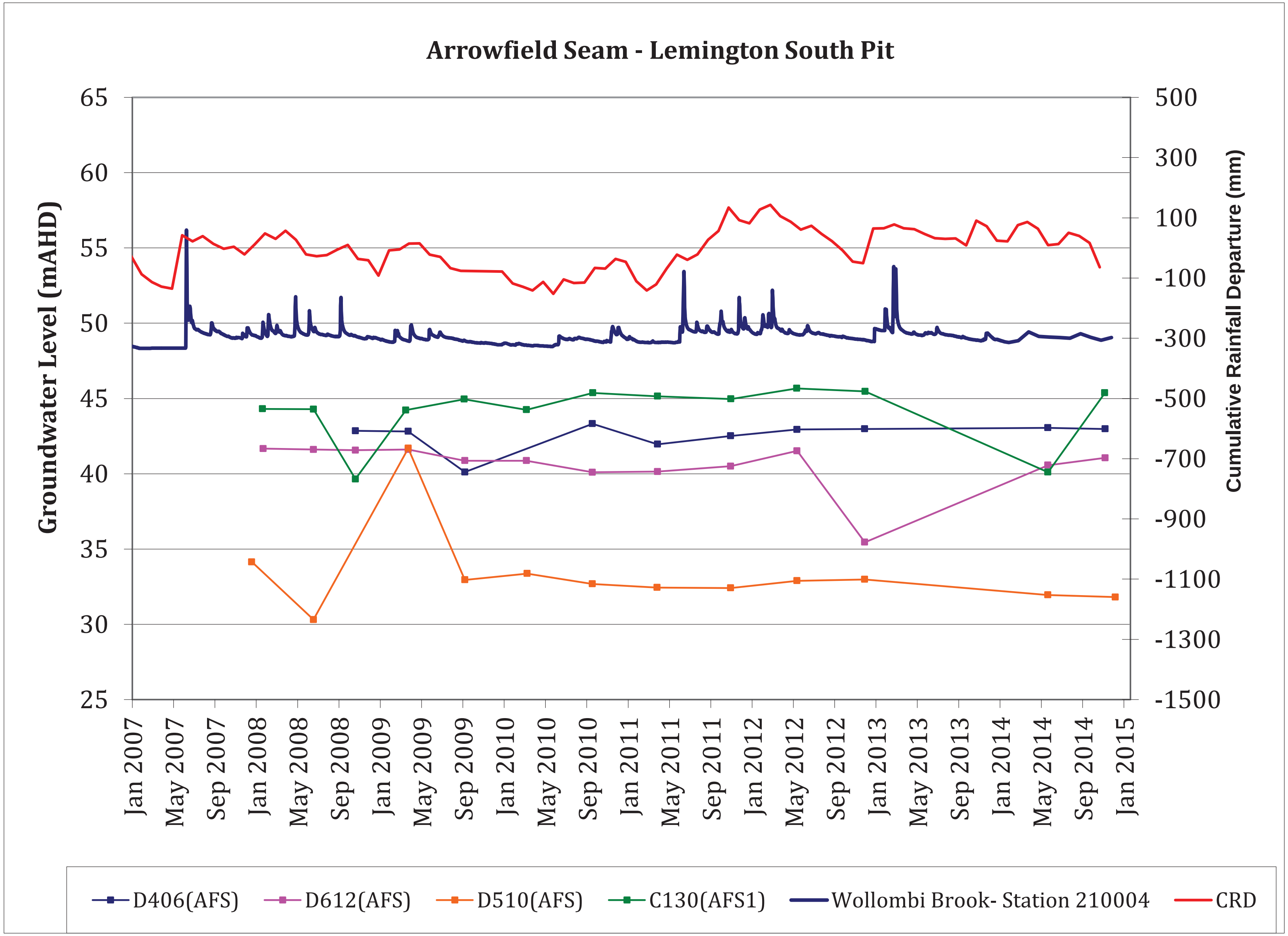
Long term hydrograph for Mount Arthur Seam bores of Barry's Pit



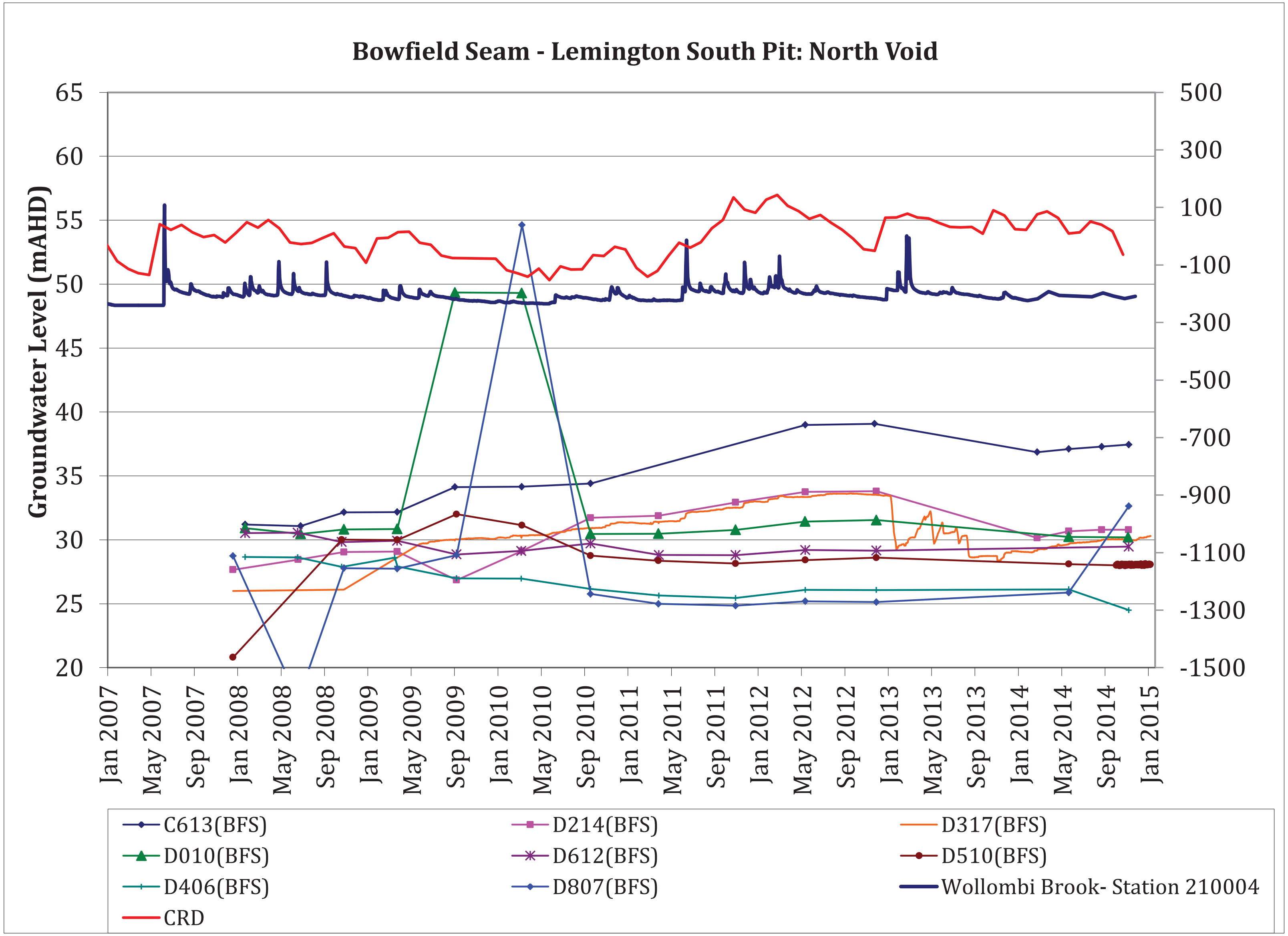
Long term hydrograph for alluvial bores of Lemington South Pit



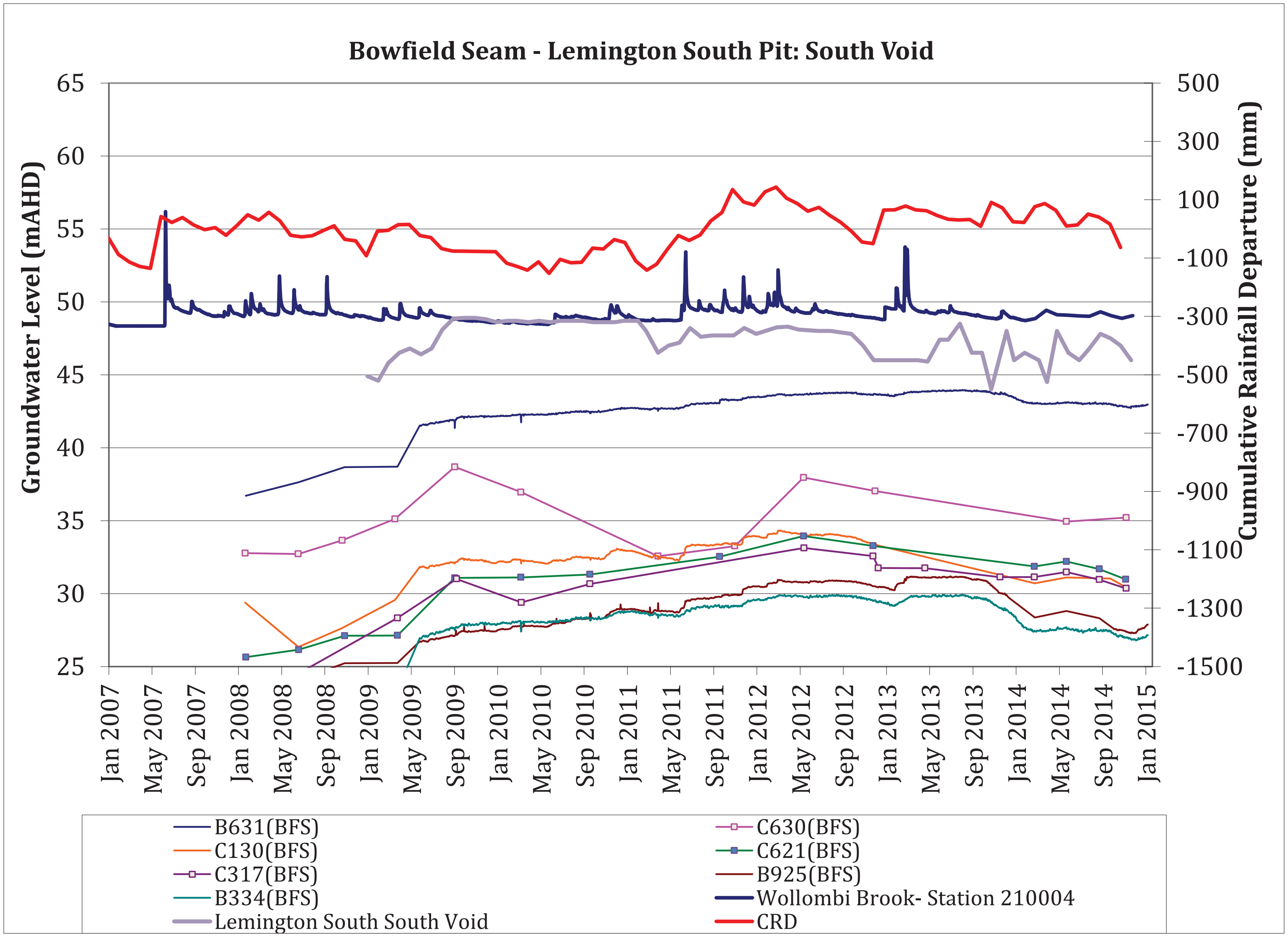
Long term hydrograph for Woodland's Hill Seam and Glen Munro Seam bores of Lemington South Pit



Long term hydrograph for Arrowfield seam bores of Lemington South Pit Bores of Lemington South Pit



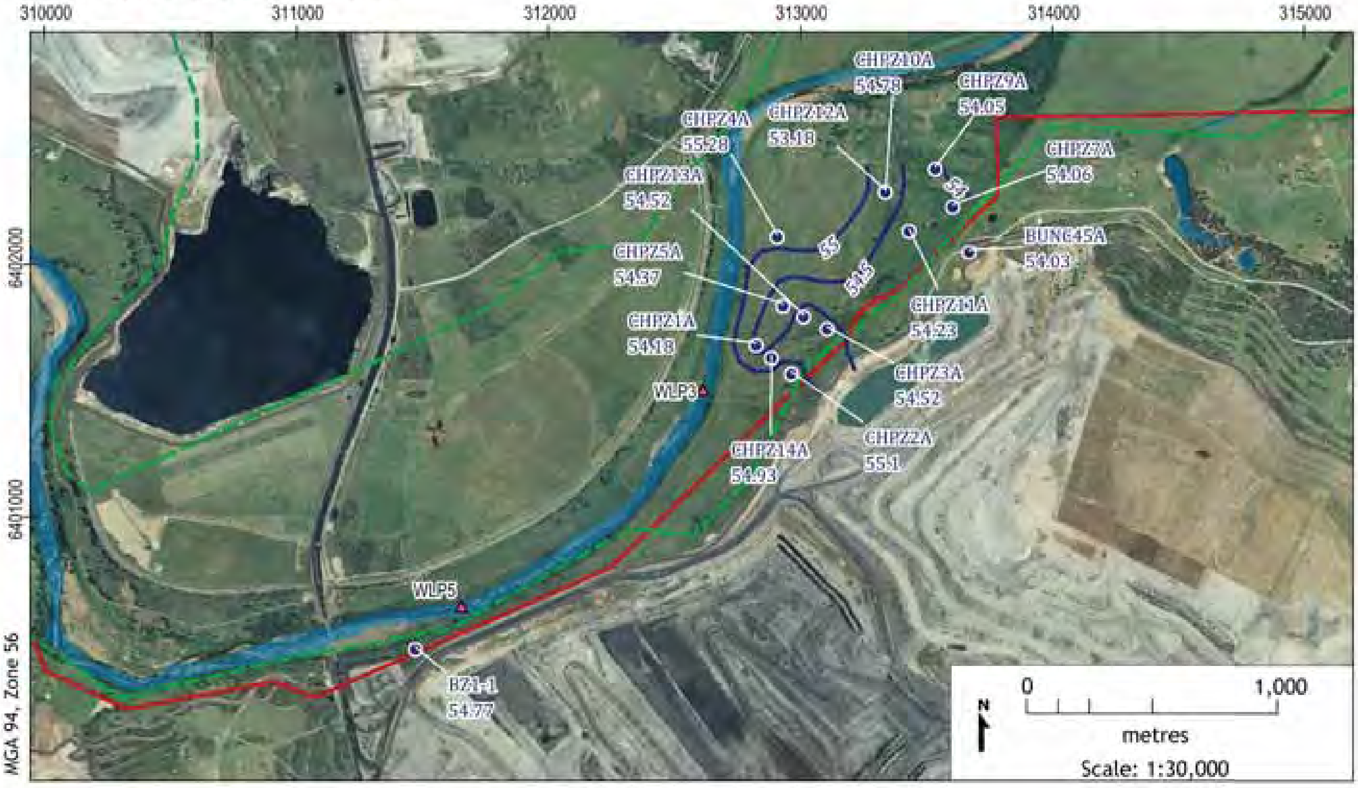
Long term hydrograph for Bowfield bores of Lemington South Pit: North Void



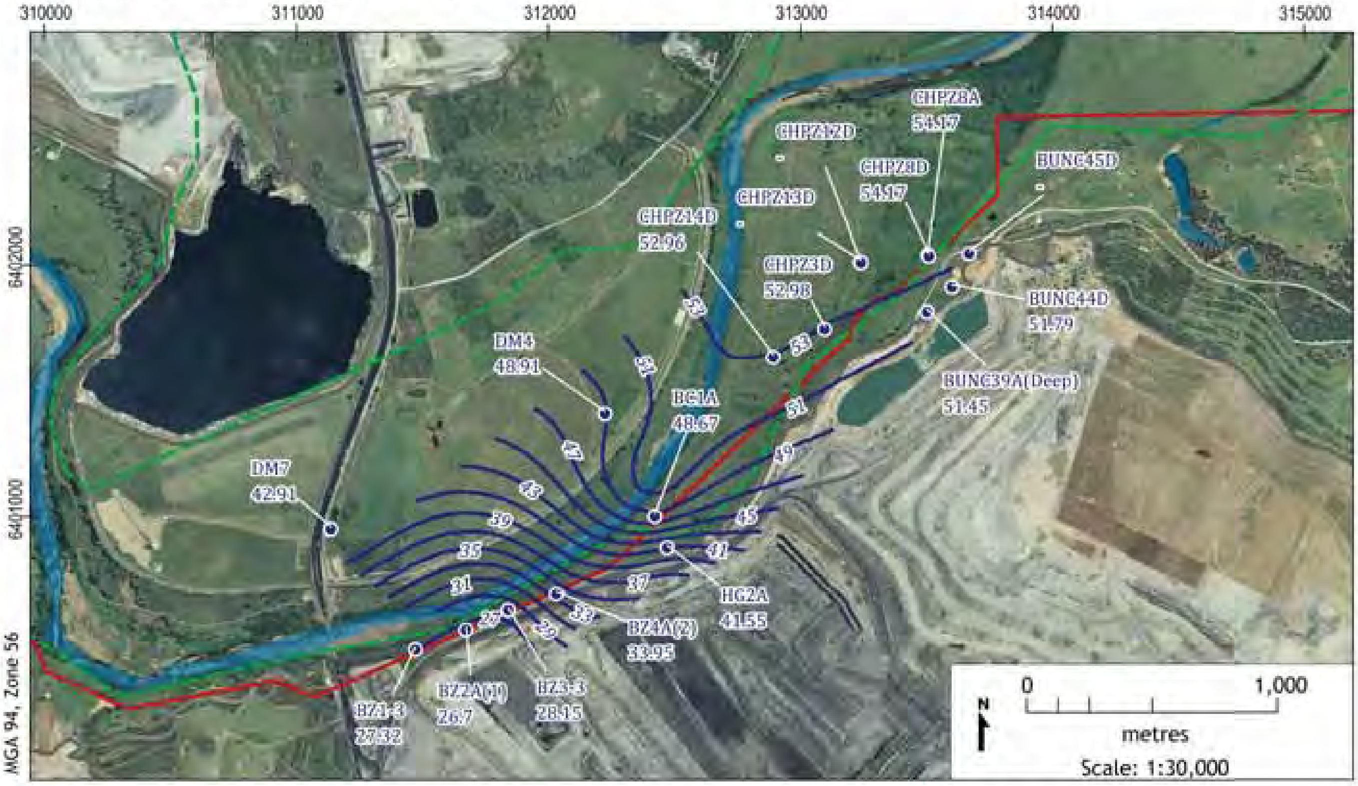
Long term hydrograph for Bowfield Seam bores of Lemington South Put: South Void

Appendix G Groundwater Contours

Alluvium Groundwater Contours



Mt Arthur Seam Groundwater Contours



LEGEND

- ● Groundwater Monitoring Bore, Observed Water Level (mAHD)
- — Groundwater Contour, Interpolated Water Level (mAHD)
- ▲ Surface Water Monitoring Sites
- – – Interpolated Palaeochannel & Alluvial Extent
- ☐ HVO Disturbance Area
- 🟥 HVO South Mine Lease
- 🟦 River / Water Area

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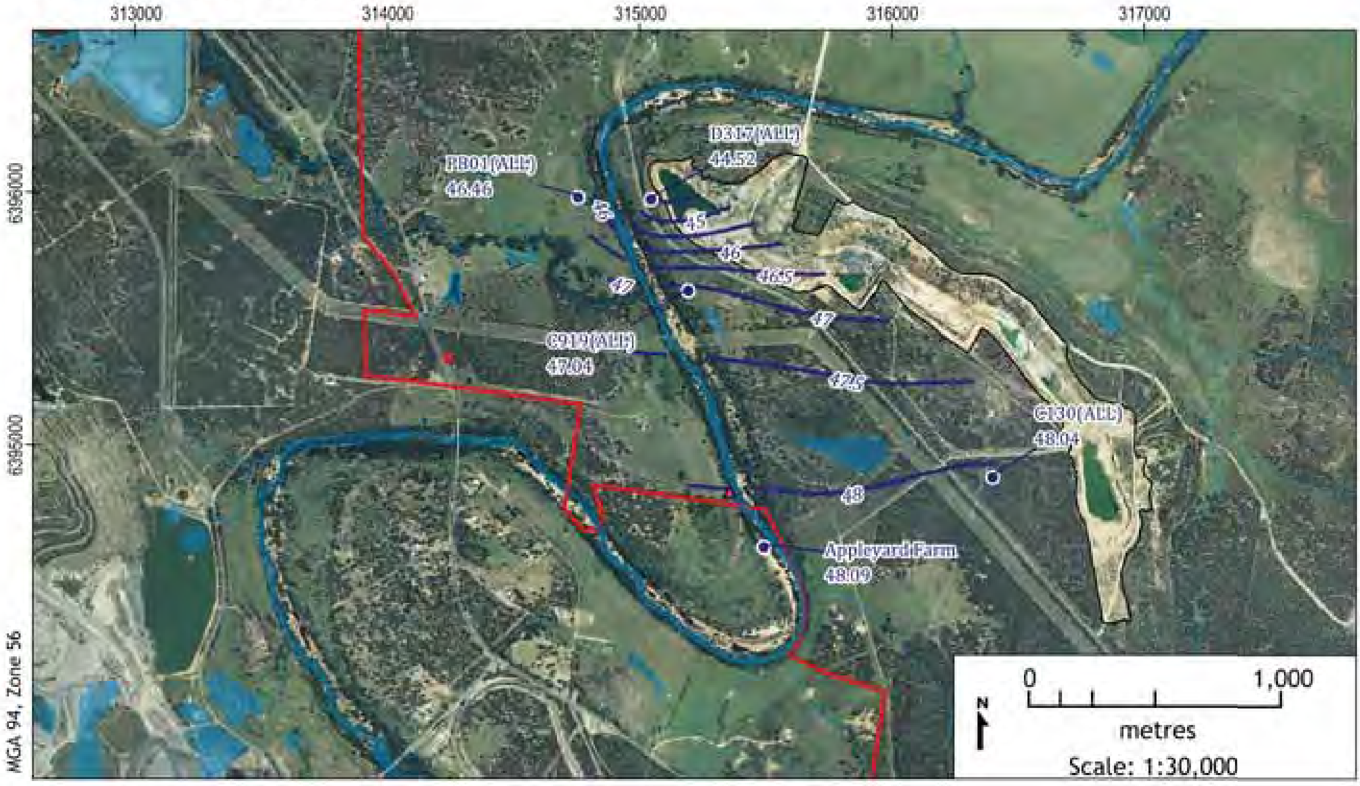
Cheshunt / Barry's Void Groundwater Contours

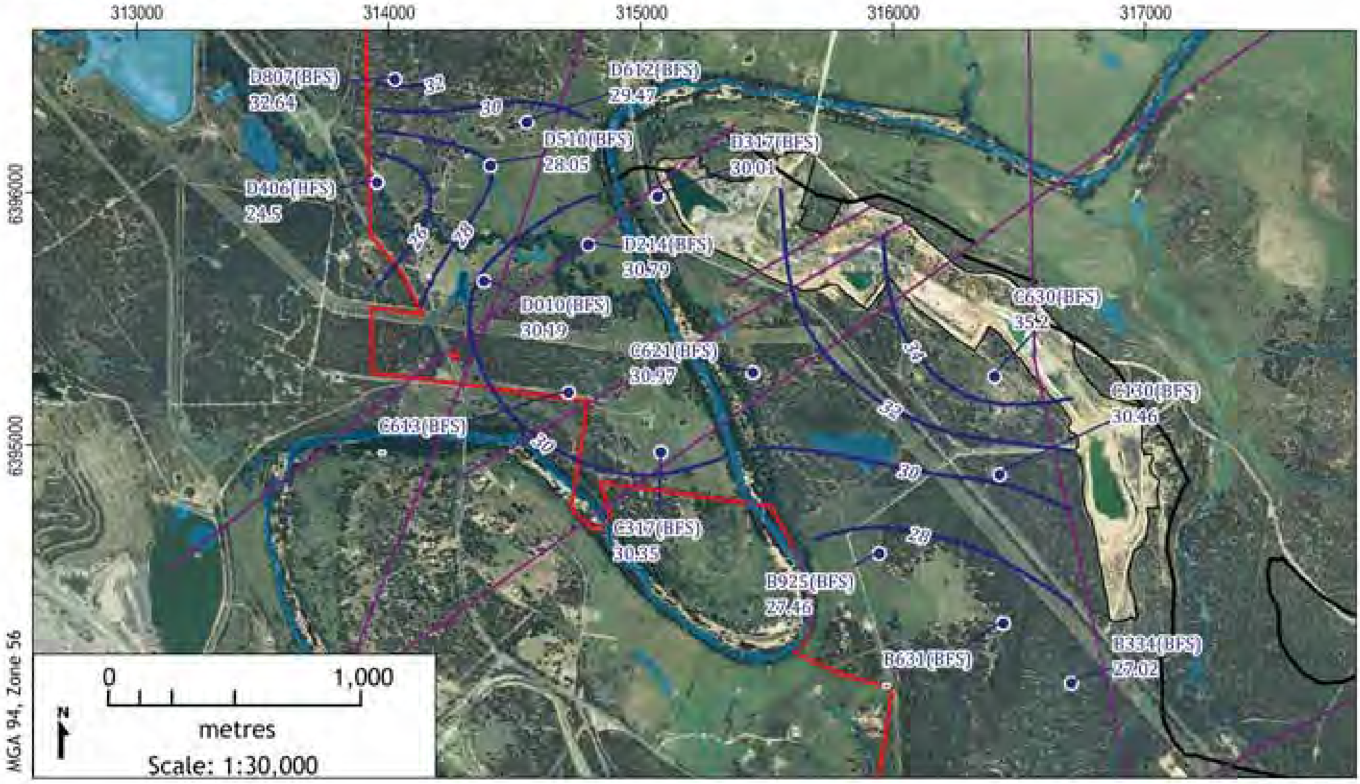
DATE:
16/2/2015

FIGURE No:
24

Alluvium Groundwater Contours



Bowfield Seam Groundwater Contours



LEGEND

- ● Groundwater Monitoring Bore, Observed Water Level (mAHD)
- — Groundwater Contour, Interpolated Water Level (mAHD)
- 🟦 River / Water Area
- ▲ Surface Water Monitoring Site
- — Fault
- — Bowfield Subcrop
- ☐ HVO Disturbance Area
- 🟥 HVO South Mine Lease

HVO South & LUG (G1593H)
2014 Groundwater Impacts Report

Lemington South Groundwater Contours

DATE:
28/1/2015

FIGURE No:
25

Appendix H Flow Loss Calculations Assumptions

In order to apply Darcy's Law, several assumptions were made in order to calculate the hydraulic conductivity (K), hydraulic gradient (i) and area (A). These assumptions are detailed below.

Hydraulic Conductivity (K)

Geological cross-sections (refer to Appendix 2) show that the Quaternary alluvium unconformably overlies the shallow dipping Permian coal measures. This has resulted in variability in the thickness and composition of interburden between the alluvium and coal seams. This natural variation creates a level of complexity in the calculations that are not dealt with using Darcy's Law. Several numerical groundwater models have been undertaken around the project area that include this complexity; however, there is a degree of variability in the hydraulic conductivities used in the models (refer to Table 6). From Table 6, the values from Rust PPK (1997) relate to the Bowfield Seam (BFS) at Lemington South Pit 1, while MER (2005 and 2010) and AGE (2010b) relate to the Mount Arthur Seam (MTA).

Vertical groundwater leakage from the alluvium into the main coal seam for Barry's Void and Lemington South Pit was calculated using the vertical hydraulic conductivity (Kz) for the intervening interburden, sourced from Rust PPK (1997). In the Cheshunt Pit area, it has been documented that in places, the MTA sub-crops beneath the alluvium (MER, 2005 and Groundsearch Australia, 2008). To reflect this variability in stratigraphy, the Kz used in the calculations, for vertical discharge from the alluvium to the coal seam was 1x10-3 m/day, compared to 1x10-4 m/day used for Barry's Void and Lemington South Pit.

Vertical groundwater leakage from the alluvium to the MTA through the anticline structure at Cheshunt Pit was based on values presented by MER (2005) and AGE (2010b). This conservative estimate was carried out to account for faulting and sub-cropping of the coal measures beneath the alluvium and any additional recharge through the anticline.

Horizontal groundwater discharge from the MTA coal seam into Cheshunt Pit and Barry's Void, and from the BFS into Lemington South Pit, were calculated using a horizontal hydraulic conductivity (Kxy) of 0.05 m/day from Rust PPK (1997). Horizontal groundwater discharge from the MTA seam into Cheshunt Pit anticline was based on estimated pump rates of between 5L/s 20L/s, (giving and estimated horizontal conductivity of 2.3 – 9.1 m/day) documented by JP Environmental (2011b). This is considered to be a conservative estimate, as the pump rates encompass incident rainfall and seepage from adjacent pit areas, as well as limiting factors due to part pump flow and flow meter calibration, which would cause over estimation of anticline inflow rates.

Hydraulic properties

KDirection	Target	Rust PPK, 1997 (m/day)	MER, 2005 (m/day)	MER, 2010 (m/day)	AGE, 2010b (m/day)	Value Used (m/day)
K_{XY}	Coal Seam	0.05	0.041	3.7×10^{-3}	-	0.05
	Alluvium	-	0.86	1 – 95†	0.2 – 1.6‡	0.86
K_Z	Coal Seam	1×10^{-03}	1.2×10^{-03}	2.10×10^{-6}	-	1×10^{-3}
	Interburden (above Coal Seams)	1×10^{-04}	2.0×10^{-5}	-	1×10^{-05}	1×10^{-4}
	Alluvium	-	0.86	1	-	0.86

Note: † Average of Permian Coal Measure (PCM) Layers 2 to 5 (MER, 2010)

K_{xy}: Horizontal permeability

K_z: Vertical hydraulic conductivity

Hydraulic Gradient (*i*)

The hydraulic gradient has been calculated using groundwater levels taken during November 2013. Equation 2 was used to calculate the horizontal hydraulic gradient (ixy) by calculating the head difference between bores BZ1-3 (Cheshunt - Money Box Pit), BZ3-3 (Cheshunt anticline), BZ2A(1) (Cheshunt Pit), BUNC45D, CHPZ14D, CHPZ8D (Barry's Void) and D317(BFS) (Lemington South Pit 1), and the pit floor elevation (encompassing all coal seams). Pit floor elevations were derived from cross-sections in the MER (2005) report (Appendix 2). The results are summarised in Table 7.

Horizontal Hydraulic Gradient Equation:

$$i_{xy} = \frac{\Delta h}{\Delta L} = \frac{h_2 - h_1}{length} \qquad \text{(Equation 2)}$$

where:

i_{xy} is the horizontal hydraulic gradient (dimensionless)

Δh is the difference between the hydraulic heads (m)

ΔL is the flow path length between the piezometer and edge of the pit (m)

Equation 3 was used to calculate the vertical hydraulic gradient (iz) between the alluvium and the coal seam. Since coal seam bores BZ1-3, BZ3-3, and BZ2A(1) are not nested with alluvial bores, the groundwater elevation in the alluvial aquifer was estimated from nearby bores screened in the alluvial aquifer.

Bore D317(ALL) is a dry bore, a conservative estimate using the base of D317(ALL) as the SWL in the alluvium has been applied, the thickness of the alluvium has been estimated at 20 m. The results are summarised in Table 8. Where completion data was not available, the base of the alluvium was assumed to be equivalent to the total depth of the alluvial bores. The surface of the coal seam was derived from cross-sections in the MER (2005) report (refer to Appendix 2).

Vertical Hydraulic Gradient Equation:

$$i_z = \frac{\Delta h}{\Delta L} \qquad \text{(Equation 3)}$$

where:

i_z is the vertical hydraulic gradient (dimensionless),

Δh hydraulic head in the alluvial bore (mRL) minus the hydraulic head in the coal seam bore (mRL),

ΔL thickness of interburden calculated from the depth of the alluvial bore (assumed as the base of the alluvium (mRL) minus the estimated depth to the base of the Permian overburden (mRL).

Horizontal hydraulic gradients

Carrington Pit Location	Bore	Discharge Point	Distance Between (m)	Coal Seam Bore Groundwater Level (mRL)	Discharge Point/Pit Elevation (mRL)	Horizontal Hydraulic Gradient (i_{XY})	Adopted <u>horizontal</u> hydraulic gradient (i_{xy})
Cheshunt - Money Box Pit	BZ1-3	Riverview Pit	150	25.77	-40	0.438	0.36
Cheshunt Pit Anticline	BZ3-3	Riverview Pit	150	28.31	-40	0.455	
Cheshunt Pit	BZ2A(1)	Cheshunt Pit	145	27.13	-20	0.325	
Cheshunt - Barry's Void	CHPZ14D	Barry's Void	140	49.61	0	0.354	
Cheshunt - Barry's Void	CHPZ8D	Barry's Void	250	52.59	0	0.210	
Cheshunt - Barry's Void	Bunc45D	Barry's Void	220	54.27	0	0.247	
Lemington South Pit 1	D317(BFS)	Lemington Sth 1	50	28.75	-20	0.975	

Note: † extrapolated width of barrier wall – through alluvium

‡ extrapolated base of alluvium north of barrier wall

Vertical hydraulic gradients

Alluvium Bore	Elevation of base Alluvium Bore (mRL)	Elevation of base of Permian Overburden (mRL)	ΔL (m)	SWL in Alluvium Bore (mRL)	SWL in Coal Bore (mRL)	Δh (m)	Vertical Hydraulic Gradient (i_z)	Average Vertical Hydraulic Gradient (i_z)
BZ1-3	50.8	35.8	15.0	55.18	25.77	29.41	0.82	BZ1-3
BZ3-3	50.0	35.0	15.0	55.50	28.31	27.19	0.78	BZ3-3
BZ2A(1)	50.0	30.0	20.0	50.25	25.76	24.49	0.82	BZ2A(1)
CHPZ14D	55.0	13.0	42.0	54.51	52.59	1.92	0.15	CHPZ14D
CHPZ8D	55.0	13.0	42.0	54.27	54.27	0.00	0.00	CHPZ8D
Bunc45D	52.0	3.0	49.0	53.87	49.58	4.29	1.43	Bunc45D
D317(BFS)	39.0	19.0	20.0	44.51	30.31	14.20	0.75	D317(BFS)

SWL - Standing Water Level

Note:

*****Depth to base of alluvium at Lemington Sth Pit 1 based on conservative 20 m thickness, SWL in alluvium base of D317(ALL)

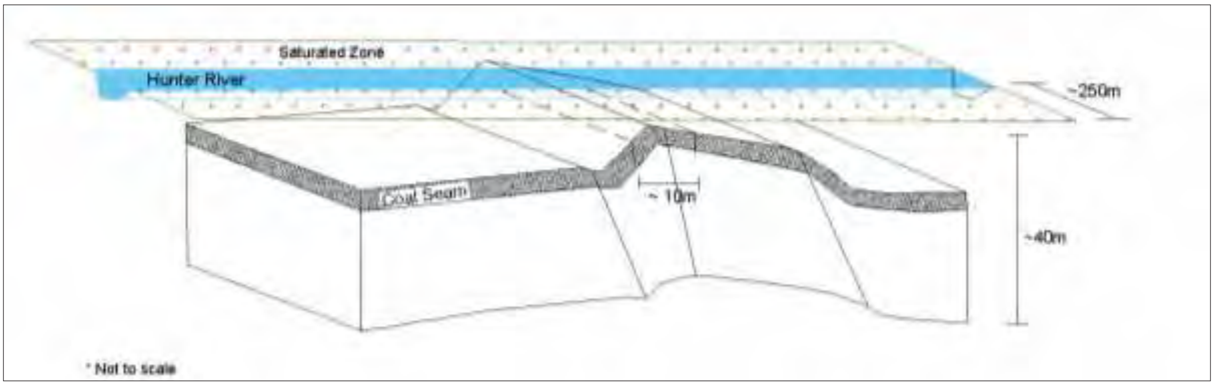
BZ1-1, BZ3-1, and BZ2A(2) are screened within the interburden, water level in BZ2A(2) assumed 55.00 mAHD

Area (A)

The area (A) used to calculate leakage of alluvial groundwater into coal measures (Qz) was based on the length of the pit wall and the width of the alluvium. The width of the alluvium was estimated from aerial photography measurements of the distance between the Hunter River or Wollombi Brook and the edge of the pit wall. This method of calculating area is considered to be conservative, as the extent of alluvium was interpreted based on 1:25,000 geological mapping, which has locally been found to over-estimate the extent of alluvium (Groundsearch Australia, 2006).

The area (A) used to calculate leakage of coal seam groundwater into the pits (Qxy) was calculated based on the length of the pit wall and the thickness of the target coal seam (MTA and BFS). The coal seam width was derived from cross-sections by MER (2005). Mining at Cheshunt Pit and Lemington South Pit accessed underlying coal seams. The thickness values used were only based on the MTA and BFS Seams respectively, due to limited availability of groundwater data for other seams. This may result in under-estimation of total flow loss (Qxy); however, AGC (1984) and MER (2002) have stated that the hydraulic conductivity in the coal measures reduces with depth.

The area (A) used to calculate vertical and horizontal leakage associated with the anticline structure on the northern high-wall of Cheshunt Pit, was based on observations made in the field. It was estimated that the main area of influence along the crest of the anticline and associated faulting is approximately 10 m wide and 40 m high (from the top of the coal seam to the pit floor). The 250 m width of alluvium was based on the distance from the high-wall to the Hunter River. This is illustrated in **Error! Reference source not found.**.



Schematic showing Cheshunt Pit anticline

Appendix I Flow Loss Calculations

Vertical Hydraulic Gradient Calculation (i_z)

Location of Nested Piezometer Bores	Alluvial Bore	Coal Seam Bore	Depth of alluvium Bore (mRL)	Elevation of top of coal (mAHD)	Depth of alluvium bore minus overburden depth ∆L (m)	Groundwater elevation in alluvium bore (mRL)	Groundwater level in coal bore (mRL)	Head difference between alluvium and coal seam bore ∆h (m)	Vertical hydraulic gradient (i_z)	Adopted vertical hydraulic gradient (i_z)	Hydraulic gradient
Cheshunt - Money Box Pit	BZ1-1	BZ1-3	50.8	15.0	35.8	55.18	25.77	29.41	0.82	0.66	Downward
Cheshunt Pit Anticline	BZ3-1	BZ3-3	50.0	15.0	35.0	55.50	28.31	27.19	0.78		Downward
Cheshunt Pit	BZ2A(2)	BZ2A(1)	50.0	20.0	30.0	50.25	25.76	24.49	0.82		Downward
Cheshunt - Barry's Void	CHPZ14A	CHPZ14D	55.0	42.0	13.0	54.51	52.59	1.92	0.15		Downward
Cheshunt - Barry's Void	CHPZ8A	CHPZ8D	55.0	42.0	13.0	54.27	54.27	0.00	0.00		Upward
Cheshunt - Barry's Void	Bunc45A	Bunc45D	52.0	49.0	3.0	53.87	49.58	4.29	1.43		Downward
Lemington South Pit 1	D317(ALL)*	D317(BFS)	39.0	20.0	19.0	44.51	30.31	14.20	0.75		Downward

Note: *Depth to base of alluvium at Lemington Sth Pit 1 based on conservative 20 m thickness, SWL in alluvium base of D317(ALL)

Note: BZ1-1, BZ3-1, and BZ2A(2) are screened within the interburden, water level in BZ2A(2) assumed 55.00 mAHD

Horizontal Hydraulic Gradient Calculation (i_{ZT})

Location	Coal Seam Bore	Discharge Point/Pit	Distance from Bore to Discharge Point/Pit (m)	Coal Seam Bore Groundwater Level (mRL)	Discharge Point/Pit Elevation (mRL)	Horizontal Hydraulic Gradient (i_{ZT})	Adopted horizontal hydraulic gradient (i_{xy})
Cheshunt - Money Box Pit	BZ1-3	Riverview Pit	150	25.77	-40	0.438	0.36
Cheshunt Pit Anticline	BZ3-3	Riverview Pit	150	28.31	-40	0.455	
Cheshunt Pit	BZ2A(1)	Cheshunt Pit	145	27.13	-20	0.325	
Cheshunt - Barry's Void	CHPZ14D	Barry's Void	140	49.61	0	0.354	
Cheshunt - Barry's Void	CHPZ8D	Barry's Void	250	52.59	0	0.210	
Cheshunt - Barry's Void	Bunc45D	Barry's Void	220	54.27	0	0.247	
Lemington South Pit 1	D317(BFS)	Lemington Sth 1	50	28.75	-20	0.975	

Horizontal Leakage from Target Coal Seam to Pit

Horizontal Leakage from Alluvium to Coal Seam Location	Location	Flow Direction	Horizontal Hydraulic Conductivity (MER, 2010) K_{ZT} (m/d)	Horizontal Hydraulic Gradient (i_{ZT})	Pit Wall Length (m)	Exposed Face (m)	Horizontal Discharge to Pit Q_{ZT} (L/s)	Horizontal Discharge from Coal Seams to Pit Q_{ZT} (ML/d)
Mt Arthur	Cheshunt - Money Box Pit	Horizontal	0.05	0.44	650	10	1.6	0.14
Mt Arthur	Cheshunt Pit Anticline	Horizontal	2.3 - 9.1	0.46	10	40	4.8 - 19.2	0.4 - 1.7
Mt Arthur	Cheshunt Pit	Horizontal	0.05	0.33	1,010	10	1.9	0.16
Mt Arthur	Cheshunt - Barry's Void	Horizontal	0.05	0.27	1,100	10	1.7	0.15
						Cheshunt Area Total	**10.1 – 24.5**	**0.9 – 2.1**
Bowfield	Lemington South Pit 1	Horizontal	0.05	0.98	350	7	1.4	0.12

Vertical Leakage from Alluvium to Target Coal Seam

Vertical Leakage from Alluvium to Coal Seam Location	Location	Flow Direction	Vertical Hydraulic of PCM Layer 2 in MER (March 2010) K_Z (m/d)	Vertical Hydraulic Gradient (i_z)	Pit Wall Length (m)	Width of Alluvium (m)	Vertical Discharge from Alluvium to Coal Seams Q_Z (L/s)	Vertical Discharge from Alluvium to Coal Seams Q_Z (ML/d)	Percentage of Pit Inflow from Alluvium Q_Z/Q_{ZT} (%)
Mt Arthur	Cheshunt - Money Box Pit	Vertical	0.001	0.82	650	250	1.5	0.13	0.94
Mt Arthur	Cheshunt Pit Anticline	Vertical	1.00	0.78	10	250	22.5	1.94	´99%
Mt Arthur	Cheshunt Pit	Vertical	0.001	0.82	1,010	250	2.4	0.21	´99%
Mt Arthur	Cheshunt - Barry's Void	Vertical	0.0001	0.53	1,100	250	0.2	0.01	0.10
						Cheshunt Area Total	**26.6**	**2.3**	-
Bowfield	Lemington South Pit 1	Vertical	0.0001	0.75	350	360	0.1	0.01	0.08

Notes

i_{ZT}	Horizontal hydraulic gradient
i_Z	Vertical hydraulic gradient. Head difference between nested bores.
K_{ZT}	Horizontal hydraulic conductivity (m/d)
K_Z	Vertical hydraulic conductivity (m/d)
Q_{ZT}	Estimated leakage of groundwater from target coal seams into pits (ML/d)
Q_Z	Estimated leakage groundwater from alluvium, through the interburden and into target coal seams (ML/d)
Q_z/Q_{xy}	Pit inflow sourced from alluvium groundwater (%)
	Estimated depth to base of Permian overburden from CFW59 lithological log & geological cross-sections in MER (2005)
	Vertical conductivity of coal seam from Rust PPK (1997)
	Vertical and horizontal hydraulic conductivity of alluvium from MER (2005) (m/d)
	Estimate based on geological cross-sections from MER (2005)
*	Estimated depth to base of Permian overburden from CFW59 lithological log & geological cross-sections in MER (2005)

Groundwater Flow

Q=KiA

Q = Discharge (m³/d)
K = Hydraulic Conductivity (m/d)
i = Hydraulic Gradient
A = Area Intersected (m²)

Appendix J LUG Bore Monitoring Data

Table 8 Summary of monitoring bores near LUG Bore

Bore	Easting	Northing	Collar RL (mAHD)	Install depth (mBGL)	Target lithology
LUG Bore	315880	6394293	65	205.5	Mount Arthur
Appleyard Farm	315491	6394639	43.44	8.77	Alluvium
C130(ALL)	316399.6	6394916	63.1	16.98	Alluvium
C919(ALL)	315191.7	6395655	57.93	11.46	Alluvium
D317(ALL)	315044	6396018	59.79	14.65	Alluvium
PB01(ALL)	314754	6396026	54.61	10.24	Alluvium
C130(AFS1)	316399.6	6394916	63.88	42.16	Arrowfield
D406(AFS)	313931	6396074	57.99	61.65	Arrowfield
D510(AFS)	314380.1	6396141	55.57	38.78	Arrowfield
D612(AFS)	314524	6396314	62.77	24.4	Arrowfield
B334(BFS)	316683.5	6394088	73	51.8	Bowfield
C130(BFS)	316399.6	6394916	63	36.7	Bowfield
C317(BFS)	315054.4	6395007	61.1	76.16	Bowfield
C613(BFS)	314688.2	6395243	64.25	85.49	Bowfield
C621(BFS)	315421.3	6395321	59	57.45	Bowfield
C630(BFS)	316377.5	6395306	69.49	49.1	Bowfield
D010(BFS)	314354.8	6395687	56.72	68.05	Bowfield
D214(BFS)	314768	6395831	57.32	53.47	Bowfield
D317(BFS)	315042.6	6396018	60.28	35.42	Bowfield
D406(BFS)	313931	6396074	57.99	61.33	Bowfield
D510(BFS)	314380.1	6396141	55.62	30.35	Bowfield
D612(BFS)	314524	6396314	62.77	35.06	Bowfield
D807(BFS)	314002	6396484	60.64	41.37	Bowfield
B631(BFS)	316415	6394327	72.73	36.09	Bowfield Seam
B925(BFS)	315920.6	6394604	63.17	41.21	Bowfield Seam
D010(GM)	314354.8	6395687	56.72	23.27	Glen Munro
B425(WDH)	316010.3	6395024	58.5	36.19	Woodlands Hill
B631(WDH)	316424.4	6394319	72.51	30.73	Woodlands Hill

Bore	Easting	Northing	Collar RL (mAHD)	Install depth (mBGL)	Target lithology
C122(WDH)	315501.2	6395007	59.02	22.69	Woodlands Hill
C130(WDH)	316399.6	6394916	63.89	21.55	Woodlands Hill
C317(WDH)	315054.4	6395007	60.54	33.89	Woodlands Hill
C809	314206.7	6395493	59.43	28.69	Woodlands Hill
D010(WDH)	314354.8	6395687	56.59	16.97	Woodlands Hill

Appendix 5:

Rehabilitation Table

Rehabilitation Table

1.0 Rehabilitation Progress

Rehabilitation Progress - HVO North Includes Carrington/North Pit/West Pit – cumulative areas affected

Rehabilitation Activity Type	Domain Identifier	Primary Domain	Secondary Domain	Total Area last reported (ha)	Total Area to Date (ha)
1.1 Active mining and infrastructure area, facilities, including roads and tracks	1A	Final Void	Final Void	176.3	194.5
	2B	Water Management	Water Management	16.2	16.2
	3D	Infrastructure Area	Rehabilitation Area - Pasture	110.9	110.9
	3E	Infrastructure Area	Rehabilitation Area - Woodlands	3.0	3.0
	4D	Tailings Storage Facility	Rehabilitation Area - Pasture	68.8	68.7
	4E	Tailings Storage Facility	Rehabilitation Area - Woodlands	96.3	96.2
	5D	Overburden Emplacement	Rehabilitation Area - Pasture	826.3	835.1
	5E	Overburden Emplacement	Rehabilitation Area - Woodlands	511.0	500.7
	Total - Active			1808.8	1825.3
1.2 Decommissioning	Total - Decommissioning			0.0	0.0
1.3 Landform Establishment (included in 1.1)	Total - Landform Establishment			24.9	0.0
1.4 Growth Medium Development (included in 1.1)	Total - Growth Medium Development			0.0	0.0
1.5 Ecosystem and Land Use Establishment	3D	Infrastructure Area	Rehabilitation Area - Pasture	0.1	0.0
	4D	Tailings Storage Facility	Rehabilitation Area - Pasture	2.9	0.3
	5D	Overburden Emplacement	Rehabilitation Area - Pasture	69.4	72.2
	5E	Overburden Emplacement	Rehabilitation Area - Woodlands	9.4	18.4
	Total - Ecosystem and Land Use Establishment			81.8	90.9

Rehabilitation Activity Type	Domain Identifier	Primary Domain	Secondary Domain	Total Area last reported (ha)	Total Area to Date (ha)
1.6 Ecosystem and Land Use Development	1A	Final Void	Final Void	4.7	4.7
	3D	Infrastructure Area	Rehabilitation Area - Pasture	0.0	0.1
	4D	Tailings Storage Facility	Rehabilitation Area - Pasture	49.3	52.2
	4E	Tailings Storage Facility	Rehabilitation Area - Woodlands	18.0	18.0
	5C	Overburden Emplacement	Rehabilitation Area Class 1 and 2 Land	72.3	72.3
	5D	Overburden Emplacement	Rehabilitation Area - Pasture	1086.7	1144.8
	5E	Overburden Emplacement	Rehabilitation Area - Woodlands	345.3	354.0
	Total - Ecosystem and Land Use Development			1576.3	1646.1
1.7 Rehabilitation Complete	Total - Rehabilitation Complete			0.0	0.0
1.8 Total Area Disturbed (items 1.1 to 1.7)	1A	Final Void	Final Void	181.0	199.2
	2B	Water Management	Water Management	16.2	16.2
	3D	Infrastructure Area	Rehabilitation Area - Pasture	111.0	111.0
	3E	Infrastructure Area	Rehabilitation Area - Woodlands	3.0	3.0
	4D	Tailings Storage Facility	Rehabilitation Area - Pasture	121.0	121.0
	4E	Tailings Storage Facility	Rehabilitation Area - Woodlands	114.3	114.3
	5C	Overburden Emplacement	Rehabilitation Area Class 1 and 2 Land	72.3	72.3
	5D	Overburden Emplacement	Rehabilitation Area - Pasture	1982.4	2053.7
	5E	Overburden Emplacement	Rehabilitation Area - Woodlands	865.7	871.6
	Total - Footprint			3466.9	3562.3

Rehabilitation Progress - HVO South Includes Riverview, Cheshunt and Lemington South - cumulative areas

Rehabilitation Activity Type	Classification	Total Area last reported (ha)	Total Area to Date (ha)
1.1 Active mining and infrastructure area, facilities, including roads and tracks	Active Mining	328.7	351.9
	Topsoil Stripped	145.2	111.1
	Infrastructure	319.6	287.0
	Infrastructure Tailings	0.0	0.0
	Waste Emplacement- Shaped	16.5	0.0
	Topsoil Spread	0.0	0.0
	Topsoil Stockpile	15.0	21.7
	Waste Emplacement - Unshaped	718.6	718.5
	Water Structures	56.9	55.0
	Total - Active	1600.5	1545.3
1.2 Decommissioning	Total - Decommissioning	0.0	0.0
1.3 Landform Establishment	Total - Landform Establishment (Included in 1.1)	16.5	0.0
1.4 Growth Medium Development	Total - Growth Medium Development (Included in 1.1)	0.0	0.0
1.5 Ecosystem and Land Use Establishment	Total - Ecosystem and Land Use Establishment	236.8	102.1
1.6 Ecosystem and Land Use Development	Total - Ecosystem and Land Use Development	530.5	862.7
1.7 Rehabilitation Complete	Total - Rehabilitation Complete	0.0	0.0
1.8 Total Area Disturbed (items 1.1 to 1.7)	Total - Total Footprint	2367.8	2509.9

Note: Primary and Secondary Domains have not yet been developed for HVO South MOP

Rehabilitation Progress, Newdell

Rehabilitation Activity Type	Classification	Total Area last reported (ha)	Total Area to Date (ha)
1.1 Active mining and infrastructure area, facilities, including roads and tracks	Active Mining	0.0	0
	Topsoil Stripped	0.0	0
	Infrastructure	42.4	42.4
	Infrastructure Tailings	0.0	0
	Waste Emplacement- Shaped	0.0	0
	Topsoil Stockpile	0.0	0
	Waste Emplacement - Unshaped	0.0	0
	Water Structures	3.3	3.3
	Total - Active	45.7	45.7
1.2 Decommissioning	Total - Decommissioning	0.0	0
1.3 Landform Establishment	Total - Landform Establishment	0.0	0
1.4 Growth Medium Development	Total - Growth Medium Development	0.0	0
1.5 Ecosystem and Land Use Establishment	Total - Ecosystem and Land Use Establishment	0.0	0
1.6 Ecosystem and Land Use Development	Total - Ecosystem and Land Use Development	37.8	37.8
1.7 Rehabilitation Complete	Total - Rehabilitation Complete	0.0	0
1.8 Total Area Disturbed (items 1.1 to 1.7)	Total - Total Footprint	83.5	83.5

Note: Primary and Secondary Domains have not yet been developed for Newdell MOP

2.0 Soil Management and Erosion Control

2.1 Soil Stockpiling/ Use	Soil Used This Period (m3)	Soil Prestripped This Period (m3)	Soil Stockpiled to Date (m3)	Soil Stockpiled Last Report (m3)
	148,700	128,200	1,798,013	1,410,000
2.2 Erosion Treatment	Total Area to Date (ha)	Total Area Last Report (ha)	Total Area This Report (ha)	Area Retreated This Period (ha)
	Not Available			
Approx. area of sheet or gully erosion requiring reshaping topdressing and/or reshowing	Not Available			

3.0 Weed Control and Feral Animal Control

	Area in ha
3.1 Approx. area adversely affected by weeds as of the date of this report.	Not Available
3.2 Area treated for weed control during the period covered by the report.	189.9ha
3.3 Give summary of control strategies used and verification by approval agency(s)	
Species targeted in rehabilitation areas during 2014included: galenia, African boxthorn, opuntia species (pear), bathurst burr, castor oil plant and *Acacia saligna*.	

4.0 Management of Rehabilitated Areas

4.1 Area treated with maintenance fertiliser.	0ha
4.2 Area treated by rotational grazing, cropping or slashing.	420ha
Give summary	300ha HVO North rehabilitation area licence agreement in place for grazing. 120ha HVO Alluvial Lands licence agreement commenced in January 2013.

5.0 Variations to Rehabilitation Program

Has rehabilitation work proceeded generally in accordance with the conditions of an accepted Mining Operations Plan	HVO North –Substantially (see below) Newdell – Yes HVO South – Yes
If not please cite any approval granted for variations, or briefly describe the seasonal conditions or other reasons for any changes and the nature of any changes which have been made.	
Actual rehabilitation completed in HVO North during period 2012 to 2014 = 174.6ha. MOP target for rehabilitation in HVO North during period 2012 to 2014 = 253.5ha. Slower progress of rehabilitation has been due to slower dump release in both West Pit and Carrington compared to what was forecast in the MOP. Rehabilitation activities at HVO have also been focused on rehabilitating high visibility areas at Cheshunt and Riverview, visible from Maison Dieu and Golden highway respectively. During 2014, there was 14.9ha more rehabilitation completed in HVO North than the MOP forecast which helped to reduce the deficit in rehabilitation over the period of the MOP to 78.9ha (from a deficit of 94ha at the end of 2013).	

6.0 Planned Operations During the Next Report Period

6.1 Area estimated to be disturbed (currently undisturbed) ha.	188.4ha
6.2 Area estimated to be rehabilitated (ha)	140ha

7.0 Remarks From The Reporting Officer

Reporting Officer Signature
Print Name and Position:
Mine Manager Signature
Print Name:
Date:
Date of Next Report Due:

Appendix 6:

Rehabilitation and Disturbance Summary and Maps

Rehabilitation Summary - 2014

Rehabilitation Site Name	Rehabilitation Type	Rehabilitation Coordinates	Rehabilitation Area (ha)	Rehabilitation Summary
Wilton Pit	Pasture and Woodland	307,180 E 6,407,460 N	14.2	▪ Topsoil was spread at a nominal thickness of 100mm. ▪ Compost was applied at a rate of 100 tonnes per hectare. ▪ Gypsum was applied at a rate of 10 tonnes per hectare. ▪ Windrowing, flexirolling and aerating as required. ▪ Millet was broadcast into Aerated pattern at a rate of approximately 35 kg per hectare.
West Pit Centre	Pasture and Woodland	308,940 E 6,409,620 N	8.0	▪ Topsoil was spread at a nominal thickness of 100mm. ▪ Compost was applied at a rate of 100 tonnes per hectare. ▪ Gypsum was applied at a rate of 10 tonnes per hectare. ▪ Windrowing, flexirolling and aerating as required. ▪ Millet/Legume mix was broadcast into an aerated pattern at a rate of approximately 30 kg/ha.
West Pit North	Pasture and Woodland	309,340 E 6,410,700 N	43	▪ Topsoil was spread at a nominal thickness of 100mm. ▪ Compost was applied at a rate of 100 tonnes per hectare. ▪ Gypsum was applied at a rate of 10 tonnes per hectare. ▪ Windrowing, flexirolling and aerating as required ▪ Barley was direct drilled into an aerated pattern at a rate of approximately 80 kg/ha to 22.6 ha of the total area. ▪ Millet/legume mix was broadcast into an aerated pattern at a rate of approximately 30 kg/ha to 20.4 ha of the total area.

Rehabilitation Site Name	Rehabilitation Type	Rehabilitation Coordinates	Rehabilitation Area (ha)	Rehabilitation Summary
Carrington	Pasture and Woodland	309,970 E 6,402,870 N	25.6	▪ Topsoil was spread at a nominal thickness of 100mm. ▪ Compost was applied at a rate of 100 tonnes per hectare. ▪ Gypsum was applied at a rate of 10 tonnes per hectare. ▪ Windrowing, flexirolling and aerating as required ▪ Millet was broadcast into an aerated pattern at a rate of approximately 35 kg per hectare.
Cheshunt	Pasture and Woodland	315,320 E 6,399,870 N	34	▪ Topsoil was spread at a nominal thickness of 100mm. ▪ Compost was applied at a rate of 100 tonnes per hectare. ▪ Gypsum was applied at a rate of 10 tonnes per hectare. ▪ Windrowing, flexirolling and aerating as required. ▪ Millet was broadcast into an aerated pattern to a total area of 22.5 ha at a rate of approximately 35 kg per hectare. ▪ Oats and Rye Grass was sown to a total area of 11.5 ha at a rate of approximately 30 kg per hectare.
Riverview 145	Pasture	311,800 E 6,398,360 N	54.6	▪ Topsoil was spread at a nominal thickness of 100mm to 15.9 ha of the total area. ▪ Compost was applied at a rate of 100 tonnes per hectare. ▪ Gypsum was applied at a rate of 10 tonnes per hectare. ▪ Windrowing, flexirolling and aerating as required ▪ Native mix was direct drilled into an aerated pattern to 38.8 Ha of the total area at a rate of 26.4kg per ha. ▪ Millet was broadcast into an aerated pattern to a total area of 15.9 ha at a rate of approximately 35 kg per hectare.

Rehabilitation Site Name	Rehabilitation Type	Rehabilitation Coordinates	Rehabilitation Area (ha)	Rehabilitation Summary
Riverview 125	Pasture	312,960 E 6,398,530 N	13.1	▪ Topsoil was spread at a nominal thickness of 100mm to 7.8 ha of the total area. ▪ Compost was applied at a rate of 100 tonnes per hectare. ▪ Gypsum was applied at a rate of 10 tonnes per hectare. ▪ Windrowing, flexirolling and aerating as required. ▪ Millet was broadcast into an aerated pattern to a total area of 7.8 ha at a rate of approximately 35 kg per hectare. ▪ Millet/legume Mix was broadcast into an aerated pattern to a total area of 5.3 ha at a rate of approximately 30 kg/ha.

Millet/Legume mix:

Product	Quantity (kg/ha)
Burgundy Bean	2.4
Lucerne	6.3
Chicory	1.5
Red Clover	2.4
Millet	17.4

Native Seed Mix:

Species		Sowing Rate (kg/ha)
Small Flowable mix		
Calotis cuneata	purple burr daisy	0.050
Calotis lappulacea	yellow burr dairy	0.050
Capillipedium spicigerum	scented top	0.027
Einadia nutans	climbing saltbush	0.185
Einadia trigonos	fishweed	0.075
Eucalyptus crebra	narrow leaved ironbark	0.150
Eucalyptus dawsonii	dawsons gum	0.020
Eucalyptus fibrosa	broad leaved ironbark	0.050
Eucalyptus moluccana	greybox	0.100
Eucalyptus punctata	grey gum	0.020
Eucalyptus tereticornis	forest redgum	0.060
Fimbristylis dichotoma	common fringe rush	0.088
Kunzea ambigua	white kunzea	0.010
Panicum effusum	hairy panic	0.429
Poa labillardieri	tussock grass	0.000
Sporobolus creber	western rats tail grass	0.000
Wahlenbergia mix	bluebells	0.023
Capillipedium spicigerum	scented top	0.111
Eucalyptus crebra	narrow leaved ironbark	0.060
Eucalyptus fibrosa	broad leaved ironbark	0.030
Eucalyptus moluccana	greybox	0.030
Indigofera australis	austral indigo	0.050
Panicum effusum	hairy panic	0.429
Poa labillardieri	tussock grass	0.033
Sporobolus creber	western rats tail grass	0.006
	Total	**1.337**
Large flowable mix		
Acacia cultriformis	knife-leaf wattle	0.050
Acacia decora	golden wattle	0.460
Acacia falcata	sickle wattle	0.300
Acacia implexa	hickory	0.100
Acacia leiocalyx	black wattle	0.150
Acacia paradoxa	kangaroo thorn	0.040
Acacia parvipinnula	silver wattle	0.010
Acacia salicina	coobah	0.120
Ajuga australis	austral bugle	0.024
Allocasuarina littoralis	black sheoak	0.020
Atriplex semibaccata	creeping saltbush	0.175
Bursaria spinosa	blackthorn	0.200

Species		Sowing Rate (kg/ha)
Large flowable mix		
Corymbia maculata	spotted gum	0.100
Daviesia ulicifolia	gorse bitter-pea	0.350
Dianella caerulea	blue flax lilly	0.044
Dianella longifolia	fairy flax lilly	0.044
Dianella revoluta	spreading flax lilly	0.039
Enchylaena tomentosa	ruby saltbush	0.010
Eremophila debilis	amulla	0.020
Eremophila deserti	desert emubush	0.010
Gahnia aspera	saw sedge	0.133
Glycine clandestina	love creeper	0.018
Hakea sericea	silky hakea	0.010
Hardenbergia violacea	native sarsparilla	0.100
Indigofera australis	austral indigo	0.210
Jacksonia scoparia	dogwood	0.010
Lomandra longifolia	mat rush	0.152
Myoporum montanum	western boobialla	0.010
Notelaea microcarpa	native olive	0.050
Paspalidium distans	spreading panic	0.267
Podolobium ilicifolium	prickly shaggy pea	0.030
Pomax umbellata	pomax	0.017
Pulteaea microphylla	small leaved bush-pea	0.050
Senna artemesioides subsp. zygophylla	punty bush	0.010
Solanum cinereum	narrawa burr	0.035
Swainsona galegifolia	darling pea	0.050
Acacia decora	golden wattle	0.250
Acacia falcata	sickle wattle	0.250
Acacia implexa	hickory	0.200
Bursaria spinosa	blackthorn	0.200
Corymbia maculata	spotted gum	0.030
Daviesia ulicifolia	gorse bitter-pea	0.100
Dianella longifolia	fairy flax lilly	0.030
Gahnia aspera	saw sedge	0.055
Hardenbergia violacea	native sarsparilla	0.100
Lomandra longifolia	mat rush	0.165
Notelaea microcarpa	native olive	0.050
Paspalidium distans	spreading panic	0.223
Senna artemesioides subsp. zygophylla	punty bush	0.010
	Total	**5.081**
Non-flowable		
Austrodanthonia setacea	small flowered wallaby grass	0.303
Austrostipa densiflora	foxtail speargrass	0.040

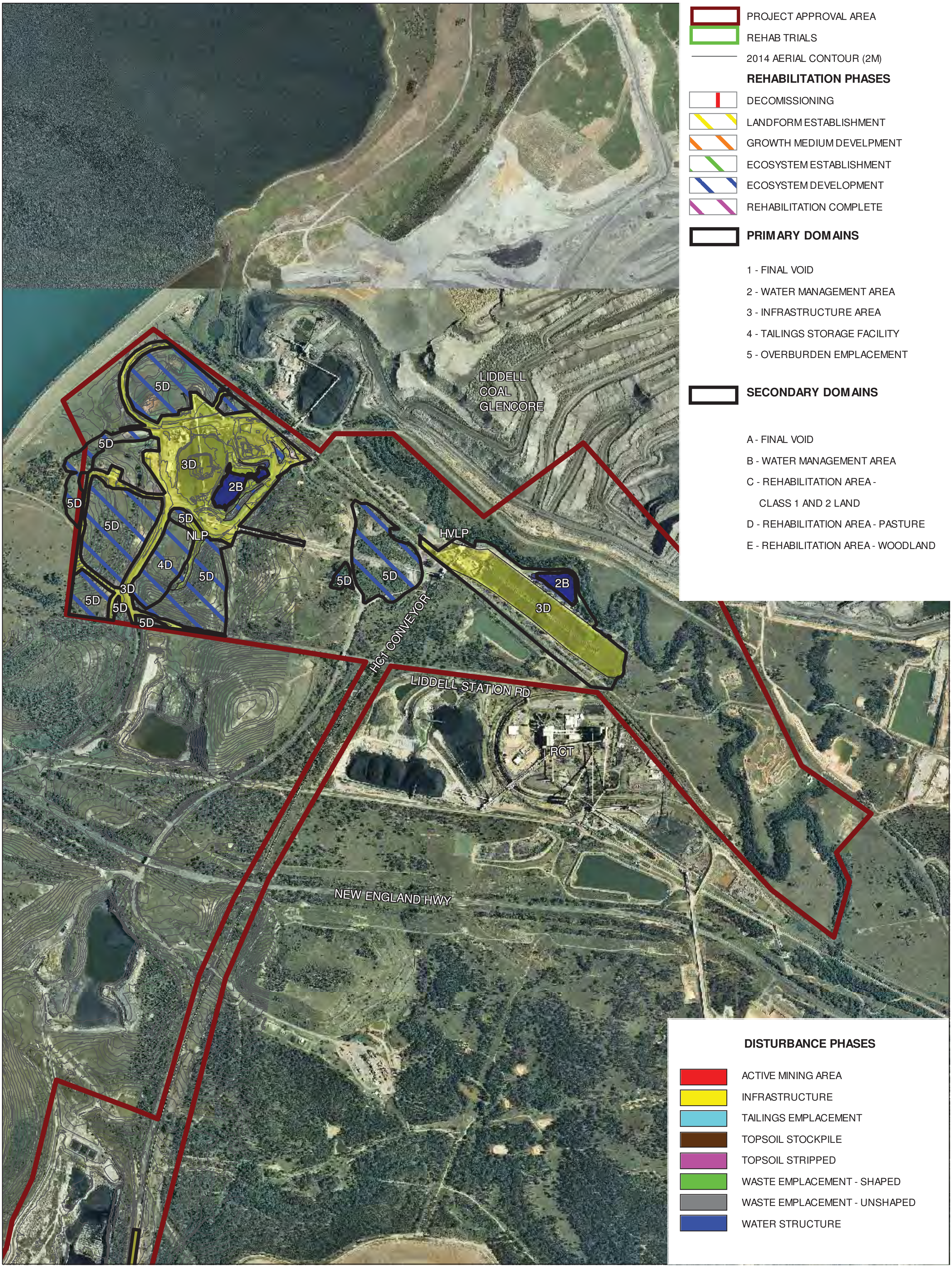
Species		Sowing Rate (kg/ha)
Non-flowable		
Austrostipa scabra	rough speargrass	1.663
Austrostipa verticillata	slender bamboo grass	0.093
Bothriochloa macra	redgrass	2.231
Cassinia arcuata	drooping cassinia	0.200
Cassinia quinquefaria	long-leaved cassinia	0.200
Chloris truncata	windmill grass	0.620
Chrysocephalum apiculatum	yellow buttons	0.201
Cymbopogon refractus	barbed wire grass	0.026
Desmodium brachypodum	large tick-trefoil	0.030
Dicanthium sericeum	bluegrass	0.446
Dichelachne crinita	plumegrass	0.071
Digitaria brownii	cotton panic	0.094
Echinopogon intermedius	hedgehog grass	0.008
Elymus scaber	wheat grass	0.044
Heteropogon contortus	black speargrass	0.178
Imperata cylindrica	blady grass	0.044
Joycea pallida	hill wallaby grass	0.080
Microleana stipoides	weeping rice grass	1.275
Olearia elliptica	sticky daisy bush	0.200
Ozothamnus diosmifolius	rice flower	0.100
Themeda triandra	kangaroo grass	4.190
Vittadinia sulcata	furrowed new holland daisy	0.037
Austrodanthonia setacea	small flowered wallaby grass	1.530
Austrostipa scabra	rough speargrass	3.000
Austrostipa setacea	corkscrew grass	1.150
Bothriochloa macra	redgrass	3.000
Chrysocephalum apiculatum	yellow buttons	0.500
Cymbopogon refractus	barbed wire grass	0.190
Dicanthium sericeum	bluegrass	2.310
Dichelachne crinita	plumegrass	0.415
Elymus scaber	wheat grass	1.923
Microleana stipoides	weeping rice grass	0.570
Themeda triandra	kangaroo grass	5.000
Aristida ramosa mix	wiregrass	0.079
Austrodanthonia fulva/blue mix	wallaby/blue	0.848
Austrodanthonia setacea	small flowered wallaby grass	1.116
Austrostipa bigeniculata	tall speargrass	0.558
Austrostipa densiflora	foxtail speargrass	0.040
Austrostipa ramosissima	stout bamboo grass	0.000
Austrostipa scabra	rough speargrass	1.663
Austrostipa setacea	corkscrew grass	0.111

Species		Sowing Rate (kg/ha)
Non-flowable		
Bothriochloa macra	redgrass	2.231
Cassinia quinquefaria	long-leaved cassinia	0.040
Chloris truncata	windmill grass	0.620
Chrysocephalum apiculatum	yellow buttons	0.250
Cymbopogon refractus	barbed wire grass	0.033
Dicanthium sericeum	bluegrass	1.000
Dichelachne crinita	plumegrass	0.089
Digitaria brownii	cotton panic	0.094
Elymus scaber	wheat grass	0.055
Heteropogon contortus	black speargrass	0.334
Imperata cylindrica	blady grass	0.055
Microleana stipoides	weeping rice grass	1.445
Themeda avenacea	oat kangaroo grass	0.033
Themeda triandra	kangaroo grass	5.915
	Total	**48.571**

Source: Hunter Valley Operations
West Pit Extension and Minor Modifications
Environmental Impact Statement (October 2003)
Volume 4 Figures 9 and 10

Figure A: Comparison of Rehabilitation Progress against EIS Prediction - HVO North

Figure B: Comparison of Rehabilitation Progress against EIS Prediction - HVO South



HVOAEMR 150227.WOR

COAL & ALLIED

N W E S

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Date: 13/03/15

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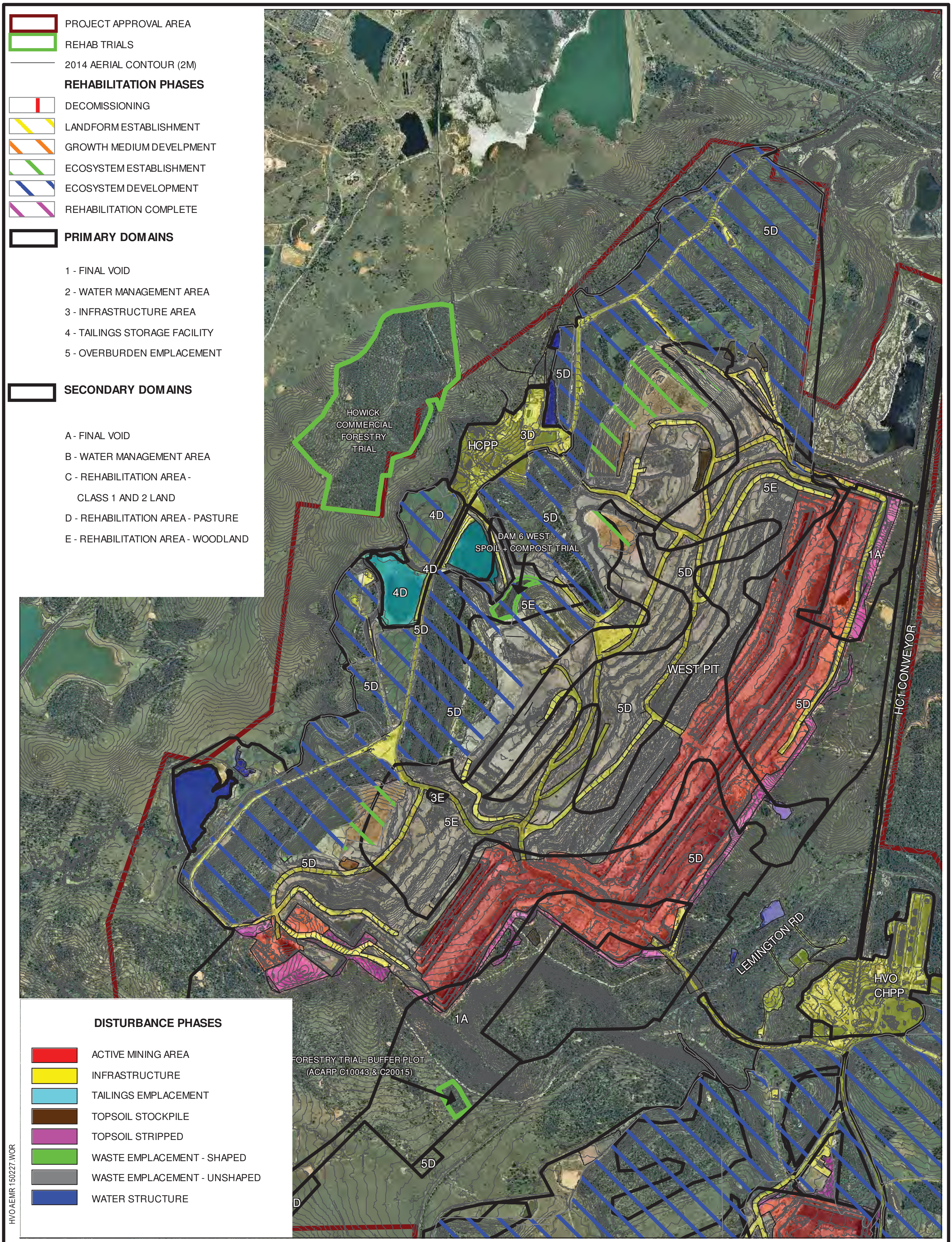
KILOMETRES

Rio Tinto Coal Australia
Hunter Valley Operations

AEMR - HVLP NLP - 2014



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Rio Tinto Coal Australia
Hunter Valley Operations

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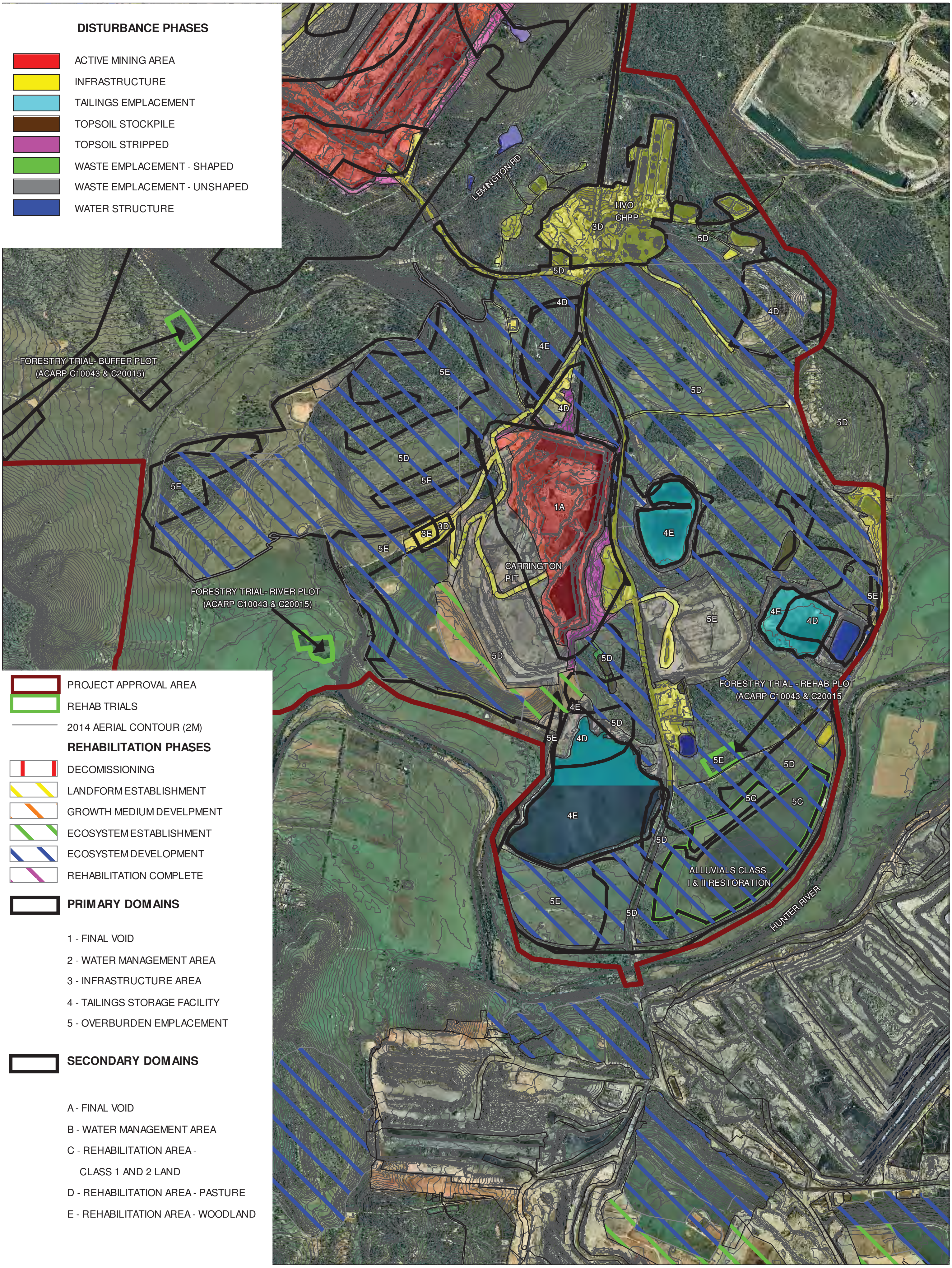

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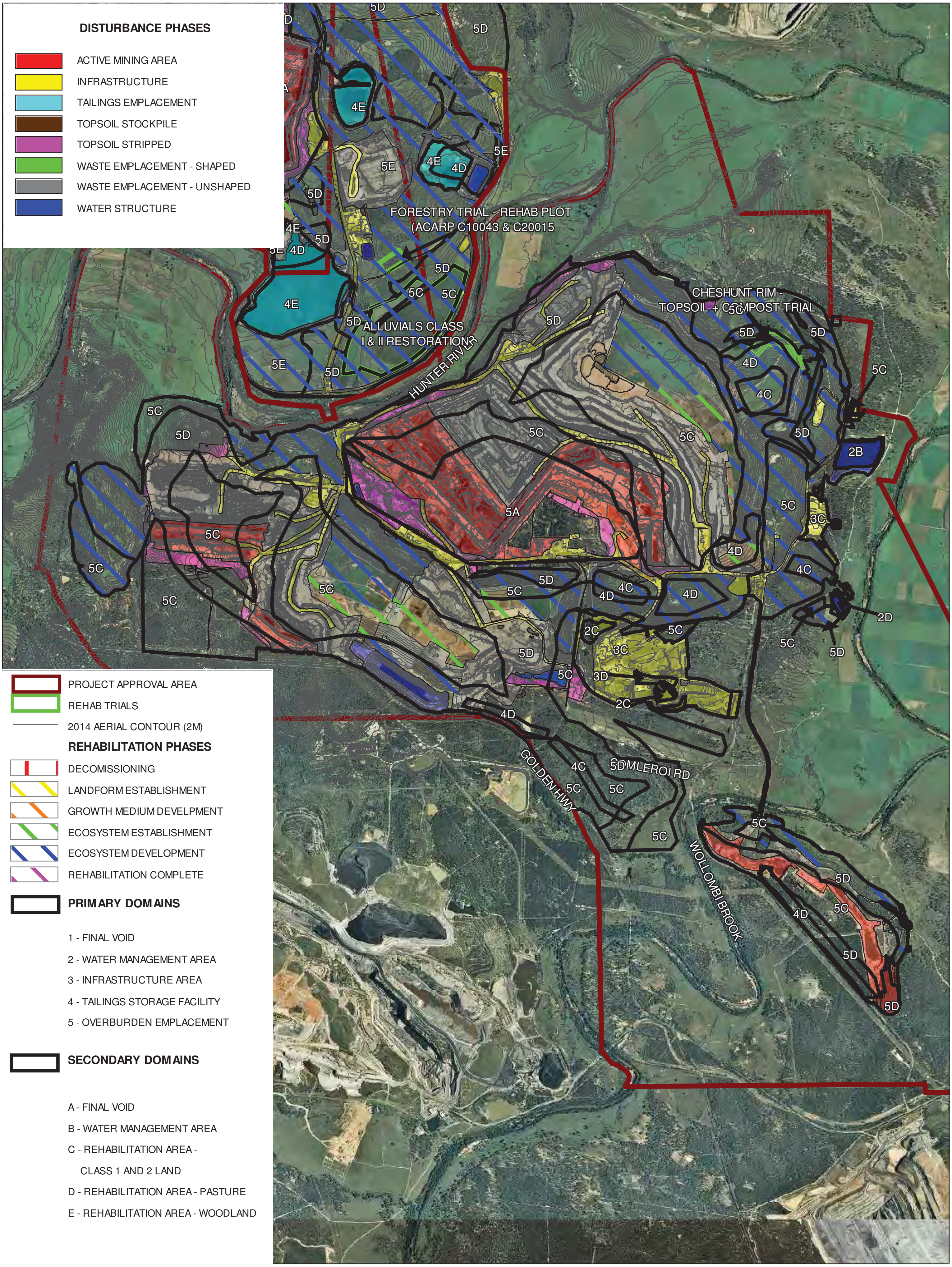
Rio Tinto Coal Australia
Hunter Valley Operations

AEMR - Carrington Pit - 2014



COAL & ALLIED

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Date: 13/03/15

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KILOMETRES

Rio Tinto Coal Australia
Hunter Valley Operations

AEMR - HVO South - 2014

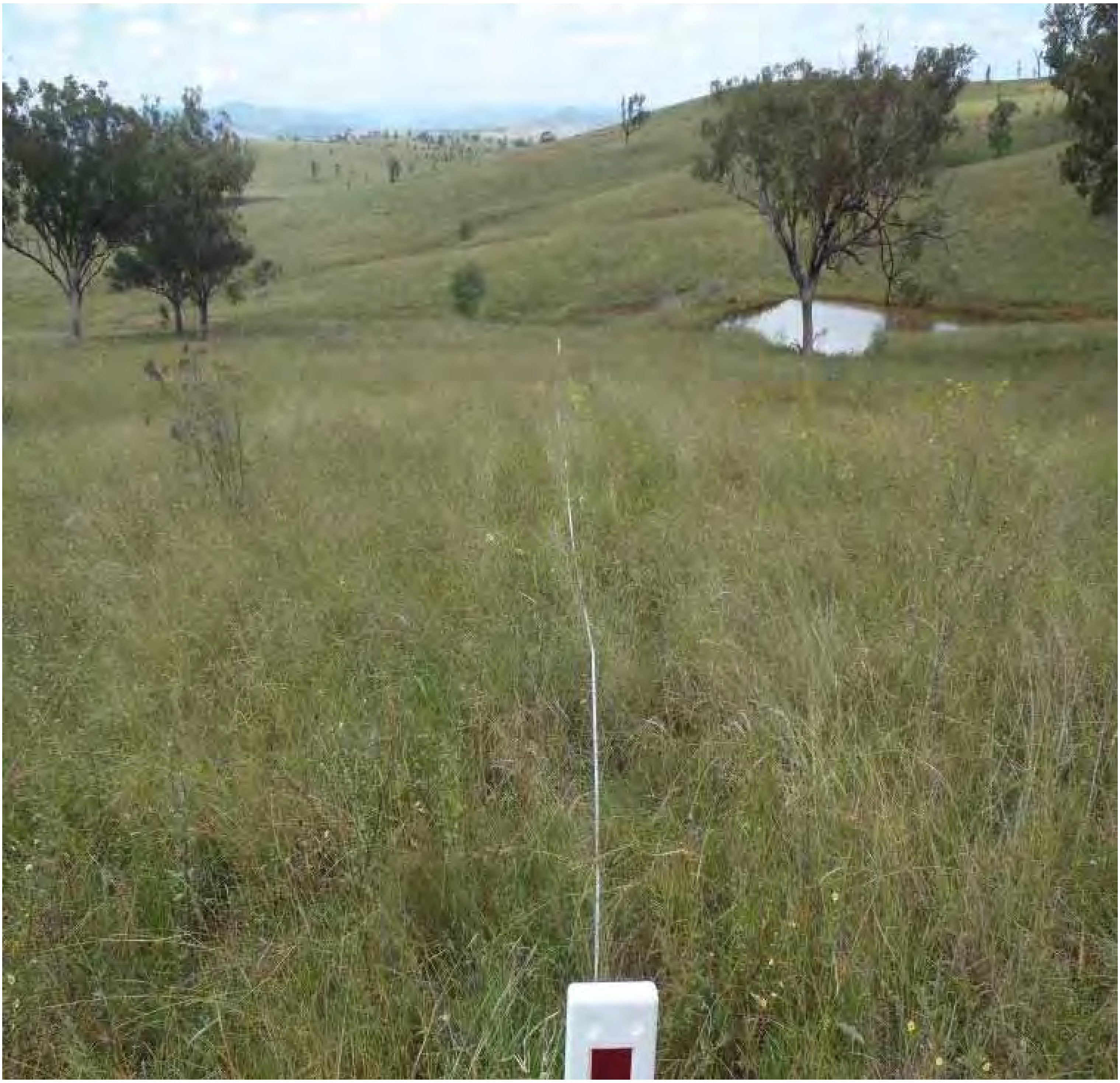
Appendix 7:

Rehabilitation Monitoring Report

Coal and Allied Operations Ltd
27-Mar-2015

Rehabilitation Monitoring - Grasslands / Pasture Lands

MTW and HVO Mine Sites, 2015



Rehabilitation Monitoring - Grasslands / Pasture Lands

MTW and HVO Mine Sites, 2015

Client: Coal and Allied Operations Ltd

ABN: 42 001 385 842

Prepared by

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27-Mar-2015

Job No.: 60340733

AECOM in Australia and New Zealand is certified to the latest version of ISO9001, ISO14001, AS/NZS4801 and OHSAS18001.

Quality Information

Document	Rehabilitation Monitoring - Grasslands / Pasture Lands
Ref	60340733
Date	27-Mar-2015
Prepared by	Matt Catteau
Reviewed by	Dee Murdoch (AECOM) and Neil Griffiths (NSW DPI)

Revision History

Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
B	27-Mar-2015	Final Report - Post Inclusion on Client feedback	James McIntyre Associate Director Environment	

Table of Contents

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1.0 Introduction

The Mount Thorley Warkworth (MTW) and Hunter Valley Operations North (HVO North) mine sites are located in the Hunter Valley of NSW, approximately 15 km southwest and 24 km northwest of Singleton, respectively. Both open cut operations are managed by Coal and Allied Operations Ltd (C&A) (which in turn is managed by Rio Tinto Coal Australia).

This report presents the results of the monitoring of post-mined rehabilitated pasture lands at MTW and HVO North (with one monitoring site located at HVO South) and associated reference / analogue sites, undertaken by AECOM Australia Pty Ltd (AECOM) in association with the NSW Department of Primary Industries (DPI) | Agriculture. Monitoring was undertaken between 23 February and 27 February 2015.

1.1 Report Structure

This report is structured as follows:

- Section 1.0 provides some background to rehabilitation monitoring at MTW and HVO and details the scope of works for this monitoring event;
- Section 2.0 outlines the methodology adopted for the selection of monitoring sites and for the field data collection programme;
- Section 3.0 presents the monitoring sites studied during this monitoring event;
- Section 4.0 presents the monitoring results;
- Section 5.0 provides an interpretation and discussion of the monitoring results; and
- Section 6.0 provides a summary of the monitoring key findings and lists some recommendations pertaining to rehabilitation performance and the monitoring programme.

1.2 Background to Rehabilitation Monitoring

Rehabilitation monitoring at MTW and HVO North is undertaken to satisfy the following regulatory obligations:

- Schedule 4 – Condition 70(h) of Development Consent DA-300-9-2002i (Warkworth mine);
- Schedule 3 – Condition 42(g) of Development Consent DA 34/95 (Mount Thorley mine);
- Schedule 4 – Condition 62C(j) of Development Consent DA 450-10-2003 (HVO North); and
- Commitments made in respective Mining Operations Plans (MOPs) for MTW and HVO North.

Rehabilitation activities at MTW and HVO North are generally divided into areas of post-mined lands being returned to either a native ecosystem or a grazing pasture (or grassland) final land use. A comprehensive rehabilitation monitoring methodology has been developed in a document titled "*Monitoring Methodology - Post-mined Lands, MTW and HVO North Mine Sites*" (AECOM, 2012), which details the suite of monitoring tools to be implemented to assess the performance of rehabilitated lands being returned to either land use type. Central to this monitoring methodology is the requirement to include relevant reference (or analogue) sites which will be used to inform target setting for rehabilitation performance criteria.

Independent rehabilitation monitoring in accordance with the current MOPs commitments had previously not been undertaken at either MTW or HVO North, and the programme of works implemented during this project initiated the long-term rehabilitation monitoring programme for these sites.

This initial monitoring event was solely focused on the monitoring and assessment of areas of grazing pasture, including post-mined rehabilitated sites and associated analogue sites. Comprehensive monitoring of all rehabilitated lands (i.e. inclusive of native ecosystem areas) is intended by C&A to be rolled out and undertaken later this year.

1.3 Scope of Works

The scope of works for this initial monitoring event included the following tasks:

1. Review of the current rehabilitation monitoring methodology (AECOM, 2012), specifically with regards to pasture monitoring to identify potential areas of improvement. This task was undertaken in collaboration with staff of the NSW DPI | Agriculture.
2. Background desktop research and GIS study to determine appropriate locations for relevant analogue sites on C&A owned land.
3. Field data collection programme at 16 monitoring sites and in accordance with the methodology as revised during Task 1. Monitoring sites included eight sites located on post-mined rehabilitated pasture lands (‘Rehabilitation Sites’) and eight analogue sites amongst those identified in Task 2 (‘Analogue Sites’).
4. Development and provision of a monitoring report covering all aspects of the field work and site assessment and including: data presentation and interpretation and a list recommendation measures developed with a view to improve rehabilitation performance where required (this report).

2.0 Methods

2.1 Monitoring Sites Selection

2.1.1 Rehabilitation Sites

Rehabilitation sites monitored during this project were chosen by C&A's Environmental Specialist – Rehabilitation, and selected to include sites with different slope, aspect and age since completion of rehabilitation activities.

Rehabilitation monitoring sites are presented in Section 3.0; they included two sites in areas of younger rehabilitation where pasture establishment was in progress, and six sites in areas of older rehabilitation where pasture ecosystems were well-established.

2.1.2 Analogue Sites

The use of analogue sites to set performance benchmarks for rehabilitation is widely recognised as an appropriate way to track rehabilitation progress and outcomes. The data collected and derived from the analogue sites accurately reflect the local environmental and biophysical conditions for a specific vegetation type, and as such can be used as target values / long term goals for the corresponding restored / rehabilitated vegetation community (Nichols, 2005).

The selection of pasture analogue sites for the monitoring programme was undertaken with consideration of the following:

- The rehabilitation objectives and commitments for both sites in terms of final landform and landuse – to ensure that the analogue sites are representative of what is trying to be achieved on post-mined rehabilitated lands; and
- To ensure that the suite of analogue sites making up the monitoring programme appropriately capture the range of environmental and biophysical conditions occurring in the region.

In order to determine suitable locations for analogue sites on C&A owned land, an overlay study was undertaken using GIS software and the following variables: soil type, land capability and the predicted extent of future mining (to ensure perpetuity of analogue sites).

- The soil type variable included the four dominant soil formations in the area, comprising Alluvial Soils, Brown Clays, Yellow Podzolic Soils and Solodic Soils (other soil types occurring within the study area but with very limited geographical extent/distribution were excluded).
- The land capability variable was divided into two categories, grouping land capability classes I to III on one hand (i.e. land capable of supporting cultivation and/or grazing), and land capability classes IV to VI on the other (i.e. land capable of supporting grazing only). Land capability classes VII and VIII were excluded as those lands are incapable of agricultural land use, and because no post-mining landforms will be rehabilitated to these lower capability classes at MTW and HVO.

Potential analogue site locations were identified to capture various combinations of the above variables, and further short-listed by C&A Environmental Specialist – Rehabilitation with insight from C&A Landcare Specialist to account for access issues and overall suitability. Analogue monitoring sites are presented in Section 3.0.

Other variables of relevance to the selection of appropriate analogue sites included slope and aspect. These could not be mapped due to absence of workable GIS layers. However, these variables were accounted for in the field when choosing the location for monitoring site establishment, with various slope steepness and orientation trying to be captured.

2.2 Field Data Collection Programme

2.2.1 Site Establishment

Each monitoring site consisted of a 50m linear transect with nested plots/quadrats along which Landscape Function Analysis (LFA) and groundcover assessments were undertaken. Transects were established in accordance with the monitoring methodology document (AECOM, 2012), as follows:

- Transect lines were directed directly downslope and aligned with the maximum slope (where possible);
- Transects were permanently located to facilitate repeated measurements over time;

- The start and end points of each transect were marked by flexi-posts, and their geographic coordinates recorded by GPS.

The Botanal assessment (refer to Section 2.2.3) was implemented within an approximately four to five hectare polygon around the LFA transect, using as far as possible landform or landscape landmarks as polygon boundaries (e.g. fences, tracks, tree lines, etc.). Polygons boundaries were mapped using a handheld GPS to facilitate repeated measurements over time.

2.2.2 Landscape Function Analysis

Landscape Function Analysis (LFA) was implemented at all monitoring sites and in accordance with the methods described in Tongway and Hindley (2004). The LFA assessment consists of the following components: landscape organisation characterisation, soil surface assessment and rill survey.

Landscape Organisation Characterisation

The objective of this task was to characterise and map the monitored sites in terms of the spatial pattern of resource loss or accumulation. The procedure involved collecting a continuous record of patch and inter-patch classification along the transect line, which was used as the base to derive the Landscape Organisation Index (LOI). The LOI is the proportion of the length of patch to the total length of the transect and reflects the heterogeneity of the landscape in terms of the distribution of ground cover and other deposited materials.

Soil Surface Assessment

The soil surface condition was assessed for each patch type identified along the transect. The assessment examined the status of surface processes at about the one metre scale, with rapidly assessed indicators identified at the coarse scale. The eleven surface condition features assessed are: percentage of rain splash protection; percentage of perennial vegetation cover; percentage of litter cover; percentage of cryptogam cover; crust brokenness; soil erosion type and severity; deposited materials; soil surface roughness; surface nature; slake test; and soil surface texture.

These eleven features are assigned a score, then are compiled and calculated into three Soil Surface Condition Indices (SSCIs) (scaled from 0–100) including:

- Stability Index: indicates the ability of the soil to withstand erosive forces and to reform following disturbance;
- Infiltration Index: defines how the soil partitions rainfall into soil-water (i.e. water available for plant use) and runoff water which is lost from the local system, and may also transport resources (e.g. soil, nutrients, seeds) away; and
- Nutrient Cycling Index: indicates how efficiently organic matter is cycled back into the soil.

Rill survey

In accordance with the LFA methodology (Tongway and Hindley, 2004), rill surveys are to be carried out where rills are observed at less than 30 m spacing across the slope.

None of the 16 monitoring sites were impacted by rill erosion at the time of the survey, and therefore no rill surveys were undertaken.

2.2.3 Botanal

The Botanal monitoring tool is not part of the current monitoring methodology document (AECOM, 2012), and was added to the monitoring programme following consultation with Mr Lester McCormick of NSW DPI Agriculture. Mr McCormick currently co-leads the ACARP study of the sustainability and profitability of grazing on mine rehabilitated land in the Upper Hunter, which uses the Botanal monitoring tool to assess the quality of pastures.

Botanal (Tothill et al 1992; Hargreaves and Kerr 1992; McDonald et al 1996) is a technique for the visual estimation of botanical composition and herbage mass of pastures. It was added to the rehabilitation monitoring programme as it provides the following benefits:

- A ‘whole-of-paddock’ vs. a fixed transect-based assessment. The technique covers a much wider sampling area than the transect approach and as such provides a more comprehensive and representative assessment of pasture performance, factoring the variability of pasture quality across individual paddocks.
- Ensuring that the monitoring of rehabilitation at MTW and HVO North is aligned to the latest research on pasture assessments, and consistent with other current studies.

- Obtaining practical data that allows the land manager to make inform decisions in terms of carrying capacity and stocking rates.

The Botanal tool is most useful to assess the quality of well-established pastures, and as such was not applied at those younger rehabilitated sites where pasture establishment was in progress. Botanal was applied at 14 sites, including the eight reference sites and the six rehabilitation sites with well-established pastures. Methods are outlined below.

Outline of Procedure

A total of 50 quadrats were sampled per site within the 4-5 ha Botanal study polygon. Sampling locations were randomly located by walking in zig-zag across the paddock and dropping the quadrat every 20 steps. Quadrats were 40cm x 40cm in size.

Measurements

At each sampling location, the following measurements were taken within the quadrat:

- **Botanical composition by dry-weight-rank** – records were taken at the species level. Species were ranked first, second or third according to their estimated contribution to dry pasture herbage mass (i.e. with contributions of approximately 70%, 21% and 9%, respectively). Estimates were improved by not relying solely on using single ranks (i.e. only allocating 1, 2, or 3). If one species was dominant (e.g. > 85% of the quadrat dry-weight), a cumulative ranking was used, giving it both a first and second rank. If species have similar dry weights then ties are used. When species are tied, the ranks are divided equally between them. For example, if two species are tied for first, they each receive 0.5 for first and 0.5 for second (0.33 for three ties).
- **Herbage mass** – a visual estimate was made of total herbage mass, green herbage mass and dry herbage mass in kg DM/ha. This value was later corrected using the estimated and actual values from the calibration quadrats.
- **Groundcover** – a visual estimate was made of protective ground cover percentage within the quadrat.

Calibration Quadrats

Calibration quadrats are required to relate estimated and actual values of herbage mass and percent green. Before sampling commenced at each monitoring site, observers selected two calibration quadrats to represent high and low biomass for the paddock (i.e. rehabilitation polygon). The observers then together examined and estimated the range of herbage mass (total, green and dry) at the two selected calibration quadrats. During the calibration process observers agreed on species and compared estimates to ensure that they are following the correct procedures.

Calibration quadrats were then harvested to ground level using electric shears, stored in paper bags and taken to the Orange laboratory for processing as follows:

- All samples were dried for 48 hours at ~70-80°C using dehydrators.
- Following drying, samples were separated into green and dead material, and both fractions were weighed using a digital scale.

These data were then used to develop a regression for each observer relating estimated against actual data. Each regression equation was then applied to each quadrat observation to determine a value for herbage mass and percent green. These values were finally meaned to obtain an overall paddock (i.e. rehabilitation polygon) value.

Data processing

All Botanal data (i.e. field observations and calibration cuts data) were input and processed into the Botanal software to derive the following outputs:

- Total herbage, and green and dead herbage values;
- Herbage composition; and
- Ground cover.

2.2.4 Ground Cover

At the two younger rehabilitation sites where Botanal was not implemented, a rapid ground cover assessment was undertaken. At every 5 m intervals along the 50 m transect line (for a total of 10 sampling points per transect), the following information was visually assessed and recorded in 1 m^2 quadrats:

- The percentage cover of protective ground cover components (including dead and live plant material, litter, cryptograms, rocks >5cm and coarse woody debris);
- The percentage cover of bare ground; and
- The percentage cover of weeds.

At each sampling point, percentage cover was visually estimated to the nearest 10% using a 1 x 1 m frame. The overall percentage cover for the site was calculated by averaging results from all ten sampling points.

This assessment was not conducted at the older, well-established pasture sites as the relevant information was captured through Botanal.

2.2.5 Forage Quality – Feed Analysis

Forage quality was determined for all well-established pasture sites (i.e. all reference sites and at the six four older rehabilitated pasture sites). Pasture sampling was undertaken generally in accordance with the monitoring methodology document (AECOM, 2012), which recommends the guidelines provided by the by the NSW DPI for pasture sampling (‘*Collection technique guidelines – Form Collect1-Version No.2-01/11/07*’, 2007).

Sampling was undertaken at random by taking between 15 and 20 ‘grab’ samples at grazing height across the Botanal polygon study area. All ‘grabs’ were combined into a bucket and mixed well. The green fraction of the sample was then immediately separated from the dead fraction whilst in the field, and both sub-samples stored in plastic zip-lock bags in a cooled iced box (and subsequently in a fridge at the end of the working day). At completion of the field survey programme, all samples were wrapped in newspaper (to minimise thawing and sample degradation) and sent to the Wagga Wagga Agricultural Institute for feed quality testing using overnight courier. The Wagga Wagga Agricultural Institute is operated by the NSW DPI and is fully accredited by NATA. Samples were tested for the parameters defined in Table 1.

The feed quality results were then combined to the Botanal data (i.e. total green and dead herbage mass) to determine the amount of feed available, and derive potential carrying capacities and stocking rates for the sampled areas based on the NSW DPI’s ‘*Beef stocking rates and farm size – Hunter Region*’ (2006).

Table 1 Feed analysis parameters

Parameter	Unit	Definition
Dry matter content (DM)	%	‘Dry Matter’ is everything remaining after all the water in the sample has been removed. DM contains the energy, proteins, vitamins and minerals required by animals for maintenance and production.
Dry matter digestibility (DMD)	% of DM	DMD is the proportion of the DM in a feed that can be digested by an animal.
Organic matter content (OM)	% of DM	OM is everything present in a feed except ash.
Dry organic matter digestibility (DOMD)	% of DM	DOMC is the proportion of the organic matter in the dry matter that can be digested by an animal.
Crude protein content (CP)	% of DM	CP is the proportion of protein and non-protein nitrogen in the feed.
Fibre content	% of DM	Fibre is the structural part of plants and feeds, consisting mainly of compounds called hemicellulose, cellulose and lignin.
Metabolisable energy (ME)	MJ ME/kg DM	ME is the amount of energy in a feed that is available to an animal to utilise for maintenance, production and reproduction.

2.2.6 Soil Sampling and Analyses

Soil sampling was undertaken at all the monitoring sites, and carried out in accordance with the guidelines detailed in the monitoring methodology (AECOM, 2012). The samples were taken from the top 100 mm of the topsoil layer using a hand held spade. Each sample consisted of a bulk sample of 7 to 9 subsamples collected from an area within a 20 m radius around the starting point of the LFA monitoring transect, with subsamples collected 10 to 15 m apart.

All samples were placed in strong plastic zip-lock bags, labelled and sent via courier to the NATA-accredited SESL laboratory for testing of the following parameters: pH and electrical conductivity, nutrients as available to plants (including Nitrate, Phosphate, Potassium, Sulphur, Calcium and Magnesium), cation balance, organic matter and organic carbon contents and trace metals.

2.2.7 Photographic Monitoring

Photographic monitoring was undertaken at all monitoring sites and in accordance with the monitoring methodology (AECOM, 2012). At each monitoring site three photographs were taken from the permanent star pickets located at the start and end of the LFA monitoring transect, looking in the direction of the transect line. Once the 50m tape was laid between the two star pickets, the following photographs were taken[1]:

- A photograph to the left of the tape (with the tape just in the frame in the far right);
- A photograph with the tape (and star picket) in the centre of the frame; and
- A photograph to the right of the tape (with the tape just in the frame in the far left).

2.3 Weather

Temperatures and rainfall in the four months preceding the field monitoring period are listed in Table 2.

Conditions during the field surveys were dry and hot, with high humidity levels. Low rainfall occurred overnight between 27th and 28th February (3.8 mm). Daily temperatures ranged from 19°C and 32°C.

Most plants were at the flowering growth phase at the time of monitoring, facilitating species identification and providing optimal conditions for Botanal data collection.

Table 2 **Weather conditions preceding and during the monitoring period (BoM Station # 061397)**

Month	Actual monthly mean			Historical average (2003-2014)		
	Min Temp (°C)	Max Temp (°C)	Rainfall (mm)	Min Temp (°C)	Max Temp (°C)	Rainfall (mm)
Oct-14	10.7	27.9	35.4	9.9	26.2	44.7
Nov-14	15.7	31.9	18.0	14.0	28.8	83.6
Dec-14	18.3	30.3	143.2	15.6	29.8	70.3
Jan-15	18.4	30.0	160.4	17.7	31.8	59.2
Feb-15#	17.7	29.5	18.6	17.5	30.2	98.5

 # includes data up to 26 February 2015.

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[1] Camera zoom lens settings was zero

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3.0 Monitoring Sites

3.1 Rehabilitation Sites

The rehabilitation monitoring sites studied during this monitoring event are listed in Table 3, with their location shown in

Figure 1 a (for HVO sites) and Figure 1 b (for MTW sites). For each rehabilitation monitoring site, the location of the LFA monitoring transect and of the Botanal study polygon are presented in Figure 2 a.

Cattle grazing had only been undertaken at ‘RHB_HVON_Carrington’ and RHB_WML_TD1 monitoring sites, the other rehabilitation sites had not been used for cattle grazing.

Table 3 Rehabilitation monitoring sites

Site name	Location	Coordinates *(GDA 94 zone 56)*		Type	Slope	Aspect	Age
		Easting	Northing				
RHB_HVON_Carrington	HVO North	309,568	6,404,407	Established exotic pasture	Flat	n/a[#]	8 yrs
RHB_HVOS_Riverview	HVO South	313,333	6,398,562	In progress exotic pasture	~2%	SSE	2 yrs
RHB_HVOW_Plane_Dump	HVO West	309,942	6,412,113	Established exotic pasture	~20%	NW	32 yrs
RHB_HVOW_Wilton	HVO West	306,305	6,407,394	Established exotic pasture	~16%	NW	20 yrs
RHB_MTO_North_Dump	Mt Thorley	320,950	6,387,294	Established exotic pasture	~10%	E	21 yrs
RHB_MTO_South_CHPP	Mt Thorley	322,923	6,386,334	Established exotic pasture	~20%	E	25 yrs
RHB_WML_Swanlake	Warkworth	319,231	6,391,585	In progress native pasture	~12%	N	2 yrs
RHB_WML_TD1	Warkworth	319,200	6,393,220	Established exotic pasture	~20%	N	22 yrs

[#] *Aspect is irrelevant on a flat landform*

3.2 Analogue Sites

A total of 22 potential locations for analogue sites were identified by the GIS overlay study, with various characteristics of land capability class and soil type. From these 22 locations, eight sites were short-listed by C&A’s Environmental Specialist – Rehabilitation for inclusion in this year’s programme of works. These are presented in Table 4, and their location shown in (for sites located on HVO land) and Figure 1 b (for sites located on MTW land). For each analogue monitoring site, the location of the LFA monitoring transect and of the Botanal study polygon are presented in Figure 2 b.

Table 4 Analogue monitoring sites

Site name	Coordinates *(GDA 94 zone 56)*		Soil type	Land Capability Class	Slope	Aspect
	Easting	Northing				
ANA_Carrington_Billabong	309,661	6,402,406	Alluvials	I-III	Flat	n/a
ANA_Cheshunt	314,650	6,403,102	Alluvials	I-III	Flat	n/a
ANA_Lemington_Rd	306,986	6,403,518	Brown Clays	I-III	~6-7%	NE
ANA_Howick	308,227	6,411,597	Soloth / Solodic	IV-VI	~12%	ENE
ANA_Parnells	306,188	6,408,198	Soloth / Solodic	IV-VI	~4-5%	S

Site name	Coordinates *(GDA 94 zone 56)*		Soil type	Land Capability Class	Slope	Aspect
	Easting	Northing				
ANA_Knodlers_Lane	318,746	6,397,496	Yellow Podzolic	IV-VI	~1-2%	N
ANA_Newport	316,464	6,385,985	Yellow Podzolic	IV-VI	~5%	S
ANA_North_CHPP	321,232	6,390,970	Yellow Podzolic	IV-VI	Flat	n/a

Figure 1 a **Rehabilitation monitoring programme – Monitoring sites locations, HVO**

Figure 1 b **Rehabilitation monitoring programme – Monitoring sites locations, MTW**

Figure 2 a **Rehabilitation monitoring sites – LFA transect and Botanal study polygon location**

Figure 2 b **Analogue monitoring sites – LFA transect and Botanal study polygon location**

Monitoring sites

- Λ Analogue
- Λ Rehabilitation
- ▭ Analogue Polygon (approx)
- ▭ Rehabilitation Polygon

Soil Type

- ■ Brown Clays
- ■ Soloths/Solodic
- ■ Yellow Podzolic
- ■ Alluvials

Land Capability Class

- ▨ I to III
- ▩ IV to VI

Monitoring Sites Locations - HVO
Rehabilitation Monitoring Programme 2015
Source: RTCA (2014), AECOM (2015)
0 250500 1,000
Metres

MAR 2015
60340733
Fig. **1a**

AECOM

Monitoring sites

Analogue

Rehabilitation

Analogue Polygon (approx)

Rehabilitation Polygon

Soil Type

🟫	Brown Clays
🟪	Soloths/Solodic
🟨	Yellow Podzolic
🟦	Alluvials

Land Capability Class

▨	I to III
▩	IV to VI

Monitoring Sites Locations - MTW

Rehabilitation Monitoring Programme 2015

Source: RTCA (2014), AECOM (2015)

0 250 500 1,000 Metres

MAR 2015

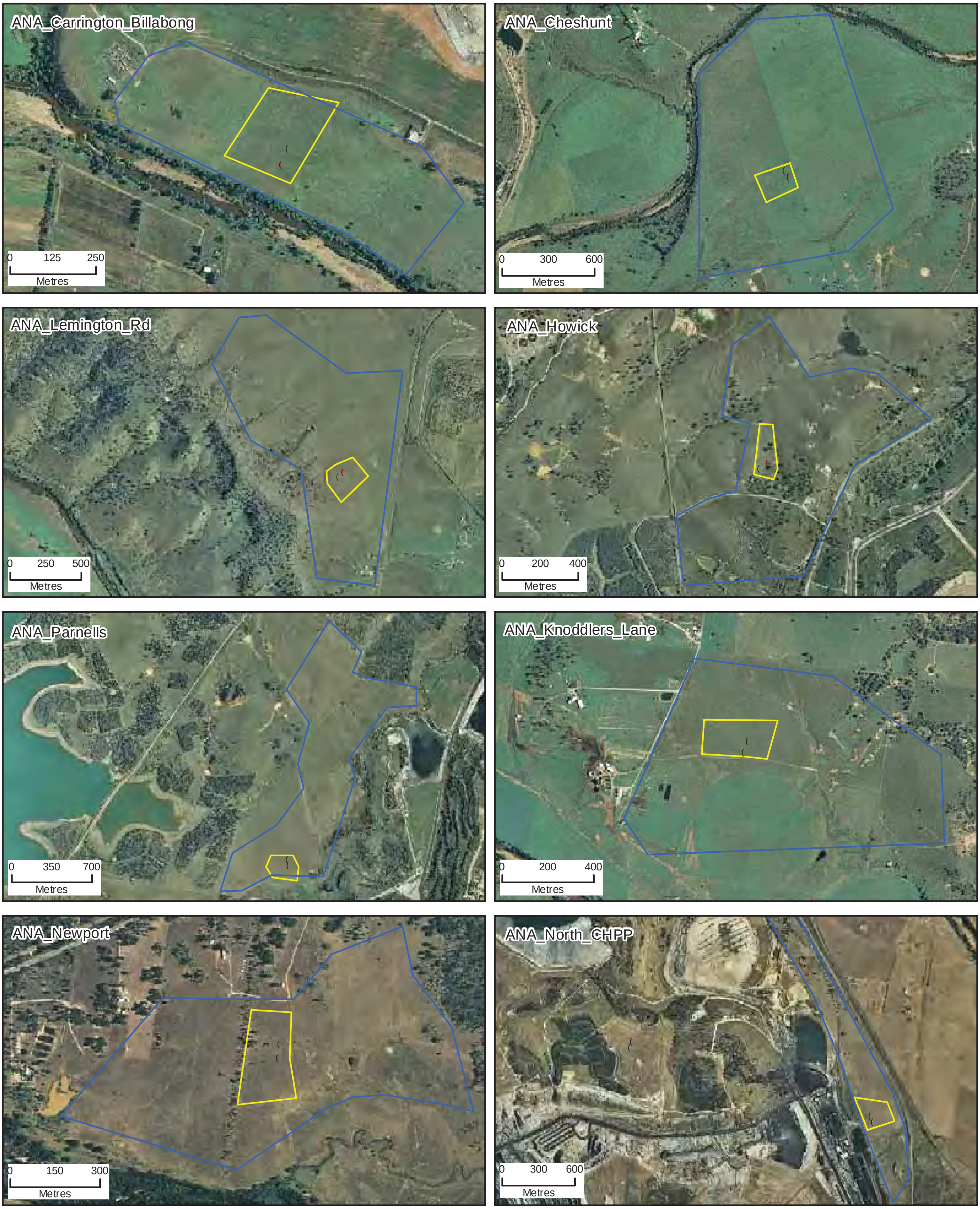
60340733

Fig. **1b**

🟩 Rehabilitation Polygon
🟨 Botanal Study Area
(LFA Transect End
(LFA Transect Start

Rehabilitation monitoring sites:
LFA transects and Botanal study area location
Rehabilitation Monitoring Programme 2015
Source: RTCA (2014), AECOM (2015)

MAR 2015
60340733
Fig. **2a**



🟦	Analogue Polygon (approx)	(	LFA Transect End
🟨	Botanal Study Area	(	LFA Transect Start

Analogue monitoring sites:
LFA transects and Botanal study area location
Rehabilitation Monitoring Programme 2015
Source: RTCA (2014), AECOM (2015)

MAR 2015
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Fig. **2b**

4.0 Monitoring Results

4.1 Landscape Function Analysis

The LFA results obtained at the 16 monitoring sites are summarised in Table 5, with the soil surface condition indices graphed in Figure 3.

Table 5 LFA monitoring results

Monitoring site		Landscape Organisation Index (LOI)	Soil surface condition indices		
			Stability	Infiltration	Nutrient cycling
Rehabilitation sites	RHB_HVON_Carrington	1.00	65.6	29.3	25.6
	RHB_HVOS_Riverview	1.00	67.2	28.0	26.6
	RHB_HVOW_Plane_Dump	1.00	66.3	32.3	28.7
	RHB_HVOW_Wilton	1.00	67.3	39.8	31.7
	RHB_MTO_North_Dump	0.98	64.7	33.3	25.8
	RHB_MTO_South_CHPP	1.0	66.3	31.1	25.1
	RHB_WML_Swanlake	0.93	60.4	30.8	22.6
	RHB_WML_TD1	0.97	66.8	34.7	30.0
Analogue sites	ANA_Carrington_Billabong	1.00	69.2	32.5	27.7
	ANA_Cheshunt	1.00	68.8	30.0	24.9
	ANA_Lemington_Rd	1.00	63.8	31.5	25.6
	ANA_Howick	1.00	66.9	36.8	30.7
	ANA_Parnells	1.00	67.2	37.3	30.7
	ANA_Knodlers_Lane	1.00	65.0	31.6	26.1
	ANA_Newport	1.00	63.8	29.4	24.1
	ANA_North_CHPP	1.00	65.6	32.2	25.6

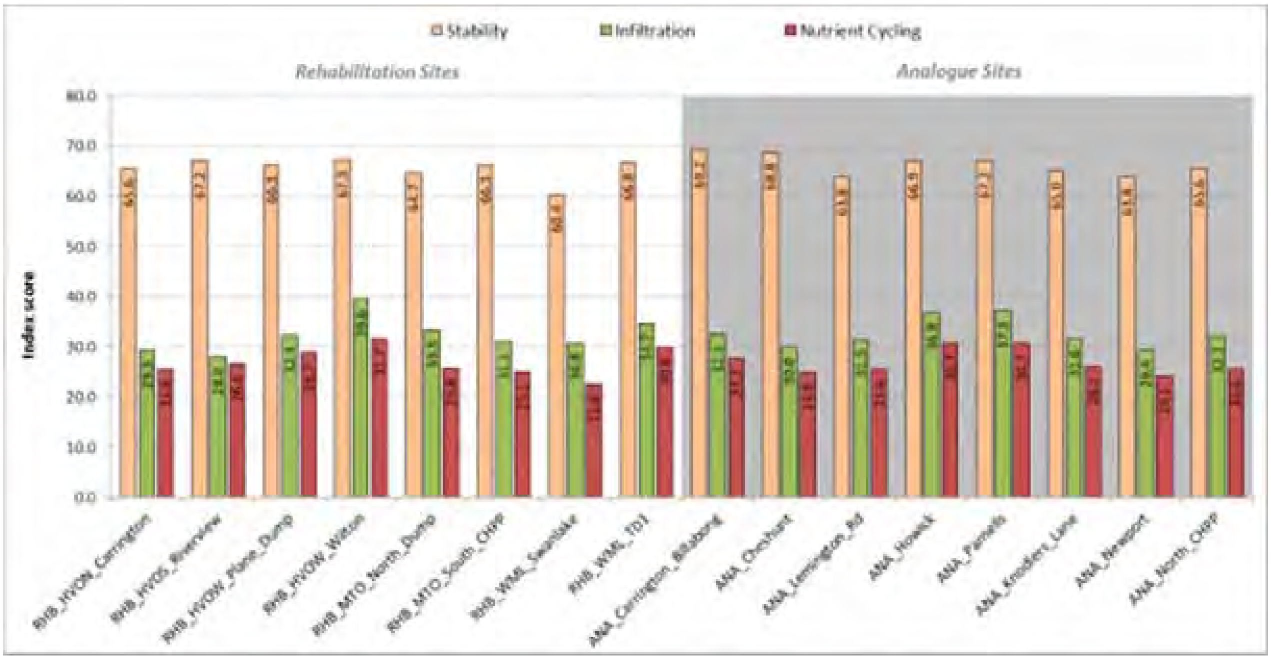

Figure 3 LFA monitoring results – Soil surface condition indices

4.2 Botanal

4.2.1 Herbage Mass

Botanal results for herbage mass (expressed in kg of Dry Matter (DM) per hectare) at each monitoring site are presented in Figure 4, which also shows the proportions of dead herbage and green herbage (by weight) making up the total herbage mass for each site.

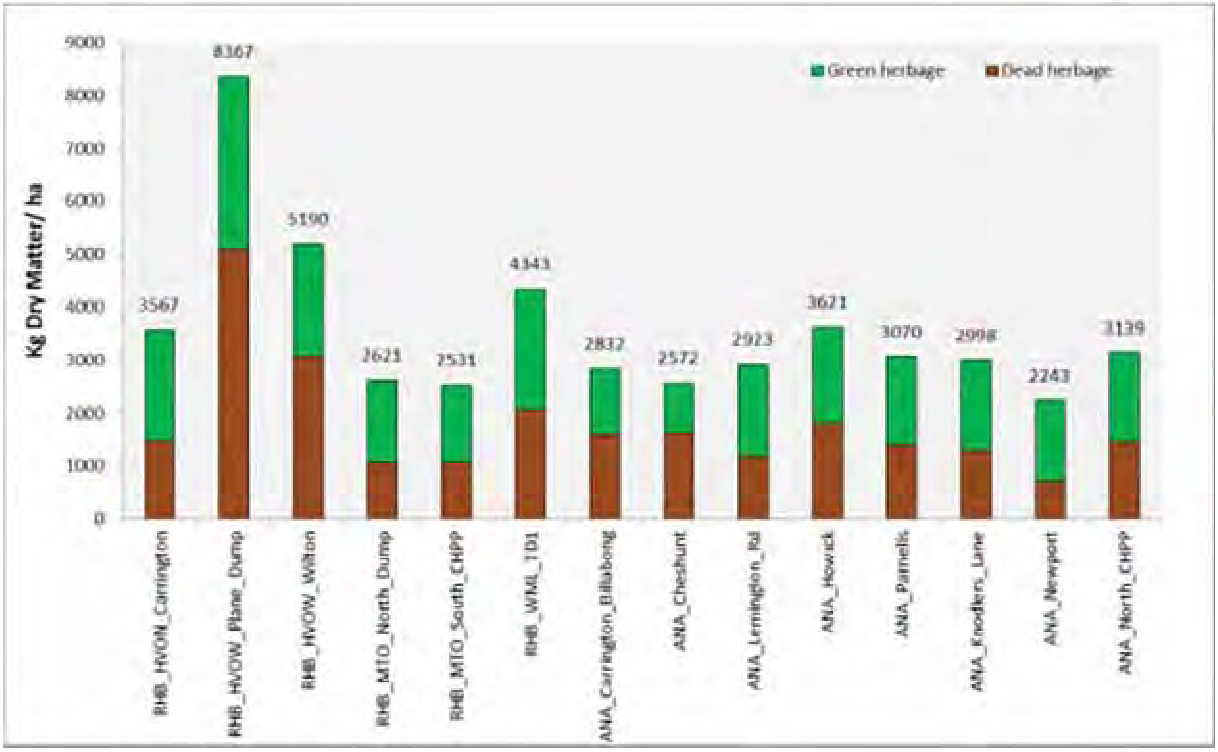

Figure 4 **Botanal monitoring results – Herbage mass**

4.2.2 Herbage Composition

Botanal results for herbage species composition (as a proportion of overall species diversity) are listed in Table 6 and presented graphically in Figure 5. The contribution of each species to the total herbage mas for each site is graphed in Figure 6.

Table 6 **Botanal monitoring results – Herbage composition (percentage)**

Monitoring site	Red Grass	Qld Bluegrass	Rat's Tail Grass	Rhodes Grass	Panic Grass	OPG# C3[2]	OPG C4[1]	Legumes	Broadleaf weeds	Native forbs	Annual Grasses	Others	Total
RHB_HVON_Carrington	0	0	0	54	33	0	7	0	5	0	0	0	100
RHB_HVOW_Plane_Dump	0	0	0	94	5	0	0	0	0	0	0	0	100
RHB_HVOW_Wilton	0	0	0	98	0	0	0	0	2	0	0	0	100

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[2] Native perennial grasses can be classified as either C3 or C4 plants, referring of the different pathways that plants use to capture carbon dioxide during photosynthesis. C3 plants are adapted to cool season establishment and growth in either wet or dry environments. On the other hand, C4 plants are more adapted to warm or hot seasonal conditions under moist or dry environments. A feature of C3 grasses is their greater tolerance of frost compared to C4 grasses. C3 species also tend to generate less bulk than C4 species; however, feed quality is often higher than C4 grasses (NSW DPI, non-dated).

Monitoring site	Red Grass	Qld Bluegrass	Rat's Tail Grass	Rhodes Grass	Panic Grass	OPG$^{\#}$ C3^{2}	OPG C4^{1}	Legumes	Broadleaf weeds	Native forbs	Annual Grasses	Others	Total
RHB_MTO_North_Dump	2	0	1	82	0	0	10	1	2	0	1	1	100
RHB_MTO_South_CHPP	35	1	6	6	2	0	34	2	12	2	1	1	100
RHB_WML_TD1	0	0	0	99	0	0	0	0	1	0	0	0	100
ANA_Carrington_Billabong	0	0	1	11	0	0	54	0	3	0	30	0	100
ANA_Cheshunt	0	0	0	0	0	0	25	0	11	0	64	0	100
ANA_Lemington_Rd	57	12	8	0	0	7	12	1	1	1	0	0	100
ANA_Howick	8	2	8	0	0	0	60	0	10	0	7	3	100
ANA_Parnells	14	4	53	0	0	1	20	1	4	0	1	1	100
ANA_Knodlers_Lane	3	1	43	0	0	0	44	0	2	1	5	1	100
ANA_Newport	31	2	30	0	0	0	20	0	2	14	1	1	100
ANA_North_CHPP	0	2	16	60	0	0	9	0	0	0	12	1	100

Key: $^{\#}$ *OPG = Other Perennial Grasses*

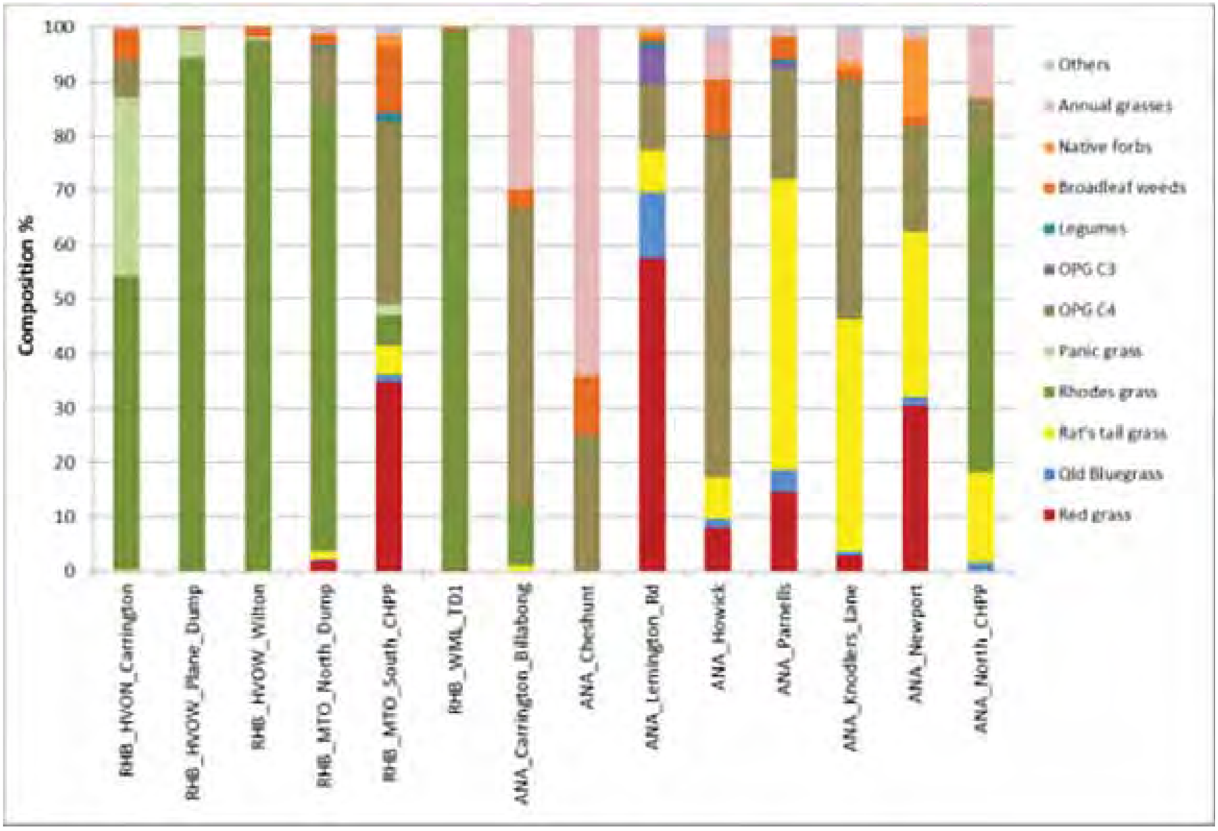

Figure 5 Botanal monitoring results – Herbage composition (percentage)

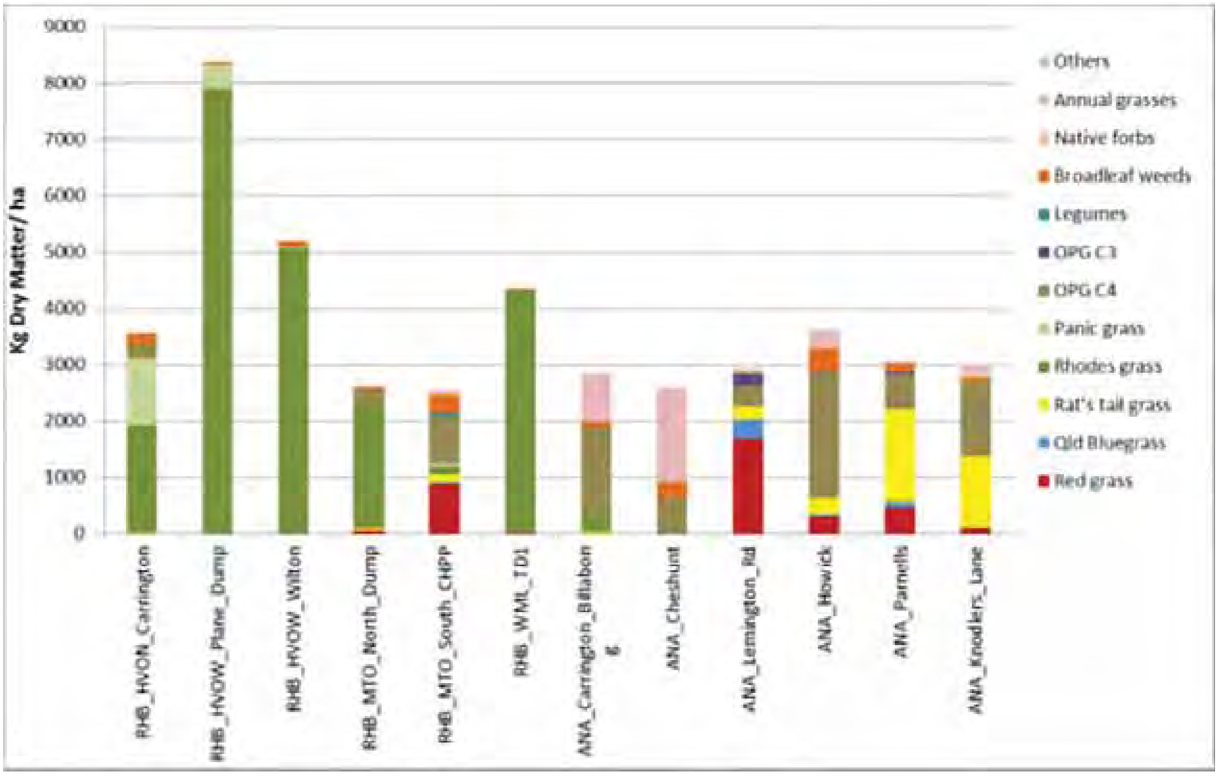

Figure 6 **Botanal monitoring results – Herbage composition (contribution to total herbage mass)**

4.3 Ground Cover

The ground cover performance of the younger rehabilitated pasture sites (assessed along the 50m linear transect) is shown in Figure 7. The ground cover results for the established rehabilitated pastures and the analogue sites (as assessed during Botanal) are graphed in Figure 8.

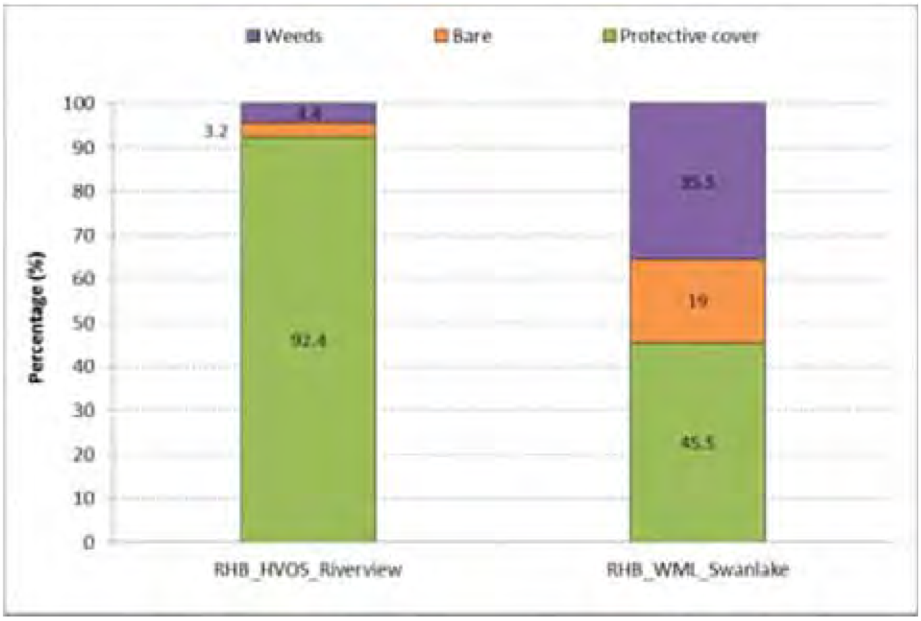

Figure 7 **Groundcover monitoring results – young rehabilitation sites**

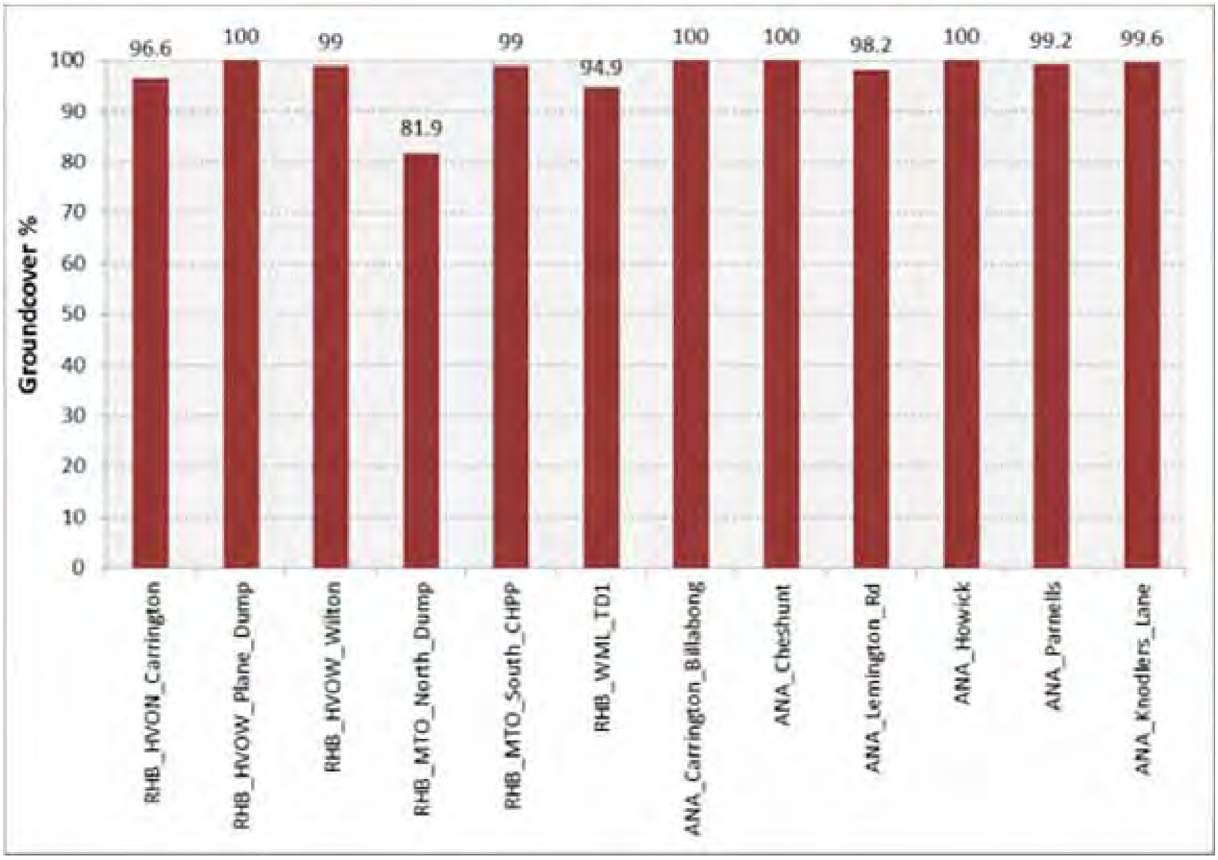

Figure 8 Groundcover monitoring results (Botanal) – Established pastures and analogue sites

4.4 Forage Quality – Feed Analysis

The feed analysis results have been summarised in Table 7, which includes the feed quality of both the green and dead components of the herbage at each monitoring site. Detailed results as provided by the laboratory are included in Appendix a.

Table 7 Feed analysis monitoring results

Monitoring site	Fraction	% of total herbage mass	DMD (%)	OM (%)	DOMD (%)	CP (%)	ME (MJ / kg DM)
RHB_HVON_Carrington	Green	58.6	60.0	90.0	58.0	7.5	8.7
	Dead	41.4	50.0	89.0	49.0	4.7	6.9
RHB_HVOW_Plane_Dump	Green	39.1	60.0	88.0	58.0	10.3	8.7
	Dead	60.9	43.0	85.9	43.0	6.9	5.7
RHB_HVOW_Wilton	Green	40.6	53.0	90.0	52.0	6.7	7.5
	Dead	59.4	46.0	91.0	46.0	3.9	6.2
RHB_MTO_North_Dump	Green	50.9	61.0	91.0	58.0	4.3	8.9
	Dead	41.0	46.0	88.0	46.0	0.1	6.2
RHB_MTO_South_CHPP	Green	57.6	58.0	91.0	56.0	7.9	8.4
	Dead	42.4	43.0	90.0	43.0	3.1	5.7
RHB_WML_TD1	Green	52.5	57.0	91.0	55.0	6.0	8.2
	Dead	47.5	45.0	88.0	45.0	2.1	6.1

Monitoring site	Fraction	% of total herbage mass	DMD (%)	OM (%)	DOMD (%)	CP (%)	ME (MJ / kg DM)
ANA_Carrington_Billabong	Green	43.3	64.0	91.0	61.0	6.4	9.4
	Dead	56.7	48.0	89.0	47.0	3.0	6.6
ANA_Cheshunt	Green	36.7	63.0	91.0	60.0	5.5	9.3
	Dead	63.3	52.0	87.0	54.0	3.9	7.6
ANA_Lemington_Rd	Green	59.1	65.0	90.0	62.0	6.2	9.6
	Dead	40.9	50.0	87.0	49.0	4.5	6.9
ANA_Howick	Green	50.2	61.0	91.0	59.0	10.8	9.0
	Dead	49.8	41.0	91.0	42.0	5.1	5.5
ANA_Parnells	Green	54.5	62.0	90.0	59.0	11.4	9.1
	Dead	45.5	46.0	90.0	46.0	6.1	6.3
ANA_Knodlers_Lane	Green	56.9	57.0	92.0	55.0	6.5	8.2
	Dead	43.1	44.0	91.0	44.0	9.0	6.0
ANA_Newport	Green	67.7	59.0	91.0	57.0	6.1	8.6
	Dead	32.3	47.0	89.0	47.0	0.1	6.5
ANA_North_CHPP	Green	53.8	55.0	90.0	54.0	4.0	7.9
	Dead	46.2	48.0	89.0	47.0	0.1	6.5

4.5 Soil Analyses

The results of the soil analyses for key soil chemistry parameters are summarised in Table 8[3] (overleaf). Note that Table 8 only includes a summary of the most significant indicators of soil condition. The analyses results for the biosolids profile (i.e. trace metals/contaminants) have not been listed in Table 8 as results were generally very low for all elements and no restrictions to rehabilitation were noted.

For reference, the detailed results as provided by SESL are included in Appendix b.

4.6 Photographic Monitoring

The results of the photographic monitoring (i.e. photos taken from the start and end points of the monitoring transects) have been included in Appendix c.

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[3] It is noted that the testing methodologies used by SESL for major nutrient analyses were not the standard methods used for the assessment of growing media in NSW pastures. This is especially important for phosphorous (P) and sulphur (S) which are the two main limiting nutrients in NSW pastures. SESL used the Mehlich testing method for these nutrients whereas for soils in the Hunter Region P should be tested using the Colwell test method and S using the KCl40 test method. However and as far as possible, relevant conversions of P and S levels from Mehlich results to Colwell / KCl40 have been made throughout the discussion sections of this report.

Table 8 **Soil analyses monitoring results**

Monitoring Site	pH ($CaCl_2$)	EC (dS/m)	Exchangeable cation percentage (%)				eCEC (me/100g)	Ca/Mg	OC (%)	Plants available nutrients (mg/kg)		
			Na	K	Ca	Mg				N (NO_3)	P (PO_4)	S (SO_4)
RHB_HVON_Carrington	6.2	0.07	2.4	5.8	48.0	43.8	16.5	1.1	3.1	2.0	29.7	8.9
RHB_HVOS_Riverview	6.6	0.09	1.6	5.6	71.0	21.7	16.3	3.3	3.0	0.6	103.8	18.0
RHB_HVOW_Plane_Dump	7.0	0.1	0.6	5.5	51.3	42.9	20.0	1.2	3.8	2.0	21.9	11.0
RHB_HVOW_Wilton	6.2	0.93	2.5	2.9	43.1	51.6	26.1	0.8	3.3	5.2	31.9	894.0
RHB_MTO_North_Dump	7.0	0.38	11.6	4.3	39.1	45.0	23.2	0.9	5.3	2.1	51.0	157.0
RHB_MTO_South_CHPP	6.4	0.4	5.7	4.3	50.5	39.7	16.7	1.3	3.8	2.3	30.4	155.0
RHB_WML_Swanlake	7.0	0.26	3.7	3.6	64.8	27.7	17.2	2.3	3.4	1.1	16.8	121.0
RHB_WML_TD1	6.0	0.09	1.4	6.3	46.1	46.2	15.7	1.0	5.3	5.5	42.2	12.0
ANA_Carrington_Billabong	5.7	0.08	0.6	4.9	55.8	38.5	29.8	1.4	4.8	3.9	67.4	12.0
ANA_Cheshunt	6.1	0.09	0.6	4.0	59.7	35.7	28.6	1.7	4.0	4.9	77.0	9.5
ANA_Lemington_Rd	6.9	0.18	0.3	2.1	81.8	15.9	56.8	5.1	4.1	3.1	6.7	12.0
ANA_Howick	5.8	0.08	1.4	7.2	52.7	38.5	20.5	1.4	5.1	6.1	8.4	11.0
ANA_Parnells	5.4	0.06	2.8	7.8	57.4	31.8	15.4	1.8	3.9	5.1	5.9	10.0
ANA_Knodlers_Lane	4.9	0.05	1.0	9.0	26.4	18.6	7.0	1.4	2.4	2.1	12.4	12.0
ANA_Newport	5.4	0.07	4.1	6.5	32.6	56.8	14.3	0.6	2.5	1.8	8.6	10.0
ANA_North_CHPP	5.6	0.1	7.9	3.8	36.1	52.2	18.9	0.7	4.9	3.7	30.2	13.0

Keys: EC – Electrical Conductivity; Na – Sodium; K – Potassium; Ca – Calcium; Mg – Magnesium; eCEC – Effective Cation Exchange Capacity; OM – Organic Matter; OC – Organic Carbon; N (NO_3) – Nitrogen as Nitrates; P (PO_4) – Phosphorous as Phosphates; S (SO_4) – Sulphur as Sulphates.

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5.0 Discussion

It is noted that the discussion of the monitoring results undertaken in the following sections is primarily oriented towards the performance of the rehabilitation sites and how it compares against the benchmarks set at the corresponding analogue sites.

5.1 Landscape Function (Including Ground Cover)

Landscape function performance showed overall consistency across all monitoring sites, and the results obtained at all rehabilitation sites generally compared positively with those of the analogue sites. For reference, Table 9 lists the desired benchmarks for landscape function indices for rehabilitated mine sites. The benchmark values have been derived from Tongway and Hindley (2003) and CSIRO (2008), and adapted based on the index scores obtained for the analogue sites.

Table 9 Benchmarks for Landscape Function Indices

Rating	LOI	Stability Index	Infiltration Index	Nutrient Cycling Index
Excellent	>0.9	65+	35+	30+
Good	0.7-0.9	60-65	30-35	25-30
Satisfactory	0.5-0.7	50-60	25-30	20-25
Poor	0.3-0.5	40-50	20-25	15-20
Very poor	<0.3	<40	<20	<15

5.1.1 Landscape Organisation

The LOI values for all rehabilitation sites were very high and comprised between 0.93 and 1.0 (with five of the eight sites achieving a LOI score of 1.0) – where all analogue sites returned a LOI value of 1.0. The LOI is a measure of the number of obstructions per unit area of the transect, and the direct reflection of the amount of protective ground cover present. As such, the scores obtained were driven by the high levels of vegetation cover (and little bare ground) observed across the monitoring sites.

Protective ground cover was greater than 80% at all sites, and greater than 90% at six of the rehabilitation sites – which is consistent with groundcover levels observed at the analogue sites. The lowest ground cover scores were recorded at the ‘RHB_WML_Swanlake’ and ‘RHB_MTO_North_Dump’ monitoring sites with approximately 81-82% cover. It is noted that a high weed cover (principally of Hedge Mustard – *Sisymbrium officinale*) at ‘RHB_WML_Swanlake’ largely contributed to the protective ground cover score at this site (accounted for ~35.5% of the total protective ground cover), and therefore its groundcover performance may temporarily drop if weed suppression and control is implemented. However pasture establishment at this site was in progress and vegetation community composition irrelevant at this stage of monitoring.

Groundcover results were well correlated to LOI scores, with the lowest ground cover scores recorded at these three sites where a LOI value of 1.0 was not achieved.

Overall, vegetative cover was excellent and well above 70% at all sites, which can be considered a benchmark value in NSW for the minimum pasture cover required for soil protection, for efficient capture and use of rainfall and nutrients, and for sustainable long-term production (Lang, 1998).

5.1.2 Soil Surface Condition

Overall, the soil surface condition index scores were very consistent across all rehabilitation sites and generally comprised in the ‘good’ to ‘excellent’ range of values (refer to Table 9), indicating that all sites performed positively against the benchmarks set by the analogue sites.

Stability

Soil stability at all sites was largely promoted by the high ground cover provided by perennial grasses, and the relatively stable nature of the soil fragments as determined during the slake test field assessment. Stability indices at most rehabilitation sites were within the ‘excellent’ range of values (i.e. ≥65%, refer to Table 9), with only ‘RHB_MTO_North_Dump’ and ‘RHB_WML_Swanlake’ returning indices falling within the ‘good’ range of values (i.e. 60-65%), which correlates well with these two sites also having the lowest ground cover percentage as discussed above. Overall, all rehabilitation sites were stable with no signs of active erosion observed during the field survey.

Infiltration

Infiltration indices were comprised between 28.0% and 39.8%. Soil infiltration potential was lowest at ‘RHB_HVON_Carrington’ and ‘RHB_HVOS_Riverview’ (yet still with index scores within the ‘satisfactory’ range of values, refer to Table 9), and highest at ‘RHB_HVOW_Wilton’ (‘excellent’ index score), with all other sites returning ‘good’ infiltration index scores (refer to Table 9). As with stability, the infiltration potential of the soils was greatly influenced by the dense grass vegetation cover across the sites. Indeed, the high vegetative ground cover present at all sites reduces water surface runoff velocities (thereby providing more time for water to infiltrate within the soil profile), and enhances infiltration processes by increasing the soil organic matter content, which in turns enhance soil aggregation and pore space within the soil profile (USDA 2008).

Nutrient Cycling

Nutrient cycling index scores are typically lower in pasture / grazing ecosystems when compared to what can be observed in areas of native vegetation, where mid and upper storey species provide for a lot more organic matter being returned to the ground. At all the pasture sites monitored, the nutrient cycling index was generally driven by the combined amount of perennial grass cover and grass litter (attached and loose). However in most cases the grass litter observed at the monitoring sites was not in an advanced stage of decomposition, generally with no fungal attack visible and no distinct layers in decomposition.

Nutrient cycling indices at the rehabilitation sites ranged from 22.6% to 31.7%, which was well aligned to the scores achieved at the analogue sites. The lowest nutrient cycling index was obtained at ‘RHB_WML_Swanlake’ – which was the least established pasture and showed lower ground cover and lower amount of grass litter, and had a high weed incidence. The site nonetheless returned a ‘satisfactory’ index (i.e. comprised between 20-25%, refer to Table 9). The highest nutrient cycling index was recorded at ‘RHB_HVOW_Wilton’ with a score within the ‘excellent’ range of values (refer to Table 9). All other sites returned indices comprised between 25-30%.

5.2 Pasture Performance

5.2.1 Herbage Mass and Composition

Herbage mass

Total herbage mass at the analogue sites was relatively uniform and comprised between ~2,200 kg DM/ha and ~3,600 kg DM/ha. In contrast, high variability was observed across the rehabilitation sites, where herbage mass ranged from ~2,500 kg DM/ha to ~8,400 kg DM/ha. In particular, the ‘RHB_WML_TD1’, ‘RHB_HVOW_Wilton’ and ‘RHB_HVOW_Plane_Dump’ monitoring sites supported herbage masses well above the analogue sites average (± standard deviation) with estimated productions of 4,343 kg DM/ha, 5,190 kg DM/ha and 8,367 kg DM/ha. This was explained by the overwhelming dominance of Rhodes grass at these three sites (accounting for ≥ 94% pasture species composition) which formed a thick and tall vegetation cover, and by light grazing pressure at RHB_WML_TD1 and the absence of grazing at the other sites (apart from very light grazing pressure from kangaroos).

The proportions of dead and green matter composing the total herbage mass were overall consistent amongst the rehabilitation sites with an average of ~48.8% dead matter; and between the rehabilitation and analogue sites (~47.2% dead matter average for the analogue sites). The green herbage mass average at the rehabilitation sites was of 2,125 kg DM/ha (± 593 stdev), and of 1,538 kg DM/ha (± 282 stdev) at the analogue sites.

Herbage composition

Pasture composition was largely dominated by Rhodes Grass at most rehabilitation sites, with the exception of the ‘RHB_MTO_South_CHPP’ site which supported a higher pasture species diversity, and to some degree of the ‘RHB_HVON_Carrington’ where a high component of Panic Grass was present. Leguminous species were generally not occurring in rehabilitation sites. This differed greatly from the analogue sites where pasture composition was more diverse and where Rhodes and Panic grasses were generally absent (apart from at ‘ANA_North_CHPP’). In this regard the ‘RHB_MTO_South_CHPP’ was the only rehabilitation site comparing reasonably well with the analogue benchmark in terms of pasture composition.

Pasture composition at the analogue sites was dominated by perennial C4 grasses (with dominant species usually including Slender Rat's Tail *Sporobolus creber* and Red grass *Bothriochloa macra*). Queensland Bluegrass *Dichanthium sericeum* was usually present but at low levels, as were native forbs and annual grasses. As for rehabilitation sites, legumes were generally absent at analogue sites.

It is noted that the condition of the pasture at 'ANA_Cheshunt' was poor with annual grasses largely dominating the pasture composition, and therefore this site may not constitute an appropriate reference for benchmark setting.

Weeds occurred at all monitoring sites inclusive of rehabilitation and analogue sites but their occurrence was overall limited (accounted for between 0% and 12% of herbage mass). Dominant weed species present were generally similar across all sites, with common species including Farmer's Friend (*Bidens pilosa*), Fennel (*Foeniculum vulgare*), Flaxleaf Fleabane (*Conyza bonariensis*), Galenia (*Galenia pubescens*), Narrow-leaf Cottonbush (*Gomphocarpus fruticosus*), Paddy's Lucerne (*Sida rhombifolia*), Plantain (*Plantago lanceolata*), Purpletop (*Verbena spp*.), Ragweed (*Ambrosia artemisiifolia*), and various Thistles.

5.2.2 Feed Quality and Potential Carrying Capacity

Despite obvious disparities in pasture composition, feed quality was very consistent across all monitoring sites, inclusive of rehabilitation and analogue sites. Of the parameters derived by the feed analyses, crude protein (CP), metabolisable energy (ME) and the digestibility of the dry matter (DMD) are the most useful indicators of feed value.

- The DMD at all sites was comprised between approximately 48-58%. The DMD of the feed at the rehabilitation sites averaged 52% (±2.55 stdev), while the analogue sites average was 54.2% (±2.52 stdev).
- The CP content was more variable amongst monitoring sites, but results for both rehabilitation and analogue sites were comprised within a comparable range of values (within 2.6-8.2% at rehabilitation sites and within 2.2-9.0% at analogue sites).
- The ME content of the feeds was very consistent across all sites. Average ME at rehabilitation sites was 7.3 MJ / kg DM (±0.45 stdev), while average ME at analogue sites was 7.8 MJ / kg DM (±0.44 stdev).

These results may be explained by the fact that Rhodes Grass (dominant in rehabilitation sites) and Slender rat's tail and Red grass (generally dominant in analogue sites) are all C4 perennial grasses and can have similar nutritional values especially in their late flowering / dough stage of growth – which was the case at all sites at the time of monitoring.

Feed quality was overall low at all sites, which is due to a number of factors including the late growth stage (flowering / dough) of plants at the time of monitoring (the feed value and digestibility of a pasture declines as it matures) and the overall absence of leguminous species. Legumes are very important to achieve a productive pasture, they provide high quality feed (generally with higher protein levels and digestibility than grasses, and more palatable to animals) and help improving soil fertility through nitrogen fixation, which in turns improves the growth of companion grass species.

Given the DMD of the feed at all monitoring sites (~52-54%), satisfactory production levels in beef cattle (dry cow) could only be maintained where a minimum green herbage mass of 3,400 kg DM/ha is available, including a legume content of 15% (NSW DPI, 2006b). As noted above, none of the monitoring sites achieved such levels of green herbage mass, nor contained sufficient proportions of legumes. Consequently, sustainable grazing enterprises could not be achieved at the monitoring sites without improved management measures being implemented. Immediate action could involve biomass reduction to keep the pastures in the growth phase where digestibility is higher (as opposed to flowering / dough phases).

Carrying capacity calculation – Using feed quality

For information and comparison purposes only, potential stocking rates and carrying capacities have been calculated in Table 10. Calculations have been made for a 450kg dry stock cattle enterprise and for a yearling production system.

- Stocking rates have been calculated using the amount of feed available, the ME content of the feed (as per laboratory results), and the average feed requirement of various livestock on a monthly basis. Importantly and for the purpose of stocking rates calculations, the following adjustments have been made to the amount of feed available (as derived by Botanal, refer to Section 4.2.1):

- Cattle do not graze herbage to ground level and grazing height is usually 5-10 cm above ground level. In a dense and abundant pasture (especially dominated by Rhodes Grass), the amount of herbage not grazed – called 'pasture residue', is usually in the order of 1,000 kg DM / ha (N. Griffiths, pers. Comm.). This amount of feed has been deducted from the total amount of feed available for each site.
- A grazing efficiency of 100% cannot be achieved in a pasture system as some herbage wastage occurs via trampling by cattle, animal manure, etc. For the pasture studied here, a wastage of 30% of the total feed available can be reasonably expected (N. Griffiths, pers. Comm.). This amount has also been deducted from the total feed available.

\- In the Hunter Valley, the average energy requirement for dry stock is 54.0 MJ/day and for 350kg yearlings gaining 1.5kg/ day is 116 MJ/day (from NSW DPI, 2006a). This equates to 1,620 MJ/month[4] for dry stock and 3480 MJ/month for yearlings, respectively.

\- Potential carrying capacities were calculated for the rehabilitation sites only, utilising the area of the rehabilitation polygon 'paddock' size (the polygon area was derived using GIS, discounting areas supporting dense tree cover occurring within a polygon). Carrying capacities could not be derived for the analogue sites as paddock size was unknown.

Table 10 Potential carrying capacities based on quality of feed available

Monitoring Site[5]	Feed available[#] (kg DM / ha)	ME (MJ / kg DM)*	Potential stocking rate (animal / ha)		Paddock area (ha)	Carrying capacity (individuals)	
			Dry stock	Yearling		Dry stock	Yearling
RHB_HVON_Carrington	1,797	8.0	8.9	4.1	76.0	674	314
RHB_HVOW_Plane_Dump	5,157	6.9	22.0	10.2	42.0	922	429
RHB_HVOW_Wilton	2,933	6.7	12.1	5.6	15.0	182	85
RHB_MTO_North_Dump	1,135	7.8	5.5	2.5	43.0	235	109
RHB_MTO_South_CHPP	1,072	7.3	4.8	2.2	48.0	231	108
RHB_WML_TD1	2,340	7.2	10.4	4.8	84.0	873	407
ANA_Carrington_Billabong	1,282	7.8	6.2	2.9	N/A	N/A	N/A
ANA_Cheshunt	1,100	8.2	5.6	2.6	N/A	N/A	N/A
ANA_Lemington_Rd	1,346	8.5	7.1	3.3	N/A	N/A	N/A
ANA_Howick	1,835	7.3	8.3	3.8	N/A	N/A	N/A
ANA_Parnells	1,449	7.8	7.0	3.2	N/A	N/A	N/A
ANA_Knodlers_Lane	1,399	7.3	6.3	2.9	N/A	N/A	N/A
ANA_Newport	870	7.9	4.2	2.0	N/A	N/A	N/A
ANA_North_CHPP	1,497	7.3	6.7	3.1	N/A	N/A	N/A

[#] *following relevant deductions of herbage residue and wastage.*

* *Averaged for green and dead fractions in proportion of their weight contribution to the total herbage mass.*

The 'RHB_HVOW_Plane_Dump' and 'RHB_HVOW_Wilton' sites returned the highest potential stocking rates of all monitoring sites. Despite having the poorest feed quality, these sites could temporarily support such stocking rates thanks to the very high amount of feed available at the site. All other rehabilitation sites returned potential stocking rates in line with those achieved at the analogue sites.

It is important to note that these calculations have been undertaken for example purposes only. In reality, the amount of energy currently contained in the feed at the rehabilitation and analogue sites (i.e. ~7.0-8.0 ME / kg

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[4] Based on a 30 day month

[5] Note that stocking rates calculations as shown in Table 10 and Table 11 and have not been undertaken for the 'RHB_HVOS_Riverview' and 'RHB_WML_Swanlake' where pasture establishment was in its early stages and thus where Botanal was not implemented.

DM) would be insufficient for yearlings to gain weight and would only provide for weight maintenance. This is based on the premise that a yearling production program based on a 350kg beast with a planned weight gain of 1.5kg/day requires 116 MJ/day of feed. As the feed quality in the paddocks averages ~7.0-8.0 ME / kg DM the beast would need to eat between 14.5 -16.5 kg of feed / day. .

Furthermore, it is noted that the stocking rates calculated in Table 10 were derived from the amount of feed available at that point in time when the monitoring was undertaken. At the time, herbage mass at most rehabilitation sites was very high due to the absence of active grazing, and to the excellent (and somewhat unseasonal) growing conditions experienced in mid-summer in the region (with unseasonably high rainfall, refer to Table 2 in Section 2.3). As such, the herbage mass recorded can be assumed to be unrepresentative of the herbage mass that would be available if the areas were actively managed with cattle grazing. Consequently, the calculated carrying capacities would be unsustainable.

Carrying capacity calculation – Using Soil phosphate levels

The NSW DPI's '*Beef Stocking Rates – Hunter Region*' (2006) provides a generic method to approximate carrying capacities based potential land productivity as regulated by available soil phosphate (P) levels. This method does not account for pasture species composition and feed quality, but relies more on a knowledge of fertiliser history and Agricultural Suitability Class. Based on the soil sample analyses results and the NSW DPI (2006) guidelines, the potential stocking rates have been calculated with results presented in Table 11. For information and comparison purposes only, potential carrying capacities at the rehabilitation sites have also been calculated in Table 11 using the rehabilitation polygon areas as discussed above.

Calculations have been made for a 450kg dry stock cattle enterprise and for a yearling production system. The feed requirements for these production systems (and used in the calculations of carrying capacities) are 6.0 DSE[6] / breeding unit and 18.6 DSE / breeding unit, respectively.

The results in Table 11 indicate that based on soil productivity, higher stocking rates can generally be achieved at rehabilitation sites than at analogue sites, where soil P levels were generally lower. The exception being for those analogue sites located on alluvial soils ('ANA_Carrington_Billabong' and 'ANA_Cheshunt') where soil P levels were highest. This indicates that when linked to pasture productivity, the growing media used in rehabilitated pasture lands (and associated historic fertiliser regime) has a potential for higher stocking rates than those analogue sites located on Brown Clays, Solodic and Yellow Podzolic soils, which are common soil types in the region and areas which have a typical fertiliser history or irregular or no super phosphate application.

It is also noted that the stocking rates achieved with this method are likely to be more realistic and sustainable than those calculated previously (using the feed quality results), as they are based on the productivity potential of the growing media over the medium term. However and as mentioned above, the legume content of the pastures would need to be increased.

Table 11 Potential carrying capacities based on soil phosphate levels

Monitoring site[7]	Soil P level[8]	Pasture productivity (DSE/ha)	Potential stocking rate (animal / ha)		Carrying capacity (individuals)[9]	
			Dry Stock	Yearling	Dry Stock	Yearling
RHB_HVON_Carrington	Med-Low	4	0.66	0.21	50.6	16.3
RHB_HVOW_Plane_Dump	Med-Low	4	0.66	0.21	28	9.0
RHB_HVOW_Wilton	Med-Low	4	0.66	0.21	10	3.2
RHB_MTO_North_Dump	High	10	1.66	0.54	71.6	23.1
RHB_MTO_South_CHPP	Med-Low	4	0.66	0.21	32	10.3

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[6] DSE = Dry Sheep Equivalent. DSE is a measure used to compare the feed requirements of different animals. 1 DSE is the average amount of pasture feed consumed by a 50kg wether (an adult but non-lactating sheep) on a monthly basis.

[7] Note that stocking rates calculations as shown in Table 10 and Table 11 and have not been undertaken for the 'RHB_HVOS_Riverview' and 'RHB_WML_Swanlake' where pasture establishment was in its early stages and thus where Botanal was not implemented.

[8] P level range was defined as follow (when P measured using the Mehlich test as per current laboratory procedure): Low (<20 mg/kg), Medium-Low (20-40 mg/kg), Medium (40-70 mg/kg), or High (>70 mg/kg).

[9] Carrying capacities could not be derived for the analogue sites as paddock size was unknown.

Monitoring site[7]	Soil P level[8]	Pasture productivity (DSE/ha)	Potential stocking rate (animal / ha)		Carrying capacity (individuals)[9]	
			Dry Stock	**Yearling**	**Dry Stock**	**Yearling**
RHB_WML_TD1	Medium	8	1.33	0.43	112	36.2
ANA_Carrington_Billabong	High	10	1.66	0.54	N/A	N/A
ANA_Cheshunt	High	10	1.66	0.54	N/A	N/A
ANA_Lemington_Rd	Low	2	0.33	0.11	N/A	N/A
ANA_Howick	Low	2	0.33	0.11	N/A	N/A
ANA_Parnells	Low	2	0.33	0.11	N/A	N/A
ANA_Knodlers_Lane	Low	2	0.33	0.11	N/A	N/A
ANA_Newport	Low	2	0.33	0.11	N/A	N/A
ANA_North_CHPP	Med-Low	4	0.66	0.21	N/A	N/A

5.3 Growing Media

Note that the discussion below focuses on the most important parameters of soil condition as pertaining to a grazing pasture land use. For reference, Table 12 details the desirable values for these significant parameters (from Reid, 2004 and Hazelton and Murphy, 2007).

Table 12 Desirable values for soil characteristics (NSW temperate pastures)

Parameter	Satisfactory level
pH ($CaCl_2$)	5.0-7.5
Electrical conductivity (salinity)	<0.2 µS/m (i.e. non-saline)
eCEC	> 10.0 meq/100g
Exchangeable calcium	65-80%
Exchangeable magnesium	10-20%
Exchangeable potassium	3-8%
Exchangeable sodium (sodicity)	< 6% (i.e. non-sodic)
Exchangeable aluminium	< 1%
Calcium/magnesium ratio	> 3
Phosphorous	Low (<20 mg/kg), Medium-Low (20-40 mg/kg), Medium (40-70 mg/kg), High (>70 mg/kg)
Nitrate	> 10 mg/kg
Sulphur	10-20 mg/kg
Organic carbon	> 2%

- pH levels at the rehabilitation sites were comprised between 6.0 and 7.0. This was generally higher than the pH observed at analogue sites (where levels were comprised between 4.9 and 6.9) yet within the satisfactory levels for pasture productivity listed in Table 12.

- Electrical conductivity levels were very low to low (i.e. non-saline) at four of the rehabilitation sites including ‘RHB_HVOW_Plane_Dump’, ‘RHB_HVOS_Riverview’, ‘RHB_HVON_Carrington’, and ‘RHB_WML_TD1'. Moderate salinity (i.e. 0.2-0.4 µS/m) was recorded at ‘RHB_MTO_South_CHPP’, ‘RHB_MTO_North_Dump’ and ‘RHB_WML_Swanlake’, whilst ‘RHB_HVOW_Wilton’ was highly saline (>0.8 µS/m). In comparison, salinity was low to very low at all analogue sites.
    - The moderate and/or high salinity levels recorded at the rehabilitation sites did not appear to have a noticeable impact on pasture productivity (plant growth, feed value) at the time. However, close monitoring of salinity at ‘RHB_HVOW_Wilton’ in particular should be undertaken to ensure leaching occurs and salinity levels decline over time. Salinity – if sustained, has the potential to affect pasture production by interfering with nitrogen and water uptake, reducing growth and stopping plant reproduction. Sensitive leguminous species would particularly struggle to establish where salinity levels are elevated.
- In line with the analogue sites, the CEC was moderate to high at all rehabilitation sites, indicating a good potential for nutrient retention and holding capacity.
    - The cation balance was highly magnesic at all rehabilitation sites, and moderate sodicity (i.e. sodium content) was present at ‘RHB_MTO_South_CHPP’ and ‘RHB_MTO_North_Dump’. At these two sites, the high magnicity combined with the moderate sodicity mean that fines in the soils are likely to be dispersive and prone to erosion. However both sites were stables with no active erosion observed.
    - With the exception of ‘RHB_HVOS_Riverview’, the Ca:Mg ratio was low for all rehabilitation site, indicating overall calcium deficiencies in the growing media.. However calcium levels were generally in line with those present at the analogue sites.
- With regards to available nutrients, the following points are raised:
    - Levels of phosphates were generally medium-low to medium, with the exception of ‘RHB_MTO_North_Dump’ where high levels were available (refer to Table 12). Phosphorous is one of the two main limiting nutrients for pasture productivity in the Hunter Valley (with sulphur), and P levels should be maintained around 20-40 mg/kg (Mehlich test) for improved pastures in the Hunter Valley. Most rehabilitation sites therefore showed adequate phosphate levels.
    - Nitrogen levels were very low at all sites and below the preferred levels of 10 mg/kg. However it is noted that nitrates levels fluctuate widely depending on the season and rainfall. Besides, N levels should not constitute a priority concern for pasture productivity in the region, and should be addressed only after satisfactory levels of P and S are achieved, and only once cattle management is introduced.
    - ‘RHB_HVOW_Plane_Dump’, ‘RHB_HVOS_Riverview’, ‘RHB_HVON_Carrington’, and ‘RHB_WML_TD1' returned very elevated levels of sulphates, which is to be linked to the salinity levels observed at these sites. Sulphur levels at the other rehabilitation sites were satisfactory and aligned to that found in analogue areas.
- Organic carbon levels were high at all sites (>3%) and comparable between rehabilitation and analogue sites. Organic carbon is a measure of the organic matter in the soil, and stores important nutrients, stabilises soil structure and feeds soil microbes. These results indicate overall good soil fertility.

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6.0 Conclusions and Recommendations

6.1 Overall Rehabilitation Performance

6.1.1 Landscape Function

Overall, the results of this monitoring event indicate that all rehabilitation monitoring sites are performing very well in terms of landscape function, with performances comparing positively with those achieved at the relevant analogue sites.

All rehabilitation sites appeared very stable with no rilling or other signs of active erosion. However, it is worth noting that two of the monitoring sites (‘RHB_MTO_South_CHPP’ and ‘RHB_MTO_North_Dump’) returned elevated levels of soil magnicity and sodicity, making them potentially prone to erosion should the protective ground cover decrease.

Soil stability was largely promoted by the excellent protective ground cover of perennial grasses achieved at all sites. Indeed, grass cover was above 80% at all sites, and ≥ 95% at six of the eight sites monitored. In all cases grass cover was well above 70%, which can be considered a benchmark value in NSW for the minimum pasture cover required for soil protection, for efficient capture and use of rainfall and nutrients, and for sustainable long-term production (Lang, 1998).

The results of the LFA were very consistent across all sites monitored, inclusive of both rehabilitation and analogue sites. All LOI scores were very high as influenced by the excellent ground cover which leads to excellent resource retention across the slopes. Likewise, SSCI scores were generally within the high range of values at all sites, with stability, infiltration and nutrient cycling indices all driven up by the high grass cover and varying amount of grass litter present. Noticeably, LFA results at the younger rehabilitation sites were also well aligned to the performance of the older sites and of the analogue sites.

Plant growth (key to efficient landscape function) was usually promoted by the adequate soil physical and chemical properties, with most parameters analysed being within satisfactory range for pasture growth and production. The characteristics of the growing media on rehabilitated lands were comparing well against the values of the analogue sites, and soil fertility was generally satisfactory for pasture production, particularly in terms of organic carbon levels and phosphorous availability. However, salinity and sulphur levels were elevated at four of the rehabilitation sites although no negative discernible effects were obvious at the time of monitoring, these levels may constrain optimal pasture establishment and production in the longer-term on rehabilitated sites and should be closely monitored accordingly.

6.1.2 Pasture quality

The pasture composition measured in the rehabilitation sites was inconsistent with that of the analogue sites. Pastures at most rehabilitation sites were largely dominated by Rhodes Grass, which formed a dense and tall layer. The exception being the ‘RHB_MTO_South_CHPP’ site which supported a higher pasture species diversity, and to some degree of the ‘RHB_HVON_Carrington’ where a high component of Panic Grass was present. It is noted that these two sites were the oldest (age since establishment) of all monitored rehabilitated pastures, and their more diverse composition may be due to different rehabilitation techniques (e.g. species mix) or to progressive dieback of the Rhodes Grass (the species usually dies out after 4-5 years if not further disturbed or fertilised (Cook et al, 2005)). Legumes were altogether absent from the rehabilitated pastures.

Rhodes Grass often dominates when sown in a mixture due to its good seedling vigour and ability to spread through runners (Moore et al, 2006). Although the species offers palatability and quality feed grazing for livestock when young shoots are present, its quality significantly decreases with age. Management practices should therefore be implemented to maintain the productivity of the rehabilitated pastures where the species was overwhelmingly dominant.

In contrast, pasture composition was much more diverse in analogue sites, which were dominated by a range of C4 grasses and where Rhodes was generally absent (however the presence of legumes was also very limited in analogue sites). Overall, there didn’t seem to be a significant difference in pasture composition at the analogue sites based on soil type and land class capability, with the exception of pasture composition on alluvial soils. However, the pasture compositions recorded at the monitored alluvial analogues were likely the result past and current land management practices, particularly with regards to the high proportion of annual grasses present.

The absence (or limited levels) of legumes at both rehabilitation[10] and analogue sites will limit their overall productivity. Indeed, legumes are very important to achieve a productive pasture as they provide high quality feed (generally with higher protein levels and digestibility than grasses, and more palatable to animals) and help improve soil fertility through nitrogen fixation, which in turns improves the palatability of companion grass species.

Feed quality was overall low at all sites, which is due to a number of factors including the late growth stage (flowering / dough) of plants at the time of monitoring (the feed value and digestibility of a pasture declining as it matures) and the overall absence of leguminous species. The comparable feed quality returned for both rehabilitation and analogue sites – despite clear difference in composition, may be explained by the fact that Rhodes Grass (dominant in rehabilitation sites) and Slender rat's tail and Red grass (generally dominant in analogue sites) can have similar nutritional values especially in their late flowering / dough stage of growth. Results from the analogue sites also imply that species diversity may not influence animal production, and that a few well adapted, productive species may support animals as well or better than a highly diverse pasture.

Total herbage mass was generally higher in rehabilitation sites than at the analogue sites, which is explained by the high incidence of Rhodes Grass. Green herbage as a proportion of the total dry herbage mass was consistent across all monitoring sites and usually comprised between 45-50%.

Overall and most importantly, the pasture composition and feed quality at the rehabilitation monitoring sites largely reflected the lack of grazing (present and past) at the sites, and it is expected that grazing introduction and management would to a large extent influence what species dominate or decline in the pasture, and in turn influence the quality of feed available. Rhodes Grass biomass could very effectively be reduced via introduction of well-informed grazing management.

Finally, weeds were generally not an issue at the monitoring sites. Although some low levels were present, the introduction of grazing should assist in maintaining weeds at acceptable levels[11], provided that well informed and proper grazing management is implemented especially ensuring that over grazing does not occur. Only the young 'RHB_WML_Swanlake' monitoring site sustained a high infestation of weeds, especially Hedge Mustard – *Sisymbrium officinale*. However pasture establishment at this site was in progress and in its early stages, and it is understood that rehabilitation management practices at this stage are aimed at suppressing the weed seed bank present in the topsoil as far as possible, and that boom spraying of the area will occur prior to the desirable pasture species mix being sown. Consequently the infestation of Hedge Mustard at this site is not considered an issue at this stage.

6.2 Recommendations

6.2.1 Pertaining to Rehabilitation Performance

The following unprioritised recommendations are formulated as possible ways to improve the performance of rehabilitated pastures:

- To improve the quality of the rehabilitated pastures, it is recommended that their biomass is reduced, which will have the benefits of improving the palatability and feed value of existing dominant species (principally Rhodes Grass) and allow for the establishment and/or growth of other desirable species (esp. legumes). This may be achieved through:
  - Slashing and mulching of over mature species, or slashing and harvesting for hay when the plant is cut at or just before early flower;
  - Introduction of grazing trials (light grazing or rotational grazing) – this would need to be managed by an experienced grazier; or
  - crash grazing of the area i.e. introduce high stock numbers over a short period using suitable class of cattle (i.e. mature dry cows) – this would need to be managed by an experienced grazier.
- The reduction is the amount of roughage material should also increase stoloniferous growth of the Rhodes Grass which should assist in reducing the risk of soil erosion.

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[10] The absence - low level of legumes at the rehabilitation site has subjectively been assumed to be associated with the inability of the species sown to establish in the areas surveyed. This assumption is based on the premise that the weeks preceding the survey provided excellent growing conditions and if the legumes had been present then they would have been recorded.

[11] This assumes that the cattle entering the site are weed free and have been allowed to vent in a stockyard situation prior to being released to the paddocks.

- As feed quality of Rhodes Grass declines rapidly with the onset of flowering, the data collected during this monitoring event may present a slightly false picture of the productivity of the rehabilitated pastures. This being the case it is recommended that should cattle be introduced then a rapid assessment of carrying capacity is undertaken at monthly increments.
- The introduction of grazing would greatly (and beneficially) influence the overall performance of rehabilitated pasture lands, including species composition, feed quality and herbage mass. Therefore, grazing introduction is recommended so long as it is driven by well-informed management practices from experienced graziers.
- Undertake maintenance direct seeding once the amount of standing feed has been reduced by grazing with a view to increase species diversity, improve pasture productivity and enhance nutrient cycling. Ensure any species mix used in maintenance seeding:
  - Includes fast germinating species to promote and maintain extensive ground cover;
  - Includes leguminous species to improve soil fertility and nutrient cycling, for example subterranean clover or white clover or Lucerne species suited for dry land farming; and
  - Promotes species diversity in order to improve productivity and resilience of the pasture, provide erosion control and increase biodiversity. The mix should contain a large number of species with varying drought tolerance, feed values and persistence when grazed. For example, native grasses with high grazing value include Wallaby grass, Weeping grass or Kangaroo grass, which retain green leaf for most of the year (DPI, 2006).
- Maintain vigilance in terms of weed invasion and implement weed management / control programme as required.
- Review soil data in terms of soil fertility and capacity to provide an optimum growing media for pasture establishment (refer to SESL result in Appendix b for specific amelioration measure). In particular:
  - Gypsum applications should be considered to balance cations and increase calcium levels, minding the potential of such application to temporarily increase salinity. However, the use of lime to raise calcium levels is not recommended given the current neutral pH levels.
  - Assess the economic rationale of fertiliser applications in terms of weight / profit gain from the resultant feed.
- It is also recommended that the species mix used in rehabilitation works for pasture establishment is reviewed, as the current practices seem to result in Rhodes Grass becoming overwhelming dominant. If the immediate objective in the early phases of rehabilitation is to provide for rapid and extensive ground cover establishment (for soil stability) with a dense layer of Rhodes Grass, then there is potential cost saving to be achieved by removing other species from the mix.
- Review the data from the ACARP study currently being undertaken by Department of Primary Industry to assess the objective of the rehabilitation program at the sites covered by this monitoring program in context of the development of a sustainable land management program. The ACARP study should provide an overview of the rationale for beef cattle grazing, an assessment of the carrying capacity and stocking rates in context of the cost effectiveness of the land management practices and maintenance requirements. This assessment would then provide data on the style of beef cattle production that is best suited to these lands (e.g. dry cows vs, yearlings vs. bullocks) whilst also providing a platform for decision making in terms of budgetary allocation and ongoing land management.

6.2.2 Pertaining to the Monitoring Programme

The following recommendations are made with the view to optimise the monitoring programme:

- Given the high uniformity of the results, the value of implementing LFA at monitoring sites where a high ground cover is achieved is highly questionable. It is recommended that LFA is removed from the monitoring programme where a ground cover of 70% or more is achieved. Its application should be strictly limited to rehabilitation sites in the early stages of ecosystem establishment, and / or following a significant extreme weather event (e.g. drought) to allow for an assessment of ecosystem recovery. This would incur significant cost saving to the overall implementation of the rehabilitation monitoring programme.

- The timeframe for the implementation of Botanal should consider the seasonal conditions to ensure plants are in flower / reproductive stage at the time of the assessment. This greatly facilitates and speeds up the field data collection, and allows for greater confidence in species identification and pasture composition description. However this implies that resources (staff) can be deployed rapidly and on relatively short notice following a spell of good weather conditions.
- If cattle are introduced on rehabilitated lands, the monitoring frequency should be increased and Botanal implemented at least on a 6-monthly basis, and ideally on a trimestral basis. This would allow timely data collection and reporting on pasture condition (amount and quality of feed available) on a seasonal basis on which suitable stocking rates could be derived.
- In future monitoring events, the laboratory contracted to undertake the soil analyses is advised of the suitable methods to be used for testing of nutrients content as required for NSW pastures.
- Given the very large area of the rehabilitation polygons monitored, high variability in pasture condition can be expected across the polygon. In this regards, the amount of monitoring sites established and monitored should be reviewed to ensure that the data collected draw a true picture of rehabilitation performance across the site. The required density of monitoring transects should be as per the recommendations made in the current monitoring methodology document (AECOM, 2012).

7.0 References

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Appendix A

Feed Analysis Results

Appendix A Feed Analysis Results

Department of Primary Industries
Wagga Wagga Agricultural Institute

Our Ref:	**R15-00295**
Your Ref:	**Pasture**
Prev. Ref:	**Samples**
Laboratory Enquiries:	
Invoice Enquiries:	**1800 675 623**
	1300 720 773

LABORATORY REPORT

To:
AECOM AUSTRALIA PTY LTD
17 Warabrook Bvde
WARABRROK
2304 NSW Australia
Attn: MATTHIEU CATTEAU

Owner:
Property:

Job Type: Feed

Job Manager: Richard Meyer
Date Sampled:
Date Sent: 2 Mar 2015
Date Received: 3 Mar 2015

Submitter Subject:

Samples Received: x FORAGE

Analysis Method	**Method ID**	**Date of Test**
Acid Detergent Fibre (Forage/Silage) - NIR - CSL	LMOP 2-1129	6 Mar 2015
*AFIA Hay and Silage Grade	AFIA GRADING	6 Mar 2015
Inorganic Ash in Plant Material (Forage/Silage) - NIR; CSL	LMOP 2-1129	6 Mar 2015
Inorganic Ash in Plant Material - Wet chemistry; AFIA Method 1.10R	LMOP 2-1123	13 Mar 2015
Calculation of Metabolisable Energy; AFIA Method 2-2R	LMOP 2-1124	6 Mar 2015
Crude Protein (Forage/Silage) - NIR; CSL	LMOP 2-1129	6 Mar 2015
Dry Matter Digestibility - NIR; CSL	LMOP 2-1129	6 Mar 2015
Dry and Grind inc Dry Matter - Reuter & Robinson 2.E.3; 2.E.4	LMOP 2-1100	6 Mar 2015
Neutral Detergent Fibre (Forage/Silage) - NIR; CSL	LMOP 2-1129	6 Mar 2015
*Water Soluble Carbohydrate (Forage/Silage) - NIR - CSL	LMOP 2-1129	6 Mar 2015

* NATA Accreditation does not cover the performance of this service

Richard Meyer
Chemist

NATA Accreditation Numbers
14173 Environmental Laboratory Wollongbar
14488 Orange Agricultural Institute
14495 Elizabeth Macarthur Agricultural Institute
14949 Wagga Wagga Chemistry Services Laboratory

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Template V02

Page 1 of 5

Wagga Wagga Feed Quality Testing Laboratory

Specimen Type: Forage

			0001	**0002**	**0003**	**0004**
			RHB_HVOW Wilton	**RHB_MTO North Dump**	**ANA_Lemington Rd**	**ANA_Cheshunt**
Results	**Units**	**LOR**	Fresh Pature-DEAD fraction	Fresh Pasture-DEAD fraction	Fresh Pasture-DEAD fraction	Fresh Pasture-DEAD fraction
Dry Matter	%	0.5	54.6	89.4	84.1	83.4
Neutral Detergent Fibre	%	10	74	72	66	63
Acid Detergent Fibre	%	4	47	43	42	41
*Water Soluble Carbohydrate	%	4.0	<4.0	<4.0	<4.0	<4.0
Crude Protein	%	2.0	3.9	<2.0	4.5	3.9
Inorganic Ash	%	3	9	12	13	13
Organic Matter	%	75	91	88	87	87
DMD	%	39	46	46	50	54
DOMD	%	38	46	46	49	52
*AFIA Grade			D4	d4	d4	c4
Metabolisable Energy	MJ/kg DM	4.3	6.2	6.2	6.9	7.6

Specimen Type: Forage

		0005	**0006**	**0007**	**0008**	**0009**
		ANA_Howick	**ANA_Carrington Billabong**	**RHB_WML TD1**	**RHB_HVON Carrington**	**ANA_Parnells**
Results	**Units**	Fresh Pasture-DEAD fraction	Fresh Pasture-DEAD fraction	Fresh Pasture-DEAD fraction	Fresh Pasture-DEAD fraction	Fresh Pasture-DEAD fraction
Dry Matter	%	86.8	86.6	82.4	77.5	84.3
Neutral Detergent Fibre	%	71	68	72	68	71
Acid Detergent Fibre	%	47	44	46	42	44
*Water Soluble Carbohydrate	%	<4.0	<4.0	<4.0	<4.0	<4.0
Crude Protein	%	5.1	3.0	2.1	4.7	6.1
Inorganic Ash	%	9	11	12	11	10
Organic Matter	%	91	89	88	89	90
DMD	%	41	48	45	50	46
DOMD	%	42	47	45	49	46
*AFIA Grade		d4	d4	d4	d4	d4
Metabolisable Energy	MJ/kg DM	5.5	6.6	6.1	6.9	6.3

Specimen Type: Forage

		0010	**0011**	**0012**	**0013**	**0014**
		RHB_HVOW Plane Dump	**ANA_Newport**	**ANA_Knodlers Lane**	**RHB_MTO South CHPP**	**ANA_North CHPP**
Results	**Units**	Fresh Pasture-DEAD fraction	Fresh Pasture-DEAD fraction	Fresh Pasture-DEAD fraction	Fresh Pasture-DEAD fraction	Fresh Pasture-DEAD fraction
Dry Matter	%	88.2	85.5	59.0	87.1	77.3
Neutral Detergent Fibre	%	75	69	71	72	70
Acid Detergent Fibre	%	50	44	44	45	44
*Water Soluble Carbohydrate	%	<4.0	<4.0	<4.0	<4.0	<4.0
Crude Protein	%	6.9	<2.0	3.0	3.1	<2.0
Inorganic Ash	%	14.1	11	9	10	11
Organic Matter	%	85.9	89	91	90	89
DMD	%	43	47	44	43	48
DOMD	%	43	47	44	43	47
*AFIA Grade		d4	d4	d4	d4	d4
Metabolisable Energy	MJ/kg DM	5.7	6.5	6.0	5.7	6.5

Specimen Type: Forage

		0015	**0016**	**0017**	**0018**	**0019**
		ANA_Newport	**ANA_Parnells**	**ANA_Carrington Billabong**	**ANA_Knodlers Lane**	**ANA_Cheshunt**
Results	**Units**	Fresh Pasture-GREEN fraction	Fresh Pasture-GREEN fraction	Fresh Pasture-GREEN fraction	Fresh Pasture-GREEN fraction	Fresh Pasture-GREEN fraction
Dry Matter	%	40.4	34.4	45.7	34.7	37.6
Neutral Detergent Fibre	%	65	67	62	66	62
Acid Detergent Fibre	%	38	39	37	37	36
*Water Soluble Carbohydrate	%	<4.0	<4.0	10.9	<4.0	6.3
Crude Protein	%	6.1	11.4	6.4	6.5	5.5
Inorganic Ash	%	9	10	9	8	9
Organic Matter	%	91	90	91	92	91
DMD	%	59	62	64	57	63
DOMD	%	57	59	61	55	60
*AFIA Grade		c4	b3	b4	c4	b4
Metabolisable Energy	MJ/kg DM	8.6	9.1	9.4	8.2	9.3

Specimen Type: Forage

		0020	**0021**	**0022**	**0023**	**0024**
		ANA_North CHPP	**ANA_Howick**	**ANA_Lemington Rd**	**RHB_HVOW Wilton**	**RHB_MTO South CHPP**
Results	**Units**	Fresh Pasture-GREEN fraction	Fresh Pasture-GREEN fraction	Fresh Pasture-GREEN fraction	Fresh Pasture-GREEN fraction	Fresh Pasture-GREEN fraction
Dry Matter	%	34.3	33.1	39.6	31.7	37.2
Neutral Detergent Fibre	%	68	65	62	69	65
Acid Detergent Fibre	%	39	40	37	40	38
*Water Soluble Carbohydrate	%	<4.0	<4.0	<4.0	<4.0	<4.0
Crude Protein	%	4.0	10.8	6.2	6.7	7.9
Inorganic Ash	%	10	9	10	10	9
Organic Matter	%	90	91	90	90	91
DMD	%	55	61	65	53	58
DOMD	%	54	59	62	52	56
*AFIA Grade		c4	b3	a4	c4	c4
Metabolisable Energy	MJ/kg DM	7.9	9.0	9.6	7.5	8.4

Specimen Type: Forage

		0025	**0026**	**0027**	**0028**
		RHB_HVOW Plane Dump	**RHB_WML TD1**	**RHB_HVON Carrington**	**RHB_MTO North Dump**
Results	**Units**	Fresh Pasture-GREEN fraction	Fresh Pasture-GREEN fraction	Fresh Pasture-GREEN fraction	Fresh Pasture-GREEN fraction
Dry Matter	%	34.2	34.6	35.4	34.7
Neutral Detergent Fibre	%	65	68	65	66
Acid Detergent Fibre	%	40	39	38	38
*Water Soluble Carbohydrate	%	4.7	<4.0	8.1	5.7
Crude Protein	%	10.3	6.0	7.5	4.3
Inorganic Ash	%	12	9	10	9
Organic Matter	%	88	91	90	91
DMD	%	60	57	60	61
DOMD	%	58	55	58	58
*AFIA Grade		b3	c4	b4	b3
Metabolisable Energy	MJ/kg DM	8.7	8.2	8.7	8.9

Comment(s): **DMD** = Dry Matter Digestibility
DOMD = Digestible Organic Matter in the Dry Matter

LOR = Limit of Reporting, the minimum quantity that can be reported with confidence.

All results are reported on a dry matter basis unless otherwise stated. All units of % are g/100g equivalent.

The results apply to the sample(s) as provided to the laboratory.

“For any further information or assistance on interpretation of results, please contact your local Livestock Officer.”

Copies

Appendix B

Soil Analysis Results

Appendix B Soil Analysis Results

SESL AUSTRALIA
Environment & Soil Sciences

Soil Chemistry Profile

Mehlich 3 - Multi-nutrient Extractant

Sample Drop Off: 16 Chilvers Road
Thornleigh NSW 2120

Mailing Address: PO Box 357
Pennant Hills NSW 1715

Tel: 1300 30 40 80
Fax: 1300 64 46 89
Em: info@sesl.com.au
Web: www.sesl.com.au

Batch N°: 33837 **Sample N°: 1** **Date Received: 3/3/15** **Report Status:** ○ **Draft** ● **Final**

Client Name: **AECOM - Newcastle**
Client Contact: **Matthieu Catteau**
Client Job N°:
Client Order N°:
Address: **PO Box 73**
HRMC NSW 2310

Project Name: **60340733 - C & A Rehabilitation Monitoring 2015**
MTW & HVO Mine Sites
SESL Quote N°: **Q4235**
Sample Name: **ANA-North CHPP**
Description: **Soil**
Test Type: **FSC, TOC_DC, M5**

RECOMMENDATIONS

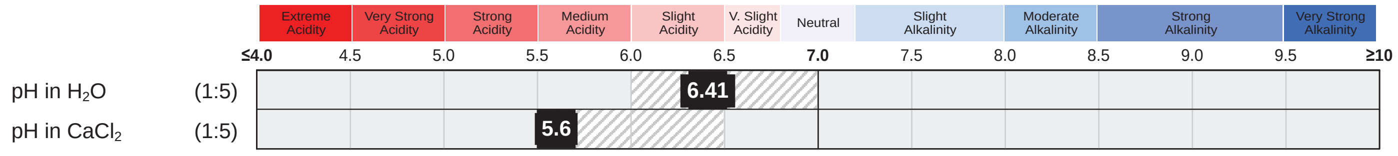
This soil sample submitted by the client was analysed for properties related to healthy plant growth, specifically the rehabilitation of soil to support pasture species. It is acidic, not saline and moderately sodic. The cation balance is magnesic. The effective cation exchange capacity (eCEC) is moderate, indicating good nutrient retention and holding capacity. The magnicity and sodicity will likely mean that any fines in this soil are dispersive and prone to erosion.

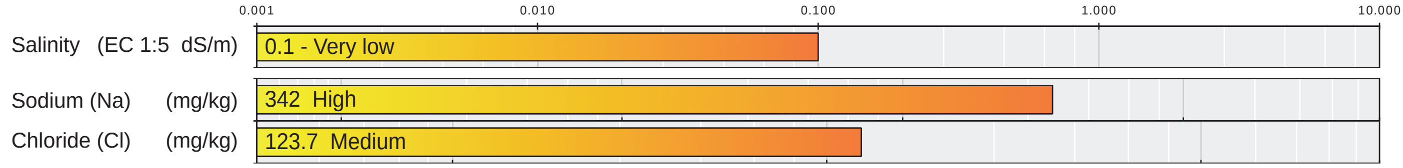
Of the plant available nutrients, N will prove most limiting to plant growth. This should be increased through split urea applications at 10 g/sqm (i.e. 2 x 10 g applications, or 2x100 kg/ha). P and K levels are also low. Apply superphosphate and muriate of potash both at 20 g/sqm (200 kg/ha). Applications of gypsum at 300 g/sqm (3 t/ha) will assist in balancing the cations and preventing any dispersion. These applications are considered the minimum to ensure pasture success.

Additionally, future application of a multi purpose NPK fertiliser (such as Dynamic Lifter or Pasture Starter) will ensure adequate nutrition as the

SOIL SAMPLE DEPTH (mm): ○ **100** ● **150** ○ **200**   FERTILITY RATING: ○ Low ● Moderate ○ High

pH and ELECTRICAL CONDUCTIVITY

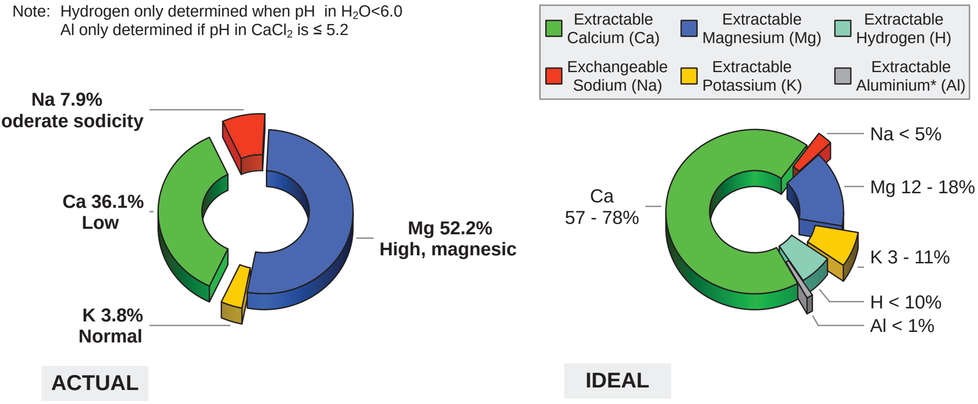




CATION BALANCE

EXCHANGEABLE CATION PERCENTAGE

Note: Hydrogen only determined when pH in $H_2O<6.0$
Al only determined if pH in $CaCl_2$ is ≤ 5.2



EFFECTIVE CATION EXCHANGE CAPACITY (eCEC)

CATION RATIOS

Ratio	Result	Target Range
Ca:Mg	0.7	4.1 – 6.0
Comment: Potential Calcium deficiency		
Mg:K	13.7	2.6 – 5.0
Comment: Potential Potassium deficiency		
K/(Ca+Mg)	0.04	< 0.07
Comment: Acceptable		
K:Na	0.5	N/A

Sodium Absorption Ratio: 0 Low

Electrochemical Stability Index (ESI):
0.01 High potential for dispersion and soil structure collapse

SOLUBLE CATIONS (meq/100g)

Na: K: Ca: Mg:

A member of the Australasian Soil and Plant Analysis Council
† This laboratory has been awarded a Certificate of Proficiency for specific soil and plant tissue analyses by the Australasian Soil and Plant Analysis Council (ASPAC). Tests for which proficiency has been demonstrated are highlighted in this report.

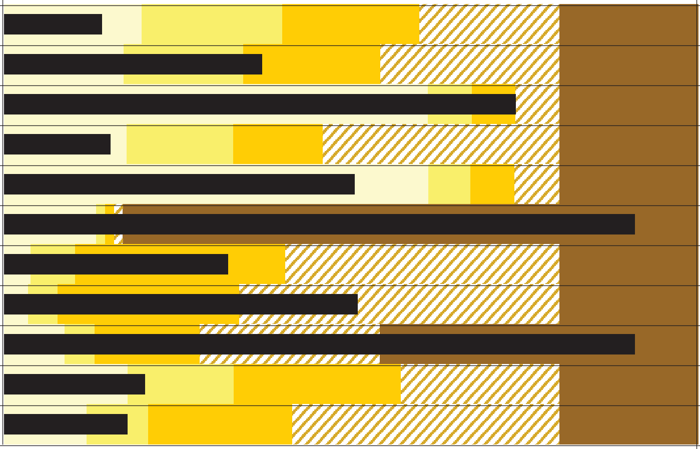
Soil Chemistry Profile

Mehlich 3 - Multi-nutrient Extractant

Sample Drop Off: 16 Chilvers Road
Thornleigh NSW 2120
Tel: 1300 30 40 80
Fax: 1300 64 46 89
Mailing Address: PO Box 357
Pennant Hills NSW 1715
Em: info@sesl.com.au
Web: www.sesl.com.au

Batch N°: 33837 **Sample N°: 1** **Date Received: 3/3/15** **Report Status:** ○ **Draft** ● **Final**

PLANT AVAILABLE NUTRIENTS



Major Nutrients	**Result** (mg/kg)	☐ Very Low 🟨 Low 🟧 Marginal ▨ Adequate 🟫 High	**Result** (g/sqm)	**Desirable** (g/sqm)	**Adjustment** (g/sqm)
Nitrate-N (NO_3)	3.7		0.7	6	5.3
Phosphate-P (PO_4)	30.2		6	12.6	6.6
Potassium (K) †	280		55.9	60.6	4.7
Sulphate-S (SO_4)	13		2.6	13.6	11
Calcium (Ca) †	1366		272.5	431.7	159.2
Magnesium (Mg) †	1198		239	44.9	Drawdown
Iron (Fe)	222.7		44.4	110.1	65.7
Manganese (Mn) †	28		5.6	8.8	3.2
Zinc (Zn) †	8.4		1.7	1	Drawdown
Copper (Cu)	1.6		0.3	1.3	1
Boron (B) †	0.6		0.1	0.5	0.4

Explanation of graph ranges:

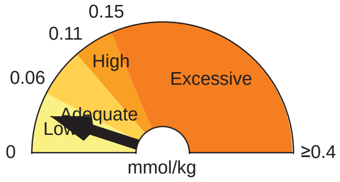
- ☐ **Very Low** Growth is likely to be severely depressed and deficiency symptoms present. Large applications for soil building purposes are usually recommended. Potential response to nutrient addition is >90%.
- 🟨 **Low** Potential "hidden hunger", or sub-clinical deficiency. Potential response to nutrient addition is 60 to 90%.
- 🟧 **Marginal** Supply of this nutrient is barely adequate for the plant, and build-up is still recommended. Potential response to nutrient addition is 30 to 60%.
- ▨ **Adequate** Supply of this nutrient is adequate for the plant, and and only maintenance application rates are recommended. Potential response to nutrient addition is 5 to 30%.
- 🟫 **High** The level is excessive and may be detrimental to plant growth (i.e. phytotoxic) and may contribute to pollution of ground and surface waters. Drawdown is recommended. Potential response to nutrient addition is <2%.

NOTES: Adjustment recommendation calculates the elemental application to shift the soil test level to within the **Adequate** band, which maximises growth/yield, and economic efficiency, and minimises impact on the environment.

Drawdown: The objective nutrient management is to utilise residual soil nutrients. There is no agronomic reason to apply fertiliser when soil test levels exceed **Adequate**.

- g/sqm measurements are based on soil bulk density of 1.33 tonne/m^3 and selected soil depth.

Phosphorus Saturation Index



0.04

Low. Plant response to applied P is likely.

Exchangeable Acidity

Adams-Evans Buffer pH (BpH): -
Sum of Base Cations (meq/100g^{-1}): **18.9**
Eff. Cation Exch. Capacity (eCEC): **18.9**
Base Saturation (%): **100**
Exchangeable Acidity (meq/100g^{-1}): -
Exchangeable Acidity (%): -

Lime Application Rate

– to achieve pH 6.0 (g/sqm): **0**
– to neutralise Al (g/sqm): -

Gypsum Application Rate

– to achieve 67.5% exch. Ca (g/sqm): **1019**

The CGAR is corrected for a soil depth of 150mm and any Lime addition to achieve pH 6.0.

Physical Description

Texture: -
Colour: -
Estimated clay content: **Did not test**
Size: -
Gravel content: -
Aggregate strength: -
Structural unit: **Did not test**
Potential infiltration rate: **Did Not Test**
Permeability (mm/hr): **Did not test**
Calculated EC_{SE} (dS/m): -

Requires EC and Soil Texture result.

Organic Carbon (OC%)†: **4.9 – Very high**
Organic Matter (OM%): **8.3**
Additional comments:

Consultant: Bronwyn Brennan

BWoodward.

Authorised Signatory: Declan McDonald

D McDonald

Date Report Generated 15/03/2015

METHOD REFERENCES:
pH (1:5 H_2O) - Rayment & Higginson (1992) 4A1,
pH (1:5 $CaCl_2$) - Rayment & Higginson (1992) 4B1,
EC (1:5) - Rayment & Higginson (1992) 3A1,
Chloride - Rayment & Higginson (1992) 5A2,
Nitrate - Rayment & Higginson (1992) 7B1
Aluminium - SESL in-house,
PO_4, K, SO_4, Ca, Mg, Na, Fe, Mn, Zn, Cu, B - Mehlich 3 (1984),
Buffer pH and Hydrogen - Adams-Evans (1972)
Texture/Structure/Colour - PM0003 (Texture- "Northcote" (1992), Structure- "Murphy" (1991), Colour- "Munsell" (2000))

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AUSTRALIA
Environment & Soil Sciences

Soil Chemistry Profile

Mehlich 3 - Multi-nutrient Extractant

Sample Drop Off: 16 Chilvers Road
Thornleigh NSW 2120
Mailing Address: PO Box 357
Pennant Hills NSW 1715
Tel: 1300 30 40 80
Fax: 1300 64 46 89
Em: info@sesl.com.au
Web: www.sesl.com.au

Batch N°: 33837 **Sample N°: 2** **Date Received: 3/3/15** **Report Status:** ○ **Draft** ● **Final**

Client Name: **AECOM - Newcastle**
Client Contact: **Matthieu Catteau**
Client Job N°:
Client Order N°:
Address: **PO Box 73**
HRMC NSW 2310

Project Name: **60340733 - C & A Rehabilitation Monitoring 2015**
MTW & HVO Mine Sites
SESL Quote N°: **Q4235**
Sample Name: **ANA-Parnells**
Description: **Soil**
Test Type: **FSC, TOC_DC, M5**

RECOMMENDATIONS

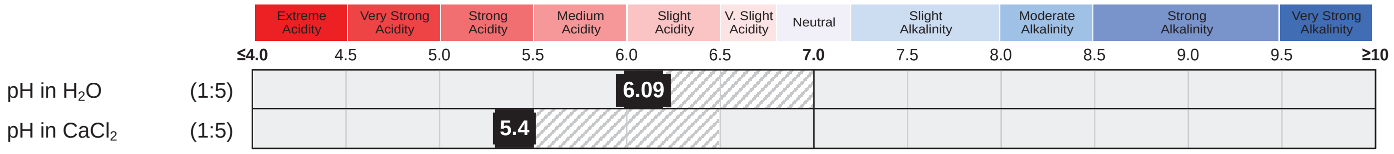
This soil sample submitted by the client was analysed for properties related to healthy plant growth, specifically the rehabilitation of soil to support pasture species. It is acidic, not saline and not sodic. The cation balance is magnesic. The effective cation exchange capacity (eCEC) is moderate, indicating good nutrient retention and holding capacity.

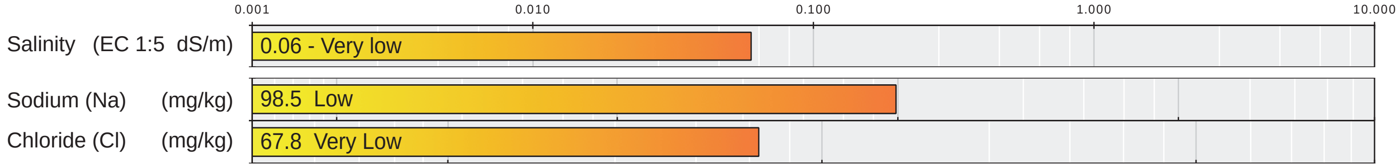
Of the plant available nutrients, N will prove most limiting to plant growth. This should be increased through split urea applications at 10 g/sqm (i.e. 2 x 10 g applications, or 200 kg/ha in total). P levels are also low. Apply super phosphate at 20 g/sqm (200 kg/ha). Applications of gypsum at 100 g/sqm (1 t/ha) will assist in balancing the cations and preventing any dispersion. These applications are considered the minimum to ensure pasture success.

Additionally, future application of a multi purpose NPK fertiliser (such as Dynamic Lifter or Pasture Starter) will ensure adequate nutrition as the pasture establishes.

SOIL SAMPLE DEPTH (mm): ○ **100** ● **150** ○ **200** FERTILITY RATING: ○ Low ● Moderate ○ High

pH and ELECTRICAL CONDUCTIVITY

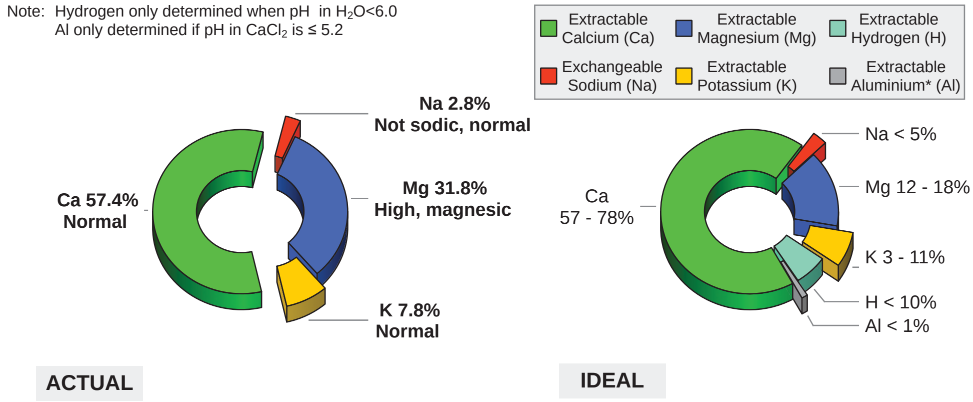




CATION BALANCE

EXCHANGEABLE CATION PERCENTAGE

Note: Hydrogen only determined when pH in H_2O<6.0
Al only determined if pH in $CaCl_2$ is ≤ 5.2



EFFECTIVE CATION EXCHANGE CAPACITY (eCEC)

CATION RATIOS

Ratio	Result	Target Range
Ca:Mg	1.8	4.1 – 6.0
Comment: Calcium low		
Mg:K	4.1	2.6 – 5.0
Comment: Balanced		
K/(Ca+Mg)	0.09	< 0.07
Comment: High		
K:Na	2.8	N/A

Sodium Absorption Ratio: 0 Low

Electrochemical Stability Index (ESI):
0.02 High potential for dispersion and soil structure collapse

SOLUBLE CATIONS (meq/100g)

Na: K: Ca: Mg:

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Environment & Soil Sciences

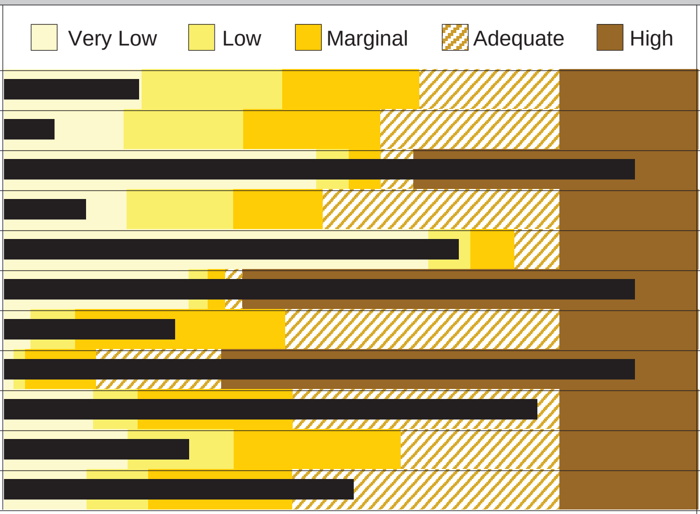
Soil Chemistry Profile

Mehlich 3 - Multi-nutrient Extractant

Sample Drop Off: 16 Chilvers Road
Thornleigh NSW 2120
Mailing Address: PO Box 357
Pennant Hills NSW 1715
Tel: 1300 30 40 80
Fax: 1300 64 46 89
Em: info@sesl.com.au
Web: www.sesl.com.au

Batch N°: 33837 **Sample N°: 2** **Date Received: 3/3/15** **Report Status:** ○ Draft ● Final

PLANT AVAILABLE NUTRIENTS



Major Nutrients	Result (mg/kg)	Result (g/sqm)	Desirable (g/sqm)	Adjustment (g/sqm)
Nitrate-N (NO_3)	5.1	1	6	5
Phosphate-P (PO_4)	5.9	1.2	12.6	11.4
Potassium (K) †	469	93.6	60.6	Drawdown
Sulphate-S (SO_4)	10	2	13.6	11.6
Calcium (Ca) †	1772	353.5	431.7	78.2
Magnesium (Mg) †	596	118.9	44.9	Drawdown
Iron (Fe)	169.7	33.9	110.1	76.2
Manganese (Mn) †	128	25.5	8.8	Drawdown
Zinc (Zn) †	4.8	1	1	0
Copper (Cu)	2.1	0.4	1.3	0.9
Boron (B) †	1.7	0.3	0.5	0.2

Explanation of graph ranges:

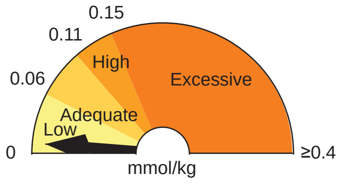
☐ **Very Low**	🟨 **Low**	🟧 **Marginal**	▨ **Adequate**	🟫 **High**
Growth is likely to be severely depressed and deficiency symptoms present. Large applications for soil building purposes are usually recommended. Potential response to nutrient addition is >90%.	Potential “hidden hunger”, or sub-clinical deficiency. Potential response to nutrient addition is 60 to 90%.	Supply of this nutrient is barely adequate for the plant, and build-up is still recommended. Potential response to nutrient addition is 30 to 60%.	Supply of this nutrient is adequate for the plant, and and only maintenance application rates are recommended. Potential response to nutrient addition is 5 to 30%.	The level is excessive and may be detrimental to plant growth (i.e. phytotoxic) and may contribute to pollution of ground and surface waters. Drawdown is recommended. Potential response to nutrient addition is <2%.

NOTES: Adjustment recommendation calculates the elemental application to shift the soil test level to within the **Adequate** band, which maximises growth/yield, and economic efficiency, and minimises impact on the environment.

Drawdown: The objective nutrient management is to utilise residual soil nutrients. There is no agronomic reason to apply fertiliser when soil test levels exceed **Adequate**.

- g/sqm measurements are based on soil bulk density of 1.33 tonne/m^3 and selected soil depth.

Phosphorus Saturation Index



0.01

Low. Plant response to applied P is likely.

Exchangeable Acidity

Adams-Evans Buffer pH (BpH):	**7.4**
Sum of Base Cations (meq/100g^{-1}):	**15.4**
Eff. Cation Exch. Capacity (eCEC):	**15.4**
Base Saturation (%):	**100**
Exchangeable Acidity (meq/100g^{-1}):	**-**
Exchangeable Acidity (%):	**-**

Lime Application Rate

– to achieve pH 6.0 (g/sqm):	**0**
– to neutralise Al (g/sqm):	**-**

Gypsum Application Rate

– to achieve 67.5% exch. Ca (g/sqm):	**267**

The CGAR is corrected for a soil depth of 150mm and any Lime addition to achieve pH 6.0.

Physical Description

Texture:	**-**
Colour:	**-**
Estimated clay content:	**Did not test**
Size:	**-**
Gravel content:	**-**
Aggregate strength:	**-**
Structural unit:	**Did not test**
Potential infiltration rate:	**Did Not Test**
Permeability (mm/hr):	**Did not test**
Calculated EC$_{SE}$ (dS/m):	**-**

Requires EC and Soil Texture result.

Organic Carbon (OC%)†: **3.9 – Very high**
Organic Matter (OM%): **6.6**
Additional comments:

Consultant: Bronwyn Brennan

BWoodward.

Authorised Signatory: Declan McDonald

D McDonald.

Date Report Generated 15/03/2015

METHOD REFERENCES:
pH (1:5 H_2O) - Rayment & Higginson (1992) 4A1,
pH (1:5 $CaCl_2$) - Rayment & Higginson (1992) 4B1,
EC (1:5) - Rayment & Higginson (1992) 3A1,
Chloride - Rayment & Higginson (1992) 5A2,
Nitrate - Rayment & Higginson (1992) 7B1
Aluminium - SESL in-house,
PO_4, K, SO_4, Ca, Mg, Na, Fe, Mn, Zn, Cu, B - Mehlich 3 (1984),
Buffer pH and Hydrogen - Adams-Evans (1972)
Texture/Structure/Colour - PM0003 (Texture- "Northcote" (1992), Structure- "Murphy" (1991), Colour- "Munsell" (2000))

ASPAC

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Disclaimer: Tests are performed under a quality system complying with ISO 9001: 2008. Results are based on the analysis of the sample taken or received by SESL. Due to the variability of sampling procedures, environmental conditions and managerial factors, SESL does not accept any liability for a lack of performance based on its interpretation and recommendations. This document must not be reproduced except in full.

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Environment & Soil Sciences

Soil Chemistry Profile

Mehlich 3 - Multi-nutrient Extractant

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Batch N°: 33837 **Sample N°: 3** **Date Received: 3/3/15** **Report Status:** ○ **Draft** ● **Final**

Client Name:	**AECOM - Newcastle**	Project Name:	**60340733 - C & A Rehabilitation Monitoring 2015 MTW & HVO Mine Sites**
Client Contact:	**Matthieu Catteau**		
Client Job N°:		SESL Quote N°:	**Q4235**
Client Order N°:		Sample Name:	**ANA-Knodlers Lane**
Address:	**PO Box 73 HRMC NSW 2310**	Description:	**Soil**
		Test Type:	**FSC, TOC_DC, M5**

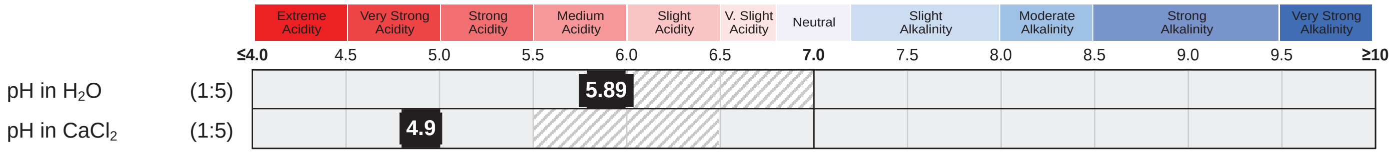
RECOMMENDATIONS

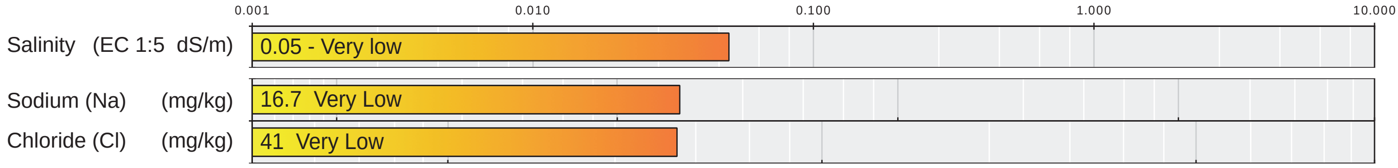
This soil sample submitted by the client was analysed for properties related to healthy plant growth, specifically the rehabilitation of soil to support pasture species. It is strongly acidic, not saline and not sodic. The cation balance is dominated by hydrogen, leading to the acidity. The effective cation exchange capacity (eCEC) is low, indicating poor nutrient retention and holding capacity. We recommend raising the pH to above 5.5 in CaCl2 to prevent toxicities. Achieve this through incorporating lime at 200 g/sqm (or 2 t/ha).

Of the plant available nutrients, N will prove most limiting to plant growth. This should be increased through split urea applications at 10 g/sqm (i.e. 2 x 10 g applications, 200 kg/ha in total). P levels are also low. Apply super phosphate (DAP) at 20 g/sqm (200 kg/ha). Applications of gypsum at 100 g/sqm (1 t/ha) will assist in balancing the cations and preventing any dispersion. These applications are considered the minimum to ensure pasture success. Additionally, future application of a multi purpose NPK fertiliser (such as Dynamic Lifter or Pasture Starter) will ensure adequate nutrition as the pasture establishes.

SOIL SAMPLE DEPTH (mm): ○ **100** ● **150** ○ **200** FERTILITY RATING: ○ Low ● Moderate ○ High

pH and ELECTRICAL CONDUCTIVITY

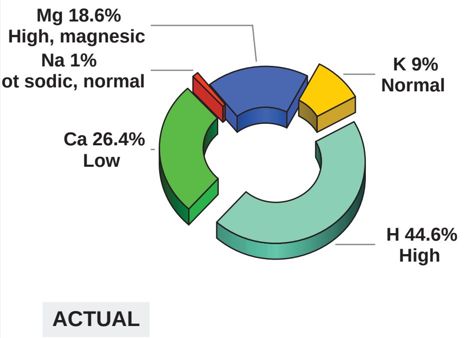


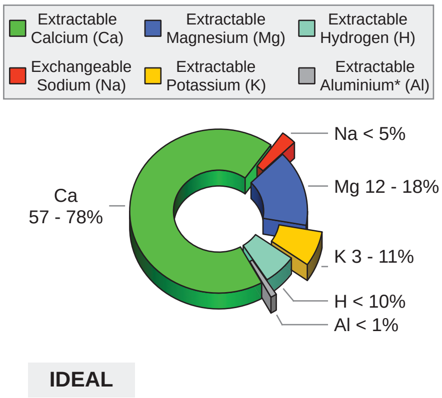


CATION BALANCE

EXCHANGEABLE CATION PERCENTAGE

Note: Hydrogen only determined when pH in $H_2O<6.0$
Al only determined if pH in $CaCl_2$ is ≤ 5.2





EFFECTIVE CATION EXCHANGE CAPACITY (eCEC)

CATION RATIOS

Ratio	Result	Target Range
Ca:Mg	**1.4**	4.1 – 6.0
Comment: Calcium low		
Mg:K	**2.1**	2.6 – 5.0
Comment: Magnesium low		
K/(Ca+Mg)	**0.2**	< 0.07
Comment: High		
K:Na	**9**	N/A

Sodium Absorption Ratio: 0 Low

Electrochemical Stability Index (ESI):
0.05 Moderate potential for dispersion and soil structure collapse

SOLUBLE CATIONS (meq/100g)

Na: K: Ca: Mg:

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Soil Chemistry Profile

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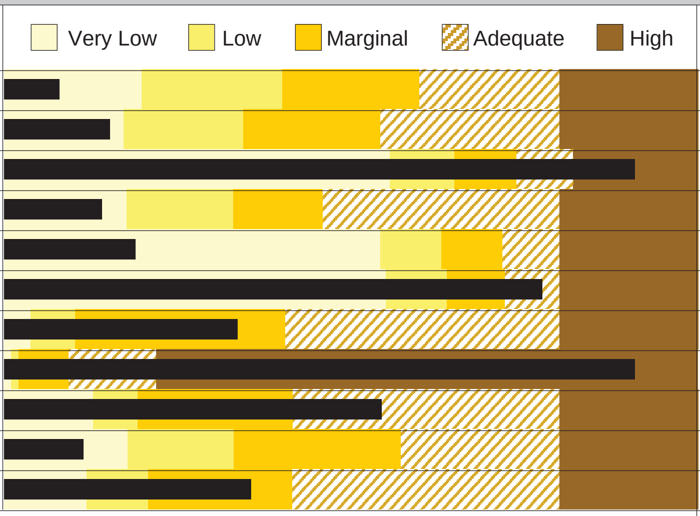
Batch N°: 33837 **Sample N°: 3** **Date Received: 3/3/15** **Report Status:** ○ Draft ● Final

PLANT AVAILABLE NUTRIENTS



Major Nutrients	Result (mg/kg)	Result (g/sqm)	Desirable (g/sqm)	Adjustment (g/sqm)
Nitrate-N (NO_3)	2.1	0.4	6	5.6
Phosphate-P (PO_4)	12.4	2.5	12.6	10.1
Potassium (K) †	244	48.7	43.9	Drawdown
Sulphate-S (SO_4)	12	2.4	13.6	11.2
Calcium (Ca) †	371	74	312.4	238.4
Magnesium (Mg) †	158	31.5	32.5	1
Iron (Fe)	232	46.3	110.1	63.8
Manganese (Mn) †	183	36.5	8.8	Drawdown
Zinc (Zn) †	3.4	0.7	1	0.3
Copper (Cu)	0.9	0.2	1.3	1.1
Boron (B) †	1.2	0.2	0.5	0.3

Explanation of graph ranges:

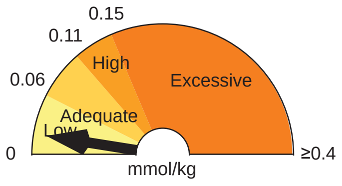
☐ **Very Low**	☐ **Low**	■ **Marginal**	▨ **Adequate**	■ **High**
Growth is likely to be severely depressed and deficiency symptoms present. Large applications for soil building purposes are usually recommended. Potential response to nutrient addition is >90%.	Potential "hidden hunger", or sub-clinical deficiency. Potential response to nutrient addition is 60 to 90%.	Supply of this nutrient is barely adequate for the plant, and build-up is still recommended. Potential response to nutrient addition is 30 to 60%.	Supply of this nutrient is adequate for the plant, and only maintenance application rates are recommended. Potential response to nutrient addition is 5 to 30%.	The level is excessive and may be detrimental to plant growth (i.e. phytotoxic) and may contribute to pollution of ground and surface waters. Drawdown is recommended. Potential response to nutrient addition is <2%.

NOTES: Adjustment recommendation calculates the elemental application to shift the soil test level to within the **Adequate** band, which maximises growth/yield, and economic efficiency, and minimises impact on the environment.

Drawdown: The objective nutrient management is to utilise residual soil nutrients. There is no agronomic reason to apply fertiliser when soil test levels exceed **Adequate**.

- g/sqm measurements are based on soil bulk density of 1.33 tonne/m^3 and selected soil depth.

Phosphorus Saturation Index



0.02

Low. Plant response to applied P is likely.

Exchangeable Acidity

Adams-Evans Buffer pH (BpH):	**7.5**
Sum of Base Cations (meq/100g^{-1}):	**3.9**
Eff. Cation Exch. Capacity (eCEC):	**7**
Base Saturation (%):	**55.71**
Exchangeable Acidity (meq/100g^{-1}):	**3.12**
Exchangeable Acidity (%):	**44.57**

Lime Application Rate

– to achieve pH 6.0 (g/sqm):	**208**
– to neutralise Al (g/sqm):	**0**

Gypsum Application Rate

– to achieve 67.5% exch. Ca (g/sqm): **137**

The CGAR is corrected for a soil depth of 150mm and any Lime addition to achieve pH 6.0.

Physical Description

Texture:	**-**
Colour:	**-**
Estimated clay content:	**Did not test**
Size:	**-**
Gravel content:	**-**
Aggregate strength:	**-**
Structural unit:	**Did not test**
Potential infiltration rate:	**Did Not Test**
Permeability (mm/hr):	**Did not test**
Calculated EC_{SE} (dS/m):	**-**

Requires EC and Soil Texture result.

Organic Carbon (OC%)†: **2.4 – High**
Organic Matter (OM%): **4.1**
Additional comments:

Consultant: Bronwyn Brennan

Authorised Signatory: Declan McDonald

Date Report Generated 15/03/2015

METHOD REFERENCES:
pH (1:5 H_2O) - Rayment & Higginson (1992) 4A1,
pH (1:5 $CaCl_2$) - Rayment & Higginson (1992) 4B1,
EC (1:5) - Rayment & Higginson (1992) 3A1,
Chloride - Rayment & Higginson (1992) 5A2,
Nitrate - Rayment & Higginson (1992) 7B1
Aluminium - SESL in-house,
PO_4, K, SO_4, Ca, Mg, Na, Fe, Mn, Zn, Cu, B - Mehlich 3 (1984),
Buffer pH and Hydrogen - Adams-Evans (1972)
Texture/Structure/Colour - PM0003 (Texture- "Northcote" (1992), Structure- "Murphy" (1991), Colour- "Munsell" (2000))

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Soil Chemistry Profile

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Batch N°: 33837 **Sample N°: 4** **Date Received: 3/3/15** **Report Status:** ○ **Draft** ● **Final**

Client Name: **AECOM - Newcastle**
Client Contact: **Matthieu Catteau**
Client Job N°:
Client Order N°:
Address: **PO Box 73**
HRMC NSW 2310

Project Name: **60340733 - C & A Rehabilitation Monitoring 2015**
MTW & HVO Mine Sites
SESL Quote N°: **Q4235**
Sample Name: **ANA Carrington Billabong**
Description: **Soil**
Test Type: **FSC, TOC_DC, M5**

RECOMMENDATIONS

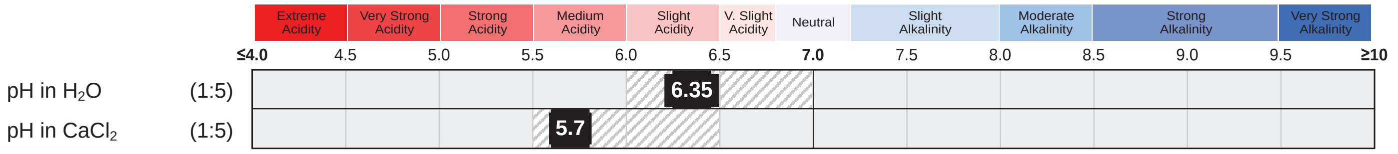
This soil sample submitted by the client was analysed for properties related to healthy plant growth, specifically the rehabilitation of soil to support pasture species. It is acidic, not saline and not sodic. The cation balance is magnesic. The effective cation exchange capacity (eCEC) is high, indicating excellent nutrient retention and holding capacity.

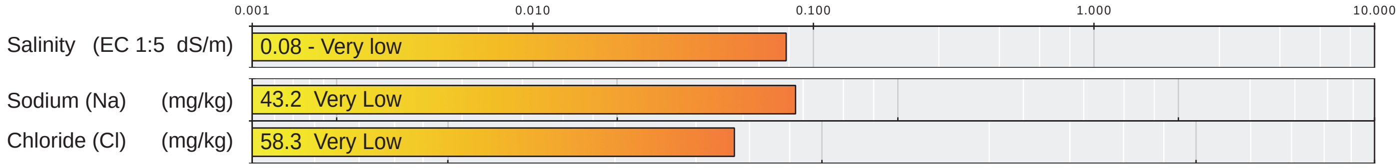
Of the plant available nutrients, N will prove most limiting to plant growth. This should be increased through split urea applications at 10 g/sqm (i.e. 2 x 10 g applications, or 200 kg/ha in total). Applications of gypsum at 200 g/sqm (2 t/ha) will assist in balancing the cations and preventing any dispersion. These applications are considered the minimum to ensure pasture success.

Additionally, future application of a multi purpose NPK fertiliser (such as Dynamic Lifter or Pasture Starter) will ensure adequate nutrition as the pasture establishes.

SOIL SAMPLE DEPTH (mm): ○ **100** ● **150** ○ **200** FERTILITY RATING: ○ Low ● Moderate ○ High

pH and ELECTRICAL CONDUCTIVITY

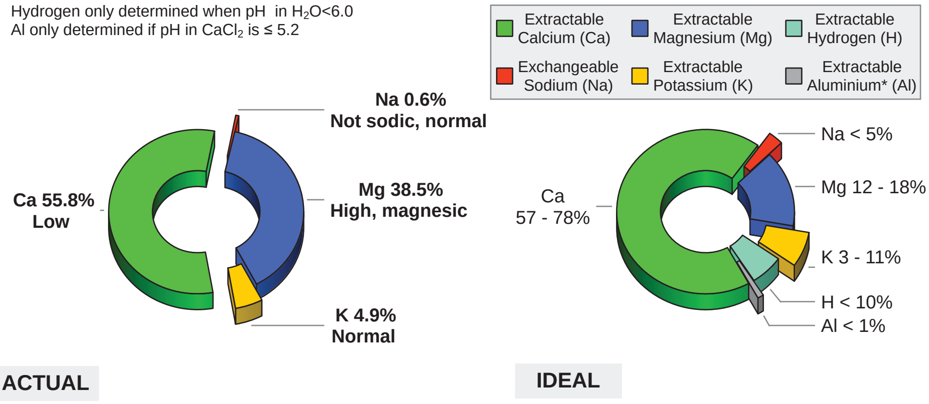




CATION BALANCE

EXCHANGEABLE CATION PERCENTAGE

Note: Hydrogen only determined when pH in H_2O<6.0
Al only determined if pH in $CaCl_2$ is ≤ 5.2



EFFECTIVE CATION EXCHANGE CAPACITY (eCEC)

CATION RATIOS

Ratio	Result	Target Range
Ca:Mg	1.4	4.1 – 6.0
Comment: Calcium low		
Mg:K	7.8	2.6 – 5.0
Comment: Potassium low		
K/(Ca+Mg)	0.05	< 0.07
Comment: Acceptable		
K:Na	7.7	N/A

Sodium Absorption Ratio: 0 Low

Electrochemical Stability Index (ESI):
0.13 Low potential for dispersion and soil structure collapse

SOLUBLE CATIONS (meq/100g)

Na: K: Ca: Mg:

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Soil Chemistry Profile

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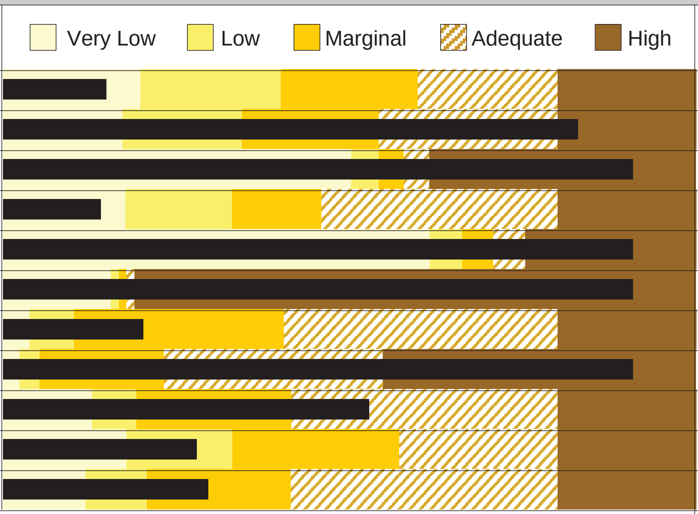
Batch N°: 33837 **Sample N°: 4** **Date Received: 3/3/15** **Report Status:** ○ **Draft** ● **Final**

PLANT AVAILABLE NUTRIENTS



Major Nutrients	Result (mg/kg)	Result (g/sqm)	Desirable (g/sqm)	Adjustment (g/sqm)
Nitrate-N (NO_3)	3.9	0.8	6	5.2
Phosphate-P (PO_4)	67.4	13.4	12.6	Drawdown
Potassium (K) †	574	114.5	77.4	Drawdown
Sulphate-S (SO_4)	12	2.4	13.6	11.2
Calcium (Ca) †	3335	665.3	551.2	Drawdown
Magnesium (Mg) †	1394	278.1	57.7	Drawdown
Iron (Fe)	139.7	27.9	110.1	82.2
Manganese (Mn) †	73	14.6	8.8	Drawdown
Zinc (Zn) †	3.3	0.7	1	0.3
Copper (Cu)	2.2	0.4	1.3	0.9
Boron (B) †	1	0.2	0.5	0.3

Explanation of graph ranges:

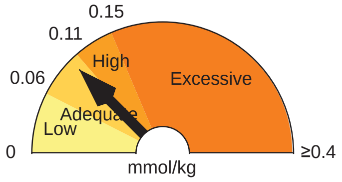
☐ **Very Low**	🟨 **Low**	🟧 **Marginal**	▨ **Adequate**	🟫 **High**
Growth is likely to be severely depressed and deficiency symptoms present. Large applications for soil building purposes are usually recommended. Potential response to nutrient addition is >90%.	Potential "hidden hunger", or sub-clinical deficiency. Potential response to nutrient addition is 60 to 90%.	Supply of this nutrient is barely adequate for the plant, and build-up is still recommended. Potential response to nutrient addition is 30 to 60%.	Supply of this nutrient is adequate for the plant, and and only maintenance application rates are recommended. Potential response to nutrient addition is 5 to 30%.	The level is excessive and may be detrimental to plant growth (i.e. phytotoxic) and may contribute to pollution of ground and surface waters. Drawdown is recommended. Potential response to nutrient addition is <2%.

NOTES: Adjustment recommendation calculates the elemental application to shift the soil test level to within the **Adequate** band, which maximises growth/yield, and economic efficiency, and minimises impact on the environment.

Drawdown: The objective nutrient management is to utilise residual soil nutrients. There is no agronomic reason to apply fertiliser when soil test levels exceed **Adequate**.

- g/sqm measurements are based on soil bulk density of 1.33 tonne/m^3 and selected soil depth.

Phosphorus Saturation Index



0.1

Adequate. Economic response to P unlikely. P application recommended maintaining current P level.

Exchangeable Acidity

Adams-Evans Buffer pH (BpH): -
Sum of Base Cations (meq/100g^{-1}): **29.8**
Eff. Cation Exch. Capacity (eCEC): **29.8**
Base Saturation (%): **100**
Exchangeable Acidity (meq/100g^{-1}): -
Exchangeable Acidity (%): -

Lime Application Rate

– to achieve pH 6.0 (g/sqm): **0**
– to neutralise Al (g/sqm): -

Gypsum Application Rate

– to achieve 67.5% exch. Ca (g/sqm): **597**

The CGAR is corrected for a soil depth of 150mm and any Lime addition to achieve pH 6.0.

Physical Description

Texture: -
Colour: -
Estimated clay content: **Did not test**
Size: -
Gravel content: -
Aggregate strength: -
Structural unit: **Did not test**
Potential infiltration rate: **Did Not Test**
Permeability (mm/hr): **Did not test**
Calculated EC_{SE} (dS/m): -

Requires EC and Soil Texture result.

Organic Carbon (OC%)†: **4.8 – Very high**
Organic Matter (OM%): **8.1**
Additional comments:

Consultant: Bronwyn Brennan

Authorised Signatory: Declan McDonald

D McDonald

Date Report Generated 15/03/2015

METHOD REFERENCES:
pH (1:5 H_2O) - Rayment & Higginson (1992) 4A1,
pH (1:5 $CaCl_2$) - Rayment & Higginson (1992) 4B1,
EC (1:5) - Rayment & Higginson (1992) 3A1,
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Nitrate - Rayment & Higginson (1992) 7B1
Aluminium - SESL in-house,
PO_4, K, SO_4, Ca, Mg, Na, Fe, Mn, Zn, Cu, B - Mehlich 3 (1984),
Buffer pH and Hydrogen - Adams-Evans (1972)
Texture/Structure/Colour - PM0003 (Texture-
"Northcote" (1992), Structure- "Murphy" (1991), Colour- "Munsell" (2000))

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Soil Chemistry Profile

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Web: www.sesl.com.au

Batch N°: 33837 **Sample N°: 5** **Date Received: 3/3/15** **Report Status:** ○ **Draft** ● **Final**

Client Name:	**AECOM - Newcastle**	Project Name:	**60340733 - C & A Rehabilitation Monitoring 2015** **MTW & HVO Mine Sites**
Client Contact:	**Matthieu Catteau**	SESL Quote N°:	**Q4235**
Client Job N°:		Sample Name:	**ANA-Newport**
Client Order N°:		Description:	**Soil**
Address:	**PO Box 73** **HRMC NSW 2310**	Test Type:	**FSC, TOC_DC, M5**

RECOMMENDATIONS

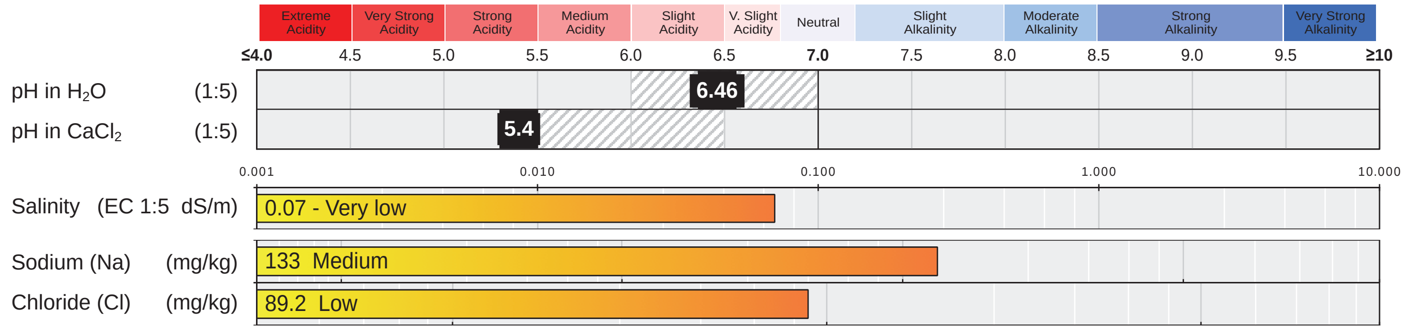
This soil sample submitted by the client was analysed for properties related to healthy plant growth, specifically the rehabilitation of soil to support pasture species. It is acidic, not saline and not sodic. The cation balance is magnesic. The effective cation exchange capacity (eCEC) is moderate, indicating good nutrient retention and holding capacity.

Of the plant available nutrients, N will prove most limiting to plant growth. This should be increased through split urea applications at 10 g/sqm (i.e. 2 x 10 g applications, or 200 kg/ha in total). P levels are also low. Apply super phosphate (DAP) at 20 g/sqm (200 kg/ha). Applications of gypsum at 300 g/sqm (3 t/ha) will assist in balancing the cations and preventing any dispersion. These applications are considered the minimum to ensure pasture success.

Additionally, future application of a multi purpose NPK fertiliser (such as Dynamic Lifter or Pasture Starter) will ensure adequate nutrition as the pasture establishes.

SOIL SAMPLE DEPTH (mm): ○ **100** ● **150** ○ **200** FERTILITY RATING: ○ Low ● Moderate ○ High

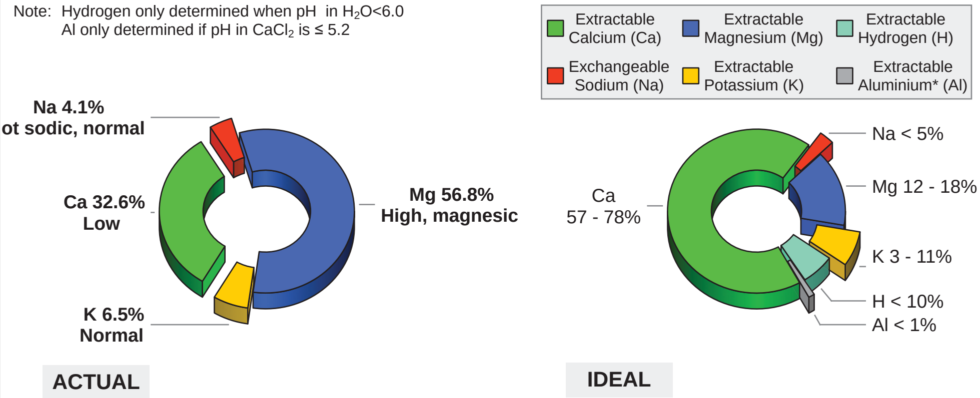
pH and ELECTRICAL CONDUCTIVITY



CATION BALANCE

EXCHANGEABLE CATION PERCENTAGE

Note: Hydrogen only determined when pH in H_2O<6.0
Al only determined if pH in $CaCl_2$ is ≤ 5.2



EFFECTIVE CATION EXCHANGE CAPACITY (eCEC)

CATION RATIOS

Ratio	Result	Target Range
Ca:Mg	0.6	4.1 – 6.0
Comment: Potential Calcium deficiency		
Mg:K	8.7	2.6 – 5.0
Comment: Potassium low		
K/(Ca+Mg)	0.07	< 0.07
Comment: High		
K:Na	1.6	N/A

Sodium Absorption Ratio: 0 Low

Electrochemical Stability Index (ESI):
0.02 High potential for dispersion and soil structure collapse

SOLUBLE CATIONS (meq/100g)

Na: K: Ca: Mg:

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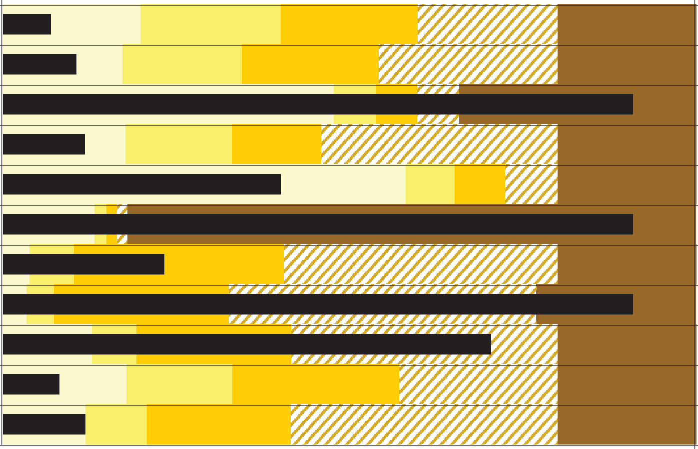
Soil Chemistry Profile

Mehlich 3 - Multi-nutrient Extractant

Sample Drop Off: 16 Chilvers Road
Thornleigh NSW 2120
Mailing Address: PO Box 357
Pennant Hills NSW 1715
Tel: 1300 30 40 80
Fax: 1300 64 46 89
Em: info@sesl.com.au
Web: www.sesl.com.au

Batch N°: 33837 **Sample N°: 5** **Date Received: 3/3/15** **Report Status:** ○ **Draft** ● **Final**

PLANT AVAILABLE NUTRIENTS

Major Nutrients	**Result** (mg/kg)	 ▢ Very Low 🟨 Low 🟧 Marginal ▨ Adequate 🟫 High	**Result** (g/sqm)	**Desirable** (g/sqm)	**Adjustment** (g/sqm)
Nitrate-N (NO_3)	1.8		0.4	6	5.6
Phosphate-P (PO_4)	8.6		1.7	12.6	10.9
Potassium (K) †	362		72.2	52.3	Drawdown
Sulphate-S (SO_4)	10		2	13.6	11.6
Calcium (Ca) †	933		186.1	372.1	186
Magnesium (Mg) †	986		196.7	38.7	Drawdown
Iron (Fe)	160.2		32	110.1	78.1
Manganese (Mn) †	52		10.4	8.8	Drawdown
Zinc (Zn) †	4.4		0.9	1	0.1
Copper (Cu)	<0.64		0.1	1.3	1.2
Boron (B) †	0.4		0.1	0.5	0.4

Explanation of graph ranges:

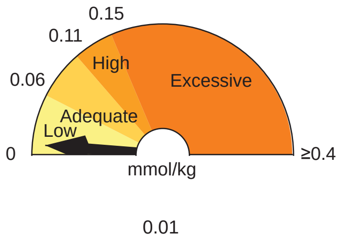
▢ **Very Low**	🟨 **Low**	🟧 **Marginal**	▨ **Adequate**	🟫 **High**
Growth is likely to be severely depressed and deficiency symptoms present. Large applications for soil building purposes are usually recommended. Potential response to nutrient addition is >90%.	Potential "hidden hunger", or sub-clinical deficiency. Potential response to nutrient addition is 60 to 90%.	Supply of this nutrient is barely adequate for the plant, and build-up is still recommended. Potential response to nutrient addition is 30 to 60%.	Supply of this nutrient is adequate for the plant, and and only maintenance application rates are recommended. Potential response to nutrient addition is 5 to 30%.	The level is excessive and may be detrimental to plant growth (i.e. phytotoxic) and may contribute to pollution of ground and surface waters. Drawdown is recommended. Potential response to nutrient addition is <2%.

NOTES: Adjustment recommendation calculates the elemental application to shift the soil test level to within the **Adequate** band, which maximises growth/yield, and economic efficiency, and minimises impact on the environment.

Drawdown: The objective nutrient management is to utilise residual soil nutrients. There is no agronomic reason to apply fertiliser when soil test levels exceed **Adequate**.

- g/sqm measurements are based on soil bulk density of 1.33 tonne/m^3 and selected soil depth.

Phosphorus Saturation Index



Low. Plant response to applied P is likely.

Exchangeable Acidity

Adams-Evans Buffer pH (BpH): **7.3**
Sum of Base Cations (meq/100g^{-1}): **14.3**
Eff. Cation Exch. Capacity (eCEC): **14.3**
Base Saturation (%): **100**
Exchangeable Acidity (meq/100g^{-1}): **-**
Exchangeable Acidity (%): **-**

Lime Application Rate

– to achieve pH 6.0 (g/sqm): **0**
– to neutralise Al (g/sqm): **-**

Gypsum Application Rate

– to achieve 67.5% exch. Ca (g/sqm): **857**

The CGAR is corrected for a soil depth of 150mm and any Lime addition to achieve pH 6.0.

Physical Description

Texture: **-**
Colour: **-**
Estimated clay content: **Did not test**
Size: **-**
Gravel content: **-**
Aggregate strength: **-**
Structural unit: **Did not test**
Potential infiltration rate: **Did Not Test**
Permeability (mm/hr): **Did not test**
Calculated EC_{SE} (dS/m): **-**

Requires EC and Soil Texture result.

Organic Carbon (OC%)†: **2.5 – High**
Organic Matter (OM%): **4.2**
Additional comments:

Consultant: Bronwyn Brennan

Authorised Signatory: Declan McDonald

Date Report Generated 15/03/2015

METHOD REFERENCES:
pH (1:5 H_2O) - Rayment & Higginson (1992) 4A1,
pH (1:5 $CaCl_2$) - Rayment & Higginson (1992) 4B1,
EC (1:5) - Rayment & Higginson (1992) 3A1,
Chloride - Rayment & Higginson (1992) 5A2,
Nitrate - Rayment & Higginson (1992) 7B1
Aluminium - SESL in-house,
PO_4, K, SO_4, Ca, Mg, Na, Fe, Mn, Zn, Cu, B - Mehlich 3 (1984),
Buffer pH and Hydrogen - Adams-Evans (1972)
Texture/Structure/Colour - PM0003 (Texture-
"Northcote" (1992), Structure- "Murphy" (1991), Colour- "Munsell" (2000))

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SESL AUSTRALIA
Environment & Soil Sciences

Soil Chemistry Profile

Mehlich 3 - Multi-nutrient Extractant

Sample Drop Off: 16 Chilvers Road
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Web: www.sesl.com.au

Batch N°: 33837 **Sample N°: 6** **Date Received: 3/3/15** **Report Status:** ○ Draft ● Final

Client Name: **AECOM - Newcastle**
Client Contact: **Matthieu Catteau**
Client Job N°:
Client Order N°:
Address: **PO Box 73**
HRMC NSW 2310

Project Name: **60340733 - C & A Rehabilitation Monitoring 2015**
MTW & HVO Mine Sites
SESL Quote N°: **Q4235**
Sample Name: **ANA-Cheshunt**
Description: **Soil**
Test Type: **FSC, TOC_DC, M5**

RECOMMENDATIONS

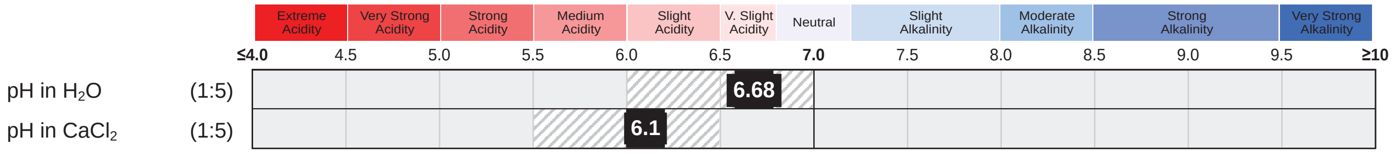
This soil sample submitted by the client was analysed for properties related to healthy plant growth, specifically the rehabilitation of soil to support pasture species. It is acidic, not saline and not sodic. The cation balance is magnesic. The effective cation exchange capacity (eCEC) is high, indicating excellent nutrient retention and holding capacity.

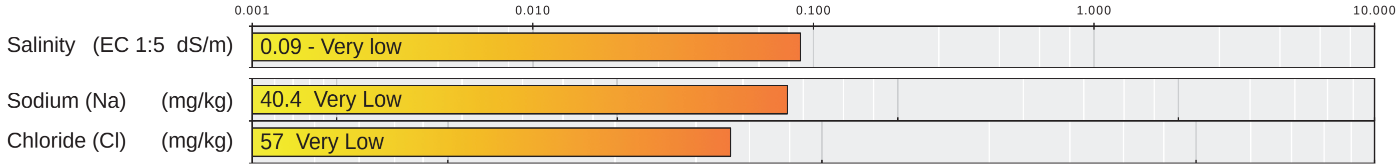
Of the plant available nutrients, N will prove most limiting to plant growth. This should be increased through split urea applications at 10 g/sqm (i.e. 2 x 10 g applications, or 200 kg/ha). Applications of gypsum at 200 g/sqm (2 t/ha) will assist in balancing the cations and preventing any dispersion. These applications are considered the minimum to ensure pasture success.

Additionally, future application of a multi purpose NPK fertiliser (such as Dynamic Lifter or Pasture Starter) will ensure adequate nutrition as the pasture establishes.

SOIL SAMPLE DEPTH (mm): ○ **100** ● **150** ○ **200** FERTILITY RATING: ○ Low ● Moderate ○ High

pH and ELECTRICAL CONDUCTIVITY

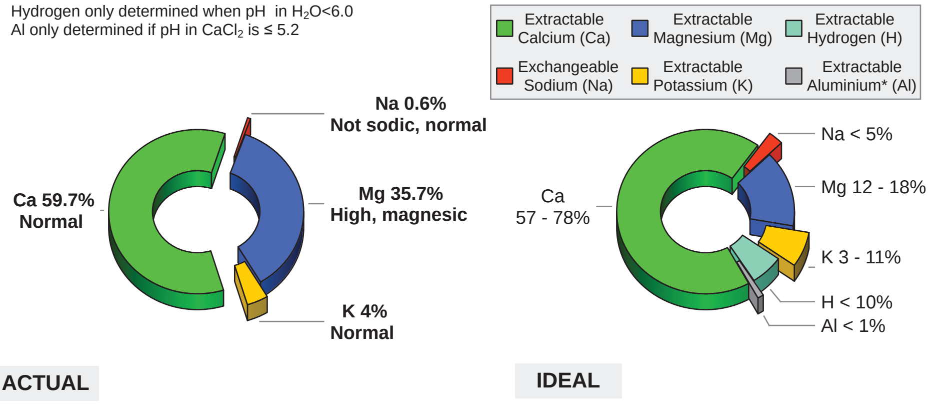




CATION BALANCE

EXCHANGEABLE CATION PERCENTAGE

Note: Hydrogen only determined when pH in H_2O<6.0
Al only determined if pH in $CaCl_2$ is ≤ 5.2



EFFECTIVE CATION EXCHANGE CAPACITY (eCEC)

CATION RATIOS

Ratio	**Result**	**Target Range**
Ca:Mg	**1.7**	4.1 – 6.0
Comment: Calcium low		
Mg:K	**8.9**	2.6 – 5.0
Comment: Potassium low		
K/(Ca+Mg)	**0.04**	< 0.07
Comment: Acceptable		
K:Na	**6.4**	N/A

Sodium Absorption Ratio: 0 Low

Electrochemical Stability Index (ESI):
0.15 Low potential for dispersion and soil structure collapse

SOLUBLE CATIONS (meq/100g)

Na: K: Ca: Mg:

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Soil Chemistry Profile

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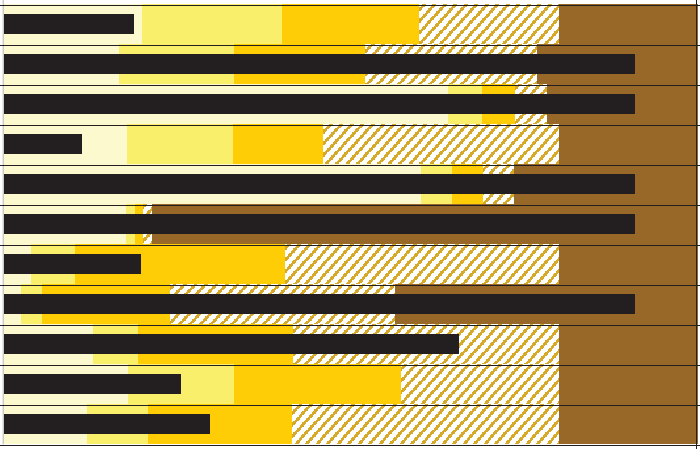
Batch N°: 33837 **Sample N°: 6** **Date Received: 3/3/15** **Report Status:** ○ Draft ● Final

PLANT AVAILABLE NUTRIENTS



Major Nutrients	Result (mg/kg)	☐ Very Low 🟨 Low 🟧 Marginal ▨ Adequate 🟫 High	Result (g/sqm)	Desirable (g/sqm)	Adjustment (g/sqm)
Nitrate-N (NO_3)	4.9		1	6	5
Phosphate-P (PO_4)	77		15.4	12.6	Drawdown
Potassium (K) †	451		90	77.4	Drawdown
Sulphate-S (SO_4)	9.5		1.9	13.6	11.7
Calcium (Ca) †	3420		682.3	551.2	Drawdown
Magnesium (Mg) †	1240		247.4	57.7	Drawdown
Iron (Fe)	135.5		27	110.1	83.1
Manganese (Mn) †	71		14.2	8.8	Drawdown
Zinc (Zn) †	4.1		0.8	1	0.2
Copper (Cu)	2		0.4	1.3	0.9
Boron (B) †	1		0.2	0.5	0.3

Explanation of graph ranges:

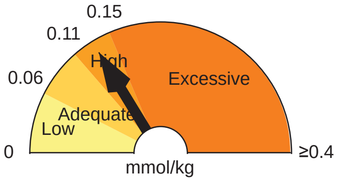
- ☐ **Very Low** Growth is likely to be severely depressed and deficiency symptoms present. Large applications for soil building purposes are usually recommended. Potential response to nutrient addition is >90%.
- 🟨 **Low** Potential "hidden hunger", or sub-clinical deficiency. Potential response to nutrient addition is 60 to 90%.
- 🟧 **Marginal** Supply of this nutrient is barely adequate for the plant, build-up is still recommended. Potential response to nutrient addition is 30 to 60%.
- ▨ **Adequate** Supply of this nutrient is adequate for the plant, and and only maintenance application rates are recommended. Potential response to nutrient addition is 5 to 30%.
- 🟫 **High** The level is excessive and may be detrimental to plant growth (i.e. phytotoxic) and may contribute to pollution of ground and surface waters. Drawdown is recommended. Potential response to nutrient addition is <2%.

NOTES: Adjustment recommendation calculates the elemental application to shift the soil test level to within the **Adequate** band, which maximises growth/yield, and economic efficiency, and minimises impact on the environment.

Drawdown: The objective nutrient management is to utilise residual soil nutrients. There is no agronomic reason to apply fertiliser when soil test levels exceed **Adequate**.

- g/sqm measurements are based on soil bulk density of 1.33 tonne/m^3 and selected soil depth.

Phosphorus Saturation Index



0.13

High. Soil P will not limit plant growth. No P recommended this season.

Exchangeable Acidity

Adams-Evans Buffer pH (BpH): -
Sum of Base Cations (meq/100g^{-1}): **28.6**
Eff. Cation Exch. Capacity (eCEC): **28.6**
Base Saturation (%): **100**
Exchangeable Acidity (meq/100g^{-1}): -
Exchangeable Acidity (%): -

Lime Application Rate

– to achieve pH 6.0 (g/sqm): **0**
– to neutralise Al (g/sqm): -

Gypsum Application Rate

– to achieve 67.5% exch. Ca (g/sqm): **384**

The CGAR is corrected for a soil depth of 150mm and any Lime addition to achieve pH 6.0.

Physical Description

Texture: -
Colour: -
Estimated clay content: **Did not test**
Size: -
Gravel content: -
Aggregate strength: -
Structural unit: **Did not test**
Potential infiltration rate: **Did Not Test**
Permeability (mm/hr): **Did not test**
Calculated EC_{SE} (dS/m): -

Requires EC and Soil Texture result.

Organic Carbon (OC%)†: **4 – Very high**
Organic Matter (OM%): **6.8**
Additional comments:

Consultant: Bronwyn Brennan

BWoodward.

Authorised Signatory: Declan McDonald

D McDonald.

Date Report Generated 15/03/2015

METHOD REFERENCES:
pH (1:5 H_2O) - Rayment & Higginson (1992) 4A1,
pH (1:5 $CaCl_2$) - Rayment & Higginson (1992) 4B1,
EC (1:5) - Rayment & Higginson (1992) 3A1,
Chloride - Rayment & Higginson (1992) 5A2,
Nitrate - Rayment & Higginson (1992) 7B1
Aluminium - SESL in-house,
PO_4, K, SO_4, Ca, Mg, Na, Fe, Mn, Zn, Cu, B - Mehlich 3 (1984),
Buffer pH and Hydrogen - Adams-Evans (1972)
Texture/Structure/Colour - PM0003 (Texture- "Northcote" (1992), Structure- "Murphy" (1991), Colour- "Munsell" (2000))

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Environment & Soil Sciences

Soil Chemistry Profile

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Web: www.sesl.com.au

Batch N°: 33837 **Sample N°: 7** **Date Received: 3/3/15** **Report Status:** ○ **Draft** ● **Final**

Client Name: **AECOM - Newcastle**
Client Contact: **Matthieu Catteau**
Client Job N°:
Client Order N°:
Address: **PO Box 73**
HRMC NSW 2310

Project Name: **60340733 - C & A Rehabilitation Monitoring 2015**
MTW & HVO Mine Sites
SESL Quote N°: **Q4235**
Sample Name: **ANA-Howick**
Description: **Soil**
Test Type: **FSC, TOC_DC, M5**

RECOMMENDATIONS

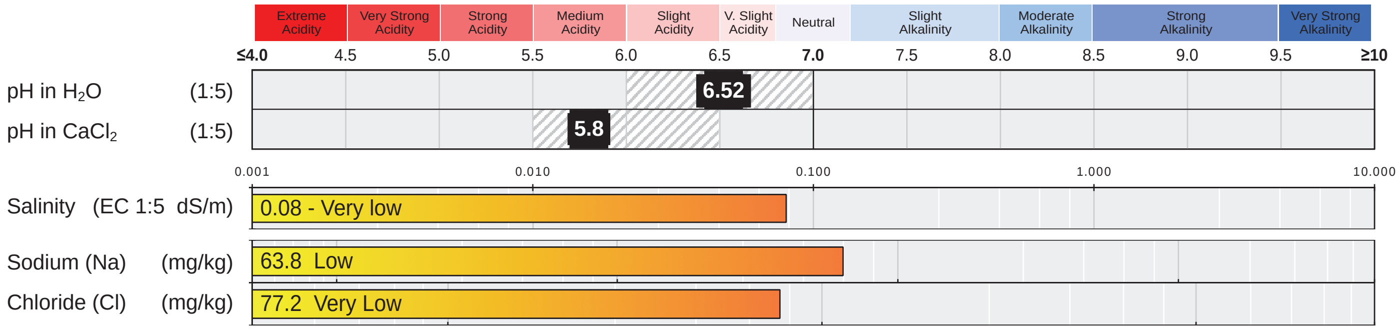
This soil sample submitted by the client was analysed for properties related to healthy plant growth, specifically the rehabilitation of soil to support pasture species. It is acidic, not saline and not sodic. The cation balance is magnesic. The effective cation exchange capacity (eCEC) is moderate, indicating good nutrient retention and holding capacity.

Of the plant available nutrients, N will prove most limiting to plant growth. This should be increased through split urea applications at 10 g/sqm (i.e. 2 x 10 g applications, or 200 kg/ha in total). P levels are also low. Apply super phosphate (DAP) at 30 g/sqm (300 kg/ha). Applications of gypsum at 200 g/sqm (2 t/ha) will assist in balancing the cations and preventing any dispersion. These applications are considered the minimum to ensure pasture success.

Additionally, future application of a multi purpose NPK fertiliser (such as Dynamic Lifter or Pasture Starter) will ensure adequate nutrition as the pasture establishes.

SOIL SAMPLE DEPTH (mm): ○ **100** ● **150** ○ **200** FERTILITY RATING: ○ Low ● Moderate ○ High

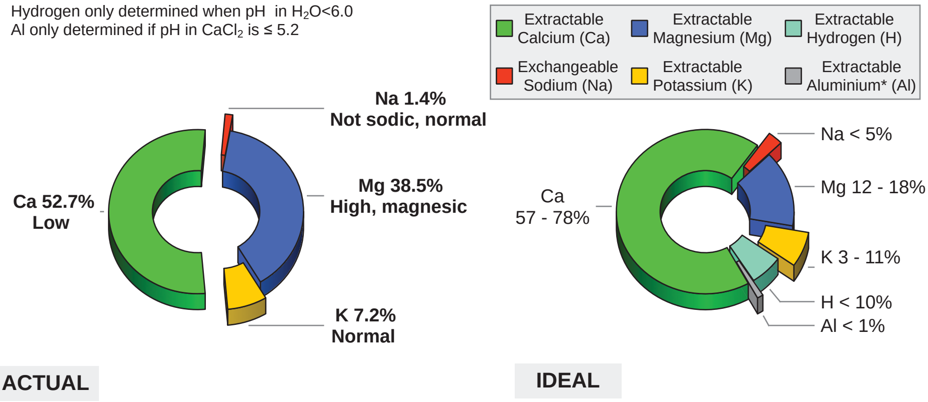
pH and ELECTRICAL CONDUCTIVITY



CATION BALANCE

EXCHANGEABLE CATION PERCENTAGE

Note: Hydrogen only determined when pH in H_2O<6.0
Al only determined if pH in $CaCl_2$ is ≤ 5.2



EFFECTIVE CATION EXCHANGE CAPACITY (eCEC)

CATION RATIOS

Ratio	Result	Target Range
Ca:Mg	1.4	4.1 – 6.0
Comment: Calcium low		
Mg:K	5.3	2.6 – 5.0
Comment: Potassium low		
K/(Ca+Mg)	0.08	< 0.07
Comment: High		
K:Na	5.3	N/A

Sodium Absorption Ratio: 0 Low

Electrochemical Stability Index (ESI):
0.06 Moderate potential for dispersion and soil structure collapse

SOLUBLE CATIONS (meq/100g)

Na: K: Ca: Mg:

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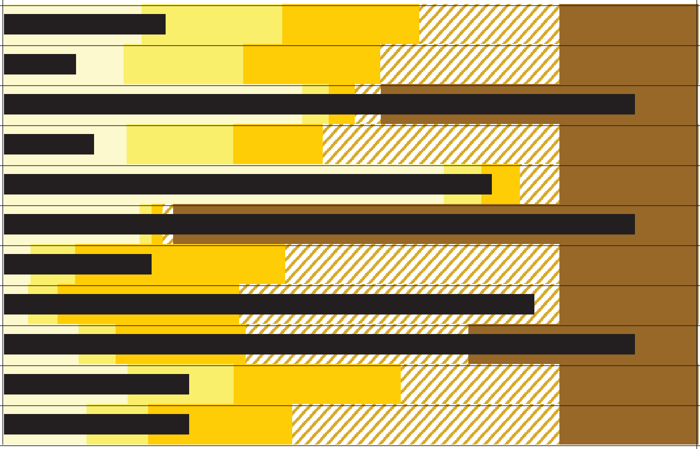
Batch N°: 33837 **Sample N°: 7** **Date Received: 3/3/15** **Report Status:** ○ Draft ● Final

PLANT AVAILABLE NUTRIENTS



Major Nutrients	Result (mg/kg)	□ Very Low 🟨 Low 🟧 Marginal ▨ Adequate 🟫 High	Result (g/sqm)	Desirable (g/sqm)	Adjustment (g/sqm)
Nitrate-N (NO_3)	6.1		1.2	6	4.8
Phosphate-P (PO_4)	8.4		1.7	12.6	10.9
Potassium (K) †	580		115.7	69	Drawdown
Sulphate-S (SO_4)	11		2.2	13.6	11.4
Calcium (Ca) †	2165		431.9	491.6	59.7
Magnesium (Mg) †	960		191.5	51.3	Drawdown
Iron (Fe)	146.6		29.2	110.1	80.9
Manganese (Mn) †	42		8.4	8.8	0.4
Zinc (Zn) †	6.8		1.4	1	Drawdown
Copper (Cu)	2.1		0.4	1.3	0.9
Boron (B) †	0.9		0.2	0.5	0.3

Explanation of graph ranges:

□ Very Low
Growth is likely to be severely depressed and deficiency symptoms present. Large applications for soil building purposes are usually recommended. Potential response to nutrient addition is >90%.

🟨 Low
Potential “hidden hunger”, or sub-clinical deficiency. Potential response to nutrient addition is 60 to 90%.

🟧 Marginal
Supply of this nutrient is barely adequate for the plant, and build-up is still recommended. Potential response to nutrient addition is 30 to 60%.

▨ Adequate
Supply of this nutrient is adequate for the plant, and only maintenance application rates are recommended. Potential response to nutrient addition is 5 to 30%.

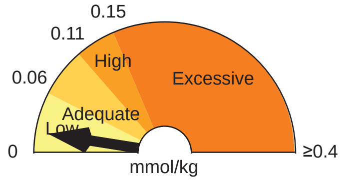
🟫 High
The level is excessive and may be detrimental to plant growth (i.e. phytotoxic) and may contribute to pollution of ground and surface waters. Drawdown is recommended. Potential response to nutrient addition is <2%.

NOTES: Adjustment recommendation calculates the elemental application to shift the soil test level to within the **Adequate** band, which maximises growth/yield, and economic efficiency, and minimises impact on the environment.

Drawdown: The objective nutrient management is to utilise residual soil nutrients. There is no agronomic reason to apply fertiliser when soil test levels exceed **Adequate**.

- g/sqm measurements are based on soil bulk density of 1.33 tonne/m^3 and selected soil depth.

Phosphorus Saturation Index



0.02

Low. Plant response to applied P is likely.

Exchangeable Acidity

Adams-Evans Buffer pH (BpH): -
Sum of Base Cations (meq/100g^{-1}): **20.5**
Eff. Cation Exch. Capacity (eCEC): **20.5**
Base Saturation (%): **100**
Exchangeable Acidity (meq/100g^{-1}): -
Exchangeable Acidity (%): -

Lime Application Rate
– to achieve pH 6.0 (g/sqm): **0**
– to neutralise Al (g/sqm): -

Gypsum Application Rate
– to achieve 67.5% exch. Ca (g/sqm): **522**
The CGAR is corrected for a soil depth of 150mm and any Lime addition to achieve pH 6.0.

Physical Description

Texture: -
Colour: -
Estimated clay content: **Did not test**
Size: -
Gravel content: -
Aggregate strength: -
Structural unit: **Did not test**
Potential infiltration rate: **Did Not Test**
Permeability (mm/hr): **Did not test**
Calculated EC_{SE} (dS/m): -
Requires EC and Soil Texture result.
Organic Carbon (OC%)†: **5.1 – Very high**
Organic Matter (OM%): **8.7**
Additional comments:

Consultant: Bronwyn Brennan

BWoodward.

Authorised Signatory: Declan McDonald

D McDonald.

Date Report Generated 15/03/2015

METHOD REFERENCES:
pH (1:5 H_2O) - Rayment & Higginson (1992) 4A1,
pH (1:5 $CaCl_2$) - Rayment & Higginson (1992) 4B1,
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Nitrate - Rayment & Higginson (1992) 7B1
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SESL AUSTRALIA
Environment & Soil Sciences

Soil Chemistry Profile

Mehlich 3 - Multi-nutrient Extractant

Sample Drop Off: 16 Chilvers Road
Thornleigh NSW 2120
Mailing Address: PO Box 357
Pennant Hills NSW 1715
Tel: 1300 30 40 80
Fax: 1300 64 46 89
Em: info@sesl.com.au
Web: www.sesl.com.au

Batch N°: 33837 **Sample N°: 8** **Date Received: 3/3/15** **Report Status:** ○ **Draft** ● **Final**

Client Name:	**AECOM - Newcastle**	Project Name:	**60340733 - C & A Rehabilitation Monitoring 2015** **MTW & HVO Mine Sites**
Client Contact:	**Matthieu Catteau**	SESL Quote N°:	**Q4235**
Client Job N°:		Sample Name:	**ANA-Lemington Rd**
Client Order N°:		Description:	**Soil**
Address:	**PO Box 73** **HRMC NSW 2310**	Test Type:	**FSC, TOC_DC, M5**

RECOMMENDATIONS

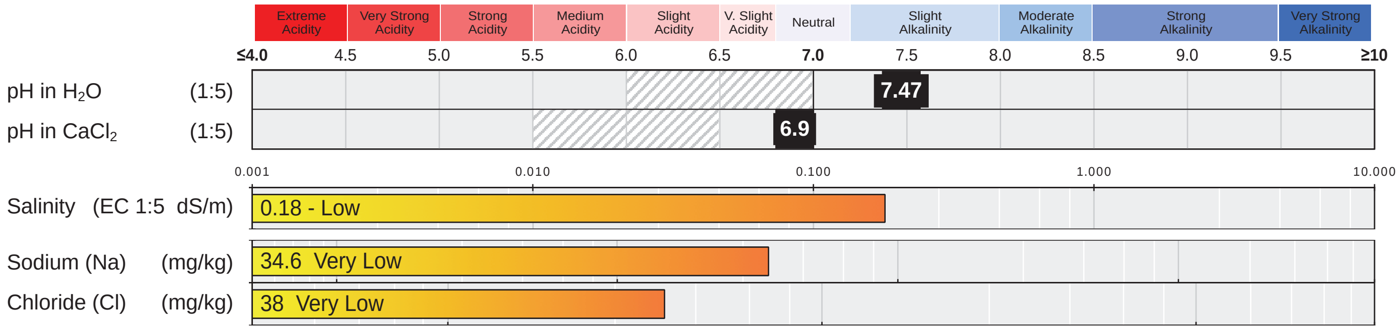
This soil sample submitted by the client was analysed for properties related to healthy plant growth, specifically the rehabilitation of soil to support pasture species. It is acidic, not saline and not sodic. The cation balance is calcic. The effective cation exchange capacity (eCEC) is high, indicating excellent nutrient retention and holding capacity.

Of the plant available nutrients, N will prove most limiting to plant growth. This should be increased through split urea applications at 10 g/sqm (i.e. 2 x 10 g applications, or 200 kg/ha in total). P levels are also low. Apply super phosphate (DAP) at 30 g/sqm (300 kg/ha). These applications are considered the minimum to ensure pasture success.

Additionally, future application of a multi purpose NPK fertiliser (such as Dynamic Lifter or Pasture Starter) will ensure adequate nutrition as the pasture establishes.

SOIL SAMPLE DEPTH (mm): ○ **100** ● **150** ○ **200** FERTILITY RATING: ○ Low ● Moderate ○ High

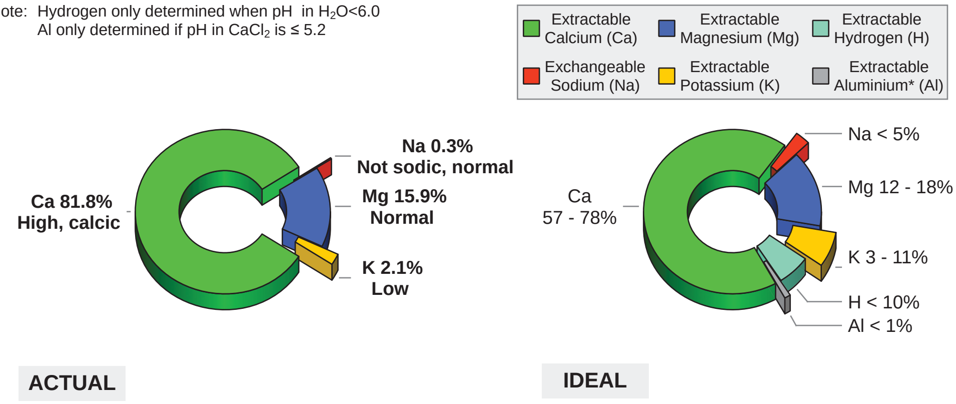
pH and ELECTRICAL CONDUCTIVITY



CATION BALANCE

EXCHANGEABLE CATION PERCENTAGE

Note: Hydrogen only determined when pH in H_2O<6.0
Al only determined if pH in $CaCl_2$ is ≤ 5.2



EFFECTIVE CATION EXCHANGE CAPACITY (eCEC)

CATION RATIOS

Ratio	Result	Target Range
Ca:Mg	5.1	4.1 – 6.0
Comment: Balanced		
Mg:K	7.6	2.6 – 5.0
Comment: Potassium low		
K/(Ca+Mg)	0.02	< 0.07
Comment: Acceptable		
K:Na	7.9	N/A

Sodium Absorption Ratio: 0 Low

Electrochemical Stability Index (ESI):
0.6 Low potential for dispersion and soil structure collapse

SOLUBLE CATIONS (meq/100g)

Na: K: Ca: Mg:

ASPAC

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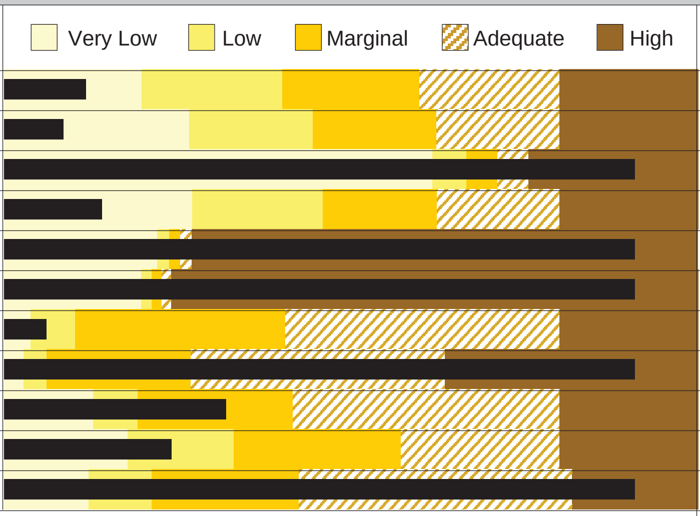
Batch N°: 33837 **Sample N°: 8** **Date Received: 3/3/15** **Report Status:** ○ Draft ● Final

PLANT AVAILABLE NUTRIENTS



Major Nutrients	Result (mg/kg)	Result (g/sqm)	Desirable (g/sqm)	Adjustment (g/sqm)
Nitrate-N (NO_3)	3.1	0.6	6	5.4
Phosphate-P (PO_4)	6.7	1.3	12.6	11.3
Potassium (K) †	467	93.2	77.4	Drawdown
Sulphate-S (SO_4)	12	2.4	13.6	11.2
Calcium (Ca) †	9306	1856.5	551.2	Drawdown
Magnesium (Mg) †	1096	218.7	57.7	Drawdown
Iron (Fe)	42.1	8.4	110.1	101.7
Manganese (Mn) †	63	12.6	8.8	Drawdown
Zinc (Zn) †	2	0.4	1	0.6
Copper (Cu)	1.9	0.4	1.3	0.9
Boron (B) †	3	0.6	0.5	Drawdown

Explanation of graph ranges:

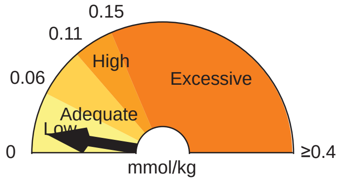
☐ **Very Low**	☐ **Low**	☐ **Marginal**	▨ **Adequate**	■ **High**
Growth is likely to be severely depressed and deficiency symptoms present. Large applications for soil building purposes are usually recommended. Potential response to nutrient addition is >90%.	Potential "hidden hunger", or sub-clinical deficiency. Potential response to nutrient addition is 60 to 90%.	Supply of this nutrient is barely adequate for the plant, and build-up is still recommended. Potential response to nutrient addition is 30 to 60%.	Supply of this nutrient is adequate for the plant, and and only maintenance application rates are recommended. Potential response to nutrient addition is 5 to 30%.	The level is excessive and may be detrimental to plant growth (i.e. phytotoxic) and may contribute to pollution of ground and surface waters. Drawdown is recommended. Potential response to nutrient addition is <2%.

NOTES: Adjustment recommendation calculates the elemental application to shift the soil test level to within the **Adequate** band, which maximises growth/yield, and economic efficiency, and minimises impact on the environment.

Drawdown: The objective nutrient management is to utilise residual soil nutrients. There is no agronomic reason to apply fertiliser when soil test levels exceed **Adequate**.

- g/sqm measurements are based on soil bulk density of 1.33 tonne/m^3 and selected soil depth.

Phosphorus Saturation Index



0.02

Low. Plant response to applied P is likely.

Exchangeable Acidity

Adams-Evans Buffer pH (BpH): -
Sum of Base Cations ($meq/100g^{-1}$): **56.8**
Eff. Cation Exch. Capacity (eCEC): **56.8**
Base Saturation (%): **100**
Exchangeable Acidity ($meq/100g^{-1}$): -
Exchangeable Acidity (%): -

Lime Application Rate

– to achieve pH 6.0 (g/sqm): **0**
– to neutralise Al (g/sqm): -

Gypsum Application Rate

– to achieve 67.5% exch. Ca (g/sqm): **0**
The CGAR is corrected for a soil depth of 150mm and any Lime addition to achieve pH 6.0.

Physical Description

Texture: -
Colour: -
Estimated clay content: **Did not test**
Size: -
Gravel content: -
Aggregate strength: -
Structural unit: **Did not test**
Potential infiltration rate: **Did Not Test**
Permeability (mm/hr): **Did not test**
Calculated EC_{SE} (dS/m): -
Requires EC and Soil Texture result.
Organic Carbon (OC%)†: **4.1 – Very high**
Organic Matter (OM%): **6.9**
Additional comments:

Consultant: Bronwyn Brennan

BWoodward.

Authorised Signatory: Declan McDonald

D McDonald.

Date Report Generated 15/03/2015

METHOD REFERENCES:
pH (1:5 H_2O) - Rayment & Higginson (1992) 4A1,
pH (1:5 $CaCl_2$) - Rayment & Higginson (1992) 4B1,
EC (1:5) - Rayment & Higginson (1992) 3A1,
Chloride - Rayment & Higginson (1992) 5A2,
Nitrate - Rayment & Higginson (1992) 7B1
Aluminium - SESL in-house,
PO_4, K, SO_4, Ca, Mg, Na, Fe, Mn, Zn, Cu, B - Mehlich 3 (1984),
Buffer pH and Hydrogen - Adams-Evans (1972)
Texture/Structure/Colour - PM0003 (Texture- "Northcote" (1992), Structure- "Murphy" (1991), Colour- "Munsell" (2000))

ASPAC

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Disclaimer: Tests are performed under a quality system complying with ISO 9001: 2008. Results are based on the analysis of the sample taken or received by SESL. Due to the variability of sampling procedures, environmental conditions and managerial factors, SESL does not accept any liability for a lack of performance based on its interpretation and recommendations. This document must not be reproduced except in full.

Soil Chemistry Profile

Mehlich 3 - Multi-nutrient Extractant

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Fax: 1300 64 46 89
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Web: www.sesl.com.au

Batch N°: 33837 **Sample N°: 9** **Date Received: 3/3/15** **Report Status:** ○ **Draft** ● **Final**

Client Name: **AECOM - Newcastle**
Client Contact: **Matthieu Catteau**
Client Job N°:
Client Order N°:
Address: **PO Box 73**
HRMC NSW 2310

Project Name: **60340733 - C & A Rehabilitation Monitoring 2015**
MTW & HVO Mine Sites
SESL Quote N°: **Q4235**
Sample Name: **RHB-MTO South CHPP**
Description: **Soil**
Test Type: **FSC, TOC_DC, M5**

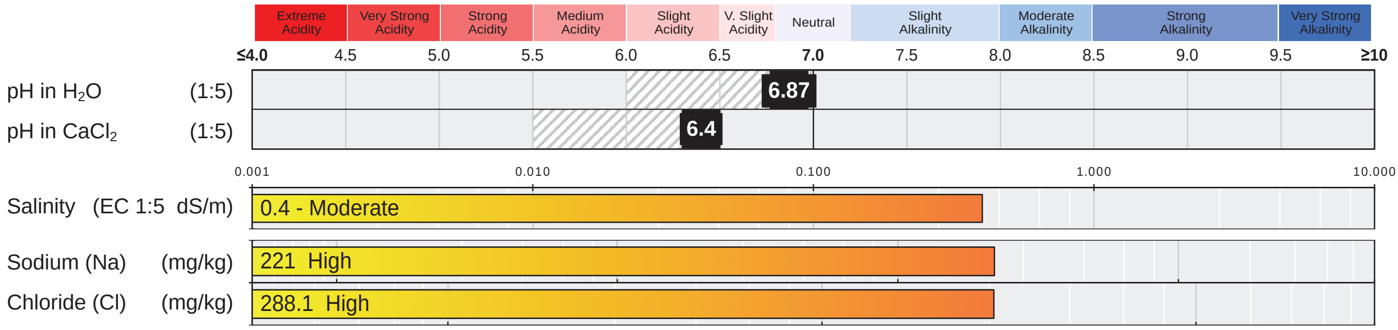
RECOMMENDATIONS

This soil sample submitted by the client was analysed for properties related to healthy plant growth, specifically the rehabilitation of soil to support pasture species. It is acidic, moderately saline and moderately sodic. The cation balance is magnesic. The effective cation exchange capacity (eCEC) is moderate, indicating good nutrient retention and holding capacity. The magnicity and sodicity will likely mean that any fines in this soil are dispersive and prone to erosion.

Of the plant available nutrients, N will prove most limiting to plant growth. This should be increased through split urea applications at 10 g/sqm (i.e. 2 x 10 g applications, or 200 kg/ha in total). P and K levels are also low. Apply super phosphate and muriate of potash both at 20 g/sqm (200 kg/ha). Applications of gypsum at 200 g/sqm (2 t/ha) will assist in balancing the cations and preventing any dispersion. This will temporarily elevate the salinity, so leaching should be encouraged through this period. These applications are considered the minimum to ensure pasture success. Additionally, future application of a multi purpose NPK fertiliser (such as Dynamic Lifter or Pasture Starter) will ensure adequate nutrition as the pasture establishes.

SOIL SAMPLE DEPTH (mm): ○ **100** ● **150** ○ **200** FERTILITY RATING: ○ Low ● Moderate ○ High

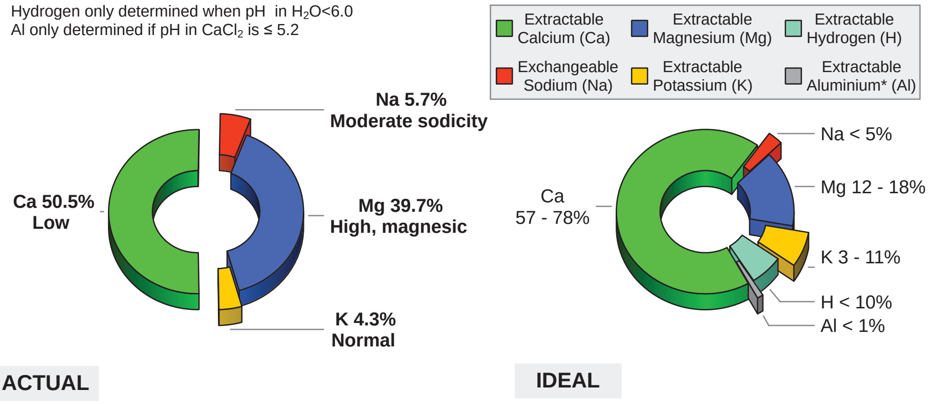
pH and ELECTRICAL CONDUCTIVITY



CATION BALANCE

EXCHANGEABLE CATION PERCENTAGE

Note: Hydrogen only determined when pH in H_2O<6.0
Al only determined if pH in $CaCl_2$ is ≤ 5.2



EFFECTIVE CATION EXCHANGE CAPACITY (eCEC)

CATION RATIOS

Ratio	Result	Target Range
Ca:Mg	1.3	4.1 – 6.0
Comment: Calcium low		
Mg:K	9.3	2.6 – 5.0
Comment: Potassium low		
K/(Ca+Mg)	0.05	< 0.07
Comment: Acceptable		
K:Na	0.7	N/A

Sodium Absorption Ratio: 0 Low

Electrochemical Stability Index (ESI):
0.07 Moderate potential for dispersion and soil structure collapse

SOLUBLE CATIONS (meq/100g)

Na: K: Ca: Mg:

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Soil Chemistry Profile

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Batch N°: 33837 **Sample N°: 9** **Date Received: 3/3/15** **Report Status:** ○ Draft ● Final

PLANT AVAILABLE NUTRIENTS

☐ Very Low ☐ Low ☐ Marginal ▨ Adequate ■ High

Major Nutrients	Result (mg/kg)	Result (g/sqm)	Desirable (g/sqm)	Adjustment (g/sqm)
Nitrate-N (NO$_3$)	2.3	0.5	6	5.5
Phosphate-P (PO$_4$)	30.4	6.1	12.6	6.5
Potassium (K) †	279	55.7	60.6	4.9
Sulphate-S (SO$_4$)	155	30.9	13.6	Drawdown
Calcium (Ca) †	1690	337.2	431.7	94.5
Magnesium (Mg) †	806	160.8	44.9	Drawdown
Iron (Fe)	127.5	25.4	110.1	84.7
Manganese (Mn) †	48	9.6	8.8	Drawdown
Zinc (Zn) †	4.9	1	1	0
Copper (Cu)	1.3	0.3	1.3	1
Boron (B) †	0.7	0.1	0.5	0.4

Explanation of graph ranges:

☐ **Very Low**
Growth is likely to be severely depressed and deficiency symptoms present. Large applications for soil building purposes are usually recommended. Potential response to nutrient addition is >90%.

☐ **Low**
Potential "hidden hunger", or sub-clinical deficiency. Potential response to nutrient addition is 60 to 90%.

☐ **Marginal**
Supply of this nutrient is barely adequate for the plant, and build-up is still recommended. Potential response to nutrient addition is 30 to 60%.

▨ **Adequate**
Supply of this nutrient is adequate for the plant, and and only maintenance application rates are recommended. Potential response to nutrient addition is 5 to 30%.

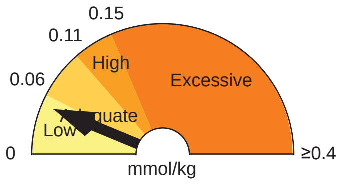
■ **High**
The level is excessive and may be detrimental to plant growth (i.e. phytotoxic) and may contribute to pollution of ground and surface waters. Drawdown is recommended. Potential response to nutrient addition is <2%.

NOTES: Adjustment recommendation calculates the elemental application to shift the soil test level to within the **Adequate** band, which maximises growth/yield, and economic efficiency, and minimises impact on the environment.

Drawdown: The objective nutrient management is to utilise residual soil nutrients. There is no agronomic reason to apply fertiliser when soil test levels exceed **Adequate**.

- g/sqm measurements are based on soil bulk density of 1.33 tonne/m^3 and selected soil depth.

Phosphorus Saturation Index



0.05

Low. Plant response to applied P is likely.

Exchangeable Acidity

Adams-Evans Buffer pH (BpH): -
Sum of Base Cations (meq/100g^{-1}): **16.7**
Eff. Cation Exch. Capacity (eCEC): **16.7**
Base Saturation (%): **100**
Exchangeable Acidity (meq/100g^{-1}): -
Exchangeable Acidity (%): -

Lime Application Rate

– to achieve pH 6.0 (g/sqm): **0**
– to neutralise Al (g/sqm): -

Gypsum Application Rate

– to achieve 67.5% exch. Ca (g/sqm): **488**
The CGAR is corrected for a soil depth of 150mm and any Lime addition to achieve pH 6.0.

Physical Description

Texture: -
Colour: -
Estimated clay content: **Did not test**
Size: -
Gravel content: -
Aggregate strength: -
Structural unit: **Did not test**
Potential infiltration rate: **Did Not Test**
Permeability (mm/hr): **Did not test**
Calculated EC$_{SE}$ (dS/m): -
Requires EC and Soil Texture result.
Organic Carbon (OC%)†: **3.8 – Very high**
Organic Matter (OM%): **6.4**
Additional comments:

Consultant: Bronwyn Brennan

Authorised Signatory: Declan McDonald

Date Report Generated 15/03/2015

METHOD REFERENCES:
pH (1:5 H$_2$O) - Rayment & Higginson (1992) 4A1,
pH (1:5 CaCl$_2$) - Rayment & Higginson (1992) 4B1,
EC (1:5) - Rayment & Higginson (1992) 3A1,
Chloride - Rayment & Higginson (1992) 5A2,
Nitrate - Rayment & Higginson (1992) 7B1
Aluminium - SESL in-house,
PO$_4$, K, SO$_4$, Ca, Mg, Na, Fe, Mn, Zn, Cu, B - Mehlich 3 (1984),
Buffer pH and Hydrogen - Adams-Evans (1972)
Texture/Structure/Colour - PM0003 (Texture- "Northcote" (1992), Structure- "Murphy" (1991), Colour- "Munsell" (2000))

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Soil Chemistry Profile

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Batch N°: 33837 **Sample N°: 10** **Date Received: 3/3/15** **Report Status:** ○ **Draft** ● **Final**

Client Name: **AECOM - Newcastle**
Client Contact: **Matthieu Catteau**
Client Job N°:
Client Order N°:
Address: **PO Box 73**
HRMC NSW 2310

Project Name: **60340733 - C & A Rehabilitation Monitoring 2015**
MTW & HVO Mine Sites
SESL Quote N°: **Q4235**
Sample Name: **RHB-HVOW Plane Dump**
Description: **Soil**
Test Type: **FSC, TOC_DC, M5**

RECOMMENDATIONS

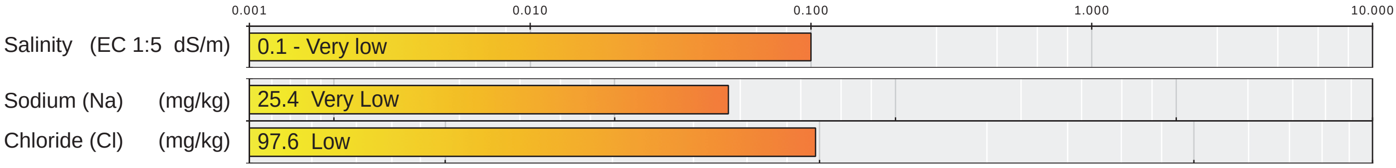
This soil sample submitted by the client was analysed for properties related to healthy plant growth, specifically the rehabilitation of soil to support pasture species. It is slightly alkaline, not saline and not sodic. The cation balance is magnesic. The effective cation exchange capacity (eCEC) is moderate, indicating good nutrient retention and holding capacity.

Of the plant available nutrients, N will prove most limiting to plant growth. This should be increased through split urea applications at 10 g/sqm (i.e. 2 x 10 g applications, or 200 kg/ha in total). P levels are also low. Apply super phosphate at 20 g/sqm (200 kg/ha). Applications of gypsum at 200 g/sqm (2 t/ha) will assist in balancing the cations and preventing any dispersion. These applications are considered the minimum to ensure pasture success.

Additionally, future application of a multi purpose NPK fertiliser (such as Dynamic Lifter or Pasture Starter) will ensure adequate nutrition as the pasture establishes.

SOIL SAMPLE DEPTH (mm): ○ **100** ● **150** ○ **200**   FERTILITY RATING: ○ Low ● Moderate ○ High

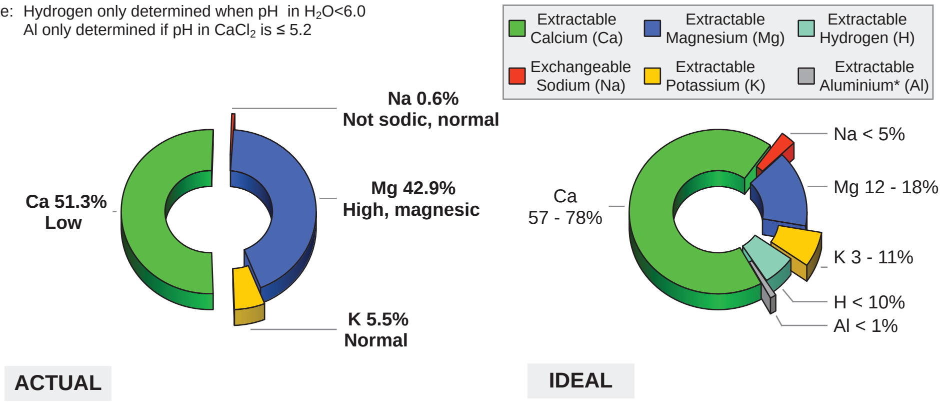
pH and ELECTRICAL CONDUCTIVITY



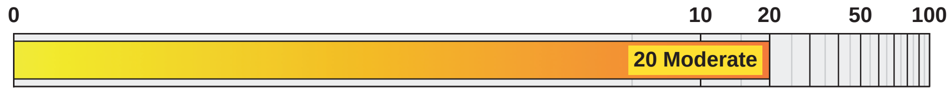
CATION BALANCE

EXCHANGEABLE CATION PERCENTAGE

Note: Hydrogen only determined when pH in H_2O<6.0
Al only determined if pH in $CaCl_2$ is ≤ 5.2



EFFECTIVE CATION EXCHANGE CAPACITY (eCEC)



CATION RATIOS

Ratio	Result	Target Range
Ca:Mg	1.2	4.1 – 6.0
Comment: Calcium low		
Mg:K	7.9	2.6 – 5.0
Comment: Potassium low		
K/(Ca+Mg)	0.06	< 0.07
Comment: Acceptable		
K:Na	9.9	N/A

Sodium Absorption Ratio: 0 Low

Electrochemical Stability Index (ESI):
0.17 Low potential for dispersion and soil structure collapse

SOLUBLE CATIONS (meq/100g)

Na: K: Ca: Mg:

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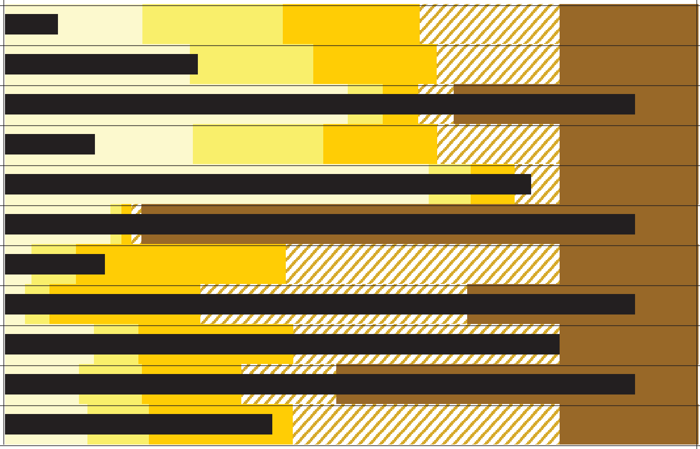
Batch N°: 33837 **Sample N°: 10** **Date Received: 3/3/15** **Report Status:** ○ **Draft** ● **Final**

PLANT AVAILABLE NUTRIENTS

Major Nutrients	Result (mg/kg)	▭ Very Low ▭ Low ▭ Marginal ▨ Adequate ▭ High	Result (g/sqm)	Desirable (g/sqm)	Adjustment (g/sqm)
Nitrate-N (NO_3)	2		0.4	6	5.6
Phosphate-P (PO_4)	21.9		4.4	12.6	8.2
Potassium (K) †	427		85.2	60.6	Drawdown
Sulphate-S (SO_4)	11		2.2	13.6	11.4
Calcium (Ca) †	2053		409.6	431.7	22.1
Magnesium (Mg) †	1042		207.9	44.9	Drawdown
Iron (Fe)	99.1		19.8	110.1	90.3
Manganese (Mn) †	60		12	8.8	Drawdown
Zinc (Zn) †	5		1	1	0
Copper (Cu)	12		2.4	1.3	Drawdown
Boron (B) †	1.3		0.3	0.5	0.2



Explanation of graph ranges:

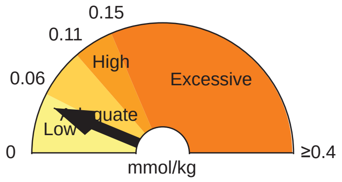
▭ Very Low	▭ Low	▭ Marginal	▨ Adequate	▭ High
Growth is likely to be severely depressed and deficiency symptoms present. Large applications for soil building purposes are usually recommended. Potential response to nutrient addition is >90%.	Potential “hidden hunger”, or sub-clinical deficiency. Potential response to nutrient addition is 60 to 90%.	Supply of this nutrient is barely adequate for the plant, and build-up is still recommended. Potential response to nutrient addition is 30 to 60%.	Supply of this nutrient is adequate for the plant, and and only maintenance application rates are recommended. Potential response to nutrient addition is 5 to 30%.	The level is excessive and may be detrimental to plant growth (i.e. phytotoxic) and may contribute to pollution of ground and surface waters. Drawdown is recommended. Potential response to nutrient addition is <2%.

NOTES: Adjustment recommendation calculates the elemental application to shift the soil test level to within the **Adequate** band, which maximises growth/yield, and economic efficiency, and minimises impact on the environment.

Drawdown: The objective nutrient management is to utilise residual soil nutrients. There is no agronomic reason to apply fertiliser when soil test levels exceed **Adequate**.

- g/sqm measurements are based on soil bulk density of 1.33 tonne/m^3 and selected soil depth.

Phosphorus Saturation Index



0.05

Low. Plant response to applied P is likely.

Exchangeable Acidity

Adams-Evans Buffer pH (BpH):	-
Sum of Base Cations (meq/100g^{-1}):	20
Eff. Cation Exch. Capacity (eCEC):	20
Base Saturation (%):	100
Exchangeable Acidity (meq/100g^{-1}):	-
Exchangeable Acidity (%):	-

Lime Application Rate

– to achieve pH 6.0 (g/sqm):	0
– to neutralise Al (g/sqm):	-

Gypsum Application Rate

– to achieve 67.5% exch. Ca (g/sqm): 558

The CGAR is corrected for a soil depth of 150mm and any Lime addition to achieve pH 6.0.

Physical Description

Texture:	-
Colour:	-
Estimated clay content:	**Did not test**
Size:	-
Gravel content:	-
Aggregate strength:	-
Structural unit:	**Did not test**
Potential infiltration rate:	**Did Not Test**
Permeability (mm/hr):	**Did not test**
Calculated EC_{SE} (dS/m):	-

Requires EC and Soil Texture result.

Organic Carbon (OC%)†: **3.8 – Very high**
Organic Matter (OM%): **6.5**
Additional comments:

Consultant: Bronwyn Brennan

BWoodward.

Authorised Signatory: Declan McDonald

D McDonald.

Date Report Generated 15/03/2015

METHOD REFERENCES:
pH (1:5 H_2O) - Rayment & Higginson (1992) 4A1,
pH (1:5 $CaCl_2$) - Rayment & Higginson (1992) 4B1,
EC (1:5) - Rayment & Higginson (1992) 3A1,
Chloride - Rayment & Higginson (1992) 5A2,
Nitrate - Rayment & Higginson (1992) 7B1
Aluminium - SESL in-house,
PO_4, K, SO_4, Ca, Mg, Na, Fe, Mn, Zn, Cu, B - Mehlich 3 (1984),
Buffer pH and Hydrogen - Adams-Evans (1972)
Texture/Structure/Colour - PM0003 (Texture- "Northcote" (1992), Structure- "Murphy" (1991), Colour- "Munsell" (2000))

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Disclaimer: Tests are performed under a quality system complying with ISO 9001: 2008. Results are based on the analysis of the sample taken or received by SESL. Due to the variability of sampling procedures, environmental conditions and managerial factors, SESL does not accept any liability for a lack of performance based on its interpretation and recommendations. This document must not be reproduced except in full.

Soil Chemistry Profile

Mehlich 3 - Multi-nutrient Extractant

Sample Drop Off: 16 Chilvers Road
Thornleigh NSW 2120
Mailing Address: PO Box 357
Pennant Hills NSW 1715

Tel: 1300 30 40 80
Fax: 1300 64 46 89
Em: info@sesl.com.au
Web: www.sesl.com.au

Batch N°: 33837 **Sample N°: 11** **Date Received: 3/3/15** **Report Status:** ○ **Draft** ● **Final**

Client Name:	**AECOM - Newcastle**	Project Name:	**60340733 - C & A Rehabilitation Monitoring 2015** **MTW & HVO Mine Sites**
Client Contact:	**Matthieu Catteau**		
Client Job N°:		SESL Quote N°:	**Q4235**
Client Order N°:		Sample Name:	**RHB-MTO North Dump**
Address:	**PO Box 73** **HRMC NSW 2310**	Description:	**Soil**
		Test Type:	**FSC, TOC_DC, M5**

RECOMMENDATIONS

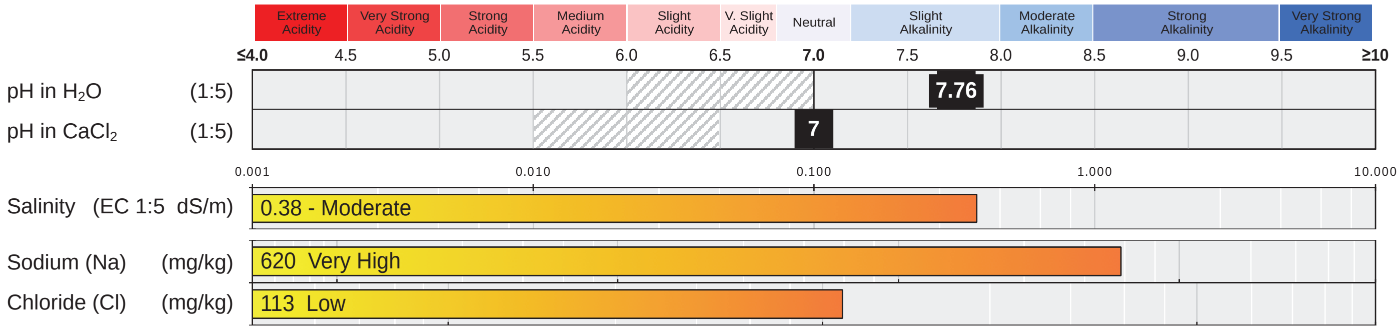
This soil sample submitted by the client was analysed for properties related to healthy plant growth, specifically the rehabilitation of soil to support pasture species. It is slightly alkaline, moderately saline and moderately sodic. The cation balance is magnesic. The effective cation exchange capacity (eCEC) is moderate, indicating good nutrient retention and holding capacity. The magnicity and sodicity will likely mean that any fines in this soil are dispersive and prone to erosion.

Of the plant available nutrients, N will prove most limiting to plant growth. This should be increased through split urea applications at 10 g/sqm (i.e. 2 x 10 g applications, or 200 kg/ha in total). Applications of super phosphate at 20g/sqm and gypsum at 300 g/sqm (3 t/ha); the latter will assist in balancing the cations and preventing any dispersion. This will temporarily elevate the salinity, so leaching should be encouraged through this period. These applications are considered the minimum to ensure pasture success. Additionally, future application of a multi purpose NPK fertiliser (such as Dynamic Lifter or Pasture Starter) will ensure adequate nutrition as the pasture establishes.

SOIL SAMPLE DEPTH (mm): ○ **100** ● **150** ○ **200**

FERTILITY RATING: ○ Low ● Moderate ○ High

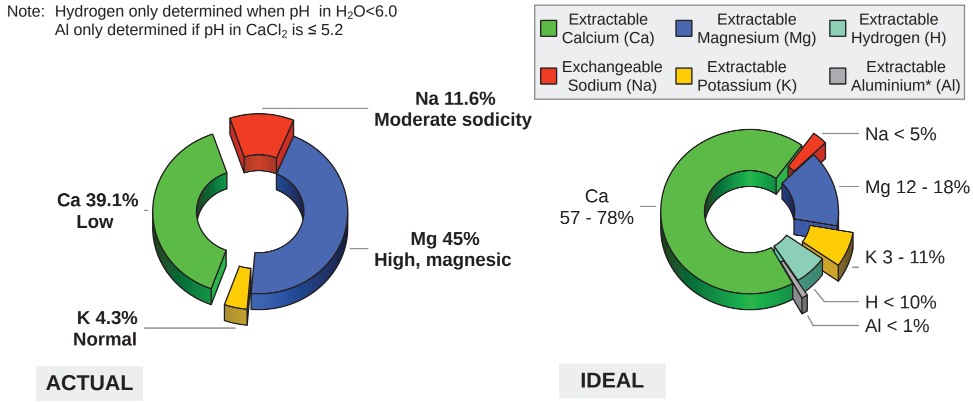
pH and ELECTRICAL CONDUCTIVITY



CATION BALANCE

EXCHANGEABLE CATION PERCENTAGE

Note: Hydrogen only determined when pH in H_2O<6.0
Al only determined if pH in $CaCl_2$ is ≤ 5.2



EFFECTIVE CATION EXCHANGE CAPACITY (eCEC)

CATION RATIOS

Ratio	**Result**	**Target Range**
Ca:Mg	**0.9**	4.1 – 6.0
Comment: Potential Calcium deficiency		
Mg:K	**10.6**	2.6 – 5.0
Comment: Potential Potassium deficiency		
K/(Ca+Mg)	**0.05**	< 0.07
Comment: Acceptable		
K:Na	**0.4**	N/A

Sodium Absorption Ratio: 0 Low

Electrochemical Stability Index (ESI):
0.03 High potential for dispersion and soil structure collapse

SOLUBLE CATIONS (meq/100g)

Na: K: Ca: Mg:

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Soil Chemistry Profile

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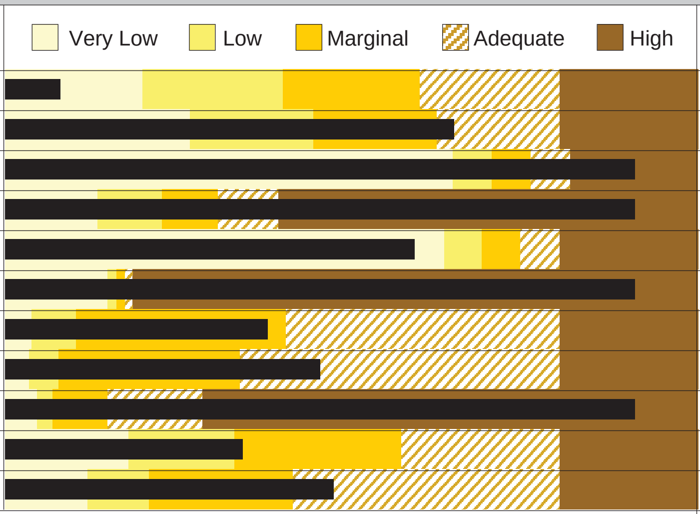
Batch N°: 33837 **Sample N°: 11** **Date Received: 3/3/15** **Report Status:** ○ **Draft** ● **Final**

PLANT AVAILABLE NUTRIENTS



Major Nutrients	Result (mg/kg)	Result (g/sqm)	Desirable (g/sqm)	Adjustment (g/sqm)
Nitrate-N (NO_3)	2.1	0.4	6	5.6
Phosphate-P (PO_4)	51	10.2	12.6	2.4
Potassium (K) †	386	77	69	Drawdown
Sulphate-S (SO_4)	157	31.3	13.6	Drawdown
Calcium (Ca) †	1819	362.9	491.6	128.7
Magnesium (Mg) †	1270	253.4	51.3	Drawdown
Iron (Fe)	261.5	52.2	110.1	57.9
Manganese (Mn) †	25	5	8.8	3.8
Zinc (Zn) †	16	3.2	1	Drawdown
Copper (Cu)	2.7	0.5	1.3	0.8
Boron (B) †	1.6	0.3	0.5	0.2

Explanation of graph ranges:

Very Low
Growth is likely to be severely depressed and deficiency symptoms present. Large applications for soil building purposes are usually recommended. Potential response to nutrient addition is >90%.

Low
Potential "hidden hunger", or sub-clinical deficiency. Potential response to nutrient addition is 60 to 90%.

Marginal
Supply of this nutrient is barely adequate for the plant, and build-up is still recommended. Potential response to nutrient addition is 30 to 60%.

Adequate
Supply of this nutrient is adequate for the plant, and and only maintenance application rates are recommended. Potential response to nutrient addition is 5 to 30%.

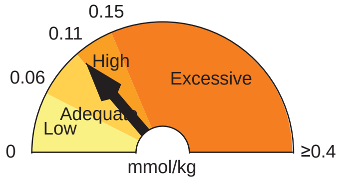
High
The level is excessive and may be detrimental to plant growth (i.e. phytotoxic) and may contribute to pollution of ground and surface waters. Drawdown is recommended. Potential response to nutrient addition is <2%.

NOTES: Adjustment recommendation calculates the elemental application to shift the soil test level to within the **Adequate** band, which maximises growth/yield, and economic efficiency, and minimises impact on the environment.

Drawdown: The objective nutrient management is to utilise residual soil nutrients. There is no agronomic reason to apply fertiliser when soil test levels exceed **Adequate**.

- g/sqm measurements are based on soil bulk density of 1.33 tonne/m^3 and selected soil depth.

Phosphorus Saturation Index



0.11

Adequate. Economic response to P unlikely. P application recommended maintaining current P level.

Exchangeable Acidity

Adams-Evans Buffer pH (BpH): -
Sum of Base Cations (meq/100g^{-1}): **23.2**
Eff. Cation Exch. Capacity (eCEC): **23.2**
Base Saturation (%): **100**
Exchangeable Acidity (meq/100g^{-1}): -
Exchangeable Acidity (%): -

Lime Application Rate

– to achieve pH 6.0 (g/sqm): **0**
– to neutralise Al (g/sqm): -

Gypsum Application Rate

– to achieve 67.5% exch. Ca (g/sqm): **1132**

The CGAR is corrected for a soil depth of 150mm and any Lime addition to achieve pH 6.0.

Physical Description

Texture: -
Colour: -
Estimated clay content: **Did not test**
Size: -
Gravel content: -
Aggregate strength: -
Structural unit: **Did not test**
Potential infiltration rate: **Did Not Test**
Permeability (mm/hr): **Did not test**
Calculated EC_{SE} (dS/m): -

Requires EC and Soil Texture result.

Organic Carbon (OC%)†: **5.3 – Very high**
Organic Matter (OM%): **9**
Additional comments:

Consultant: Bronwyn Brennan

Authorised Signatory: Declan McDonald

Date Report Generated 15/03/2015

METHOD REFERENCES:
pH (1:5 H_2O) - Rayment & Higginson (1992) 4A1,
pH (1:5 $CaCl_2$) - Rayment & Higginson (1992) 4B1,
EC (1:5) - Rayment & Higginson (1992) 3A1,
Chloride - Rayment & Higginson (1992) 5A2,
Nitrate - Rayment & Higginson (1992) 7B1
Aluminium - SESL in-house,
PO_4, K, SO_4, Ca, Mg, Na, Fe, Mn, Zn, Cu, B - Mehlich 3 (1984),
Buffer pH and Hydrogen - Adams-Evans (1972)
Texture/Structure/Colour - PM0003 (Texture- "Northcote" (1992), Structure- "Murphy" (1991), Colour- "Munsell" (2000))

ASPAC

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Soil Chemistry Profile

Mehlich 3 - Multi-nutrient Extractant

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Tel: 1300 30 40 80
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Web: www.sesl.com.au

Batch N°: 33837 **Sample N°: 12** **Date Received: 3/3/15** **Report Status:** ○ Draft ● Final

Client Name:	**AECOM - Newcastle**	Project Name:	**60340733 - C & A Rehabilitation Monitoring 2015 MTW & HVO Mine Sites**
Client Contact:	**Matthieu Catteau**	SESL Quote N°:	**Q4235**
Client Job N°:		Sample Name:	**RHB-HVOS Riverview**
Client Order N°:		Description:	**Soil**
Address:	**PO Box 73 HRMC NSW 2310**	Test Type:	**FSC, TOC_DC, M5**

RECOMMENDATIONS

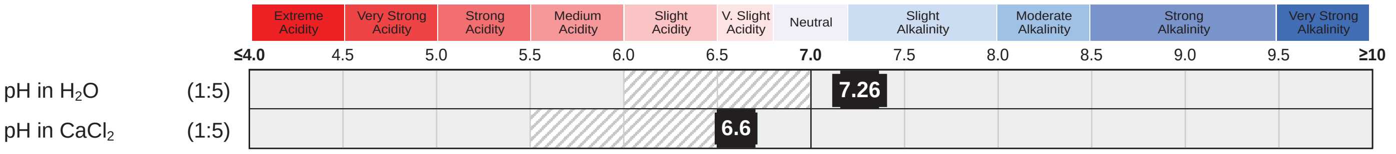
This soil sample submitted by the client was analysed for properties related to healthy plant growth, specifically the rehabilitation of soil to support pasture species. It is pH neutral, not saline and not sodic. The cation balance is magnesic. The effective cation exchange capacity (eCEC) is moderate, indicating good nutrient retention and holding capacity.

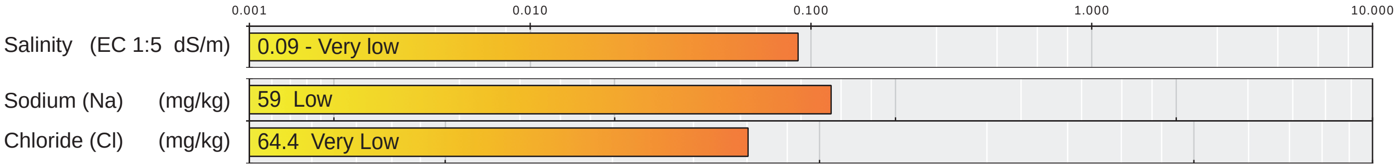
Of the plant available nutrients, N will prove most limiting to plant growth. This should be increased through split urea applications at 10 g/sqm (i.e. 2 x 10 g applications, or 200 kg/ha in total). Applications of gypsum at 100 g/sqm (1 t/ha) will assist in balancing the cations and preventing any dispersion. These applications are considered the minimum to ensure pasture success.

Additionally, future application of a multi purpose NPK fertiliser (such as Dynamic Lifter or Pasture Starter) will ensure adequate nutrition as the pasture establishes.

SOIL SAMPLE DEPTH (mm): ○ 100 ● 150 ○ 200 FERTILITY RATING: ○ Low ● Moderate ○ High

pH and ELECTRICAL CONDUCTIVITY

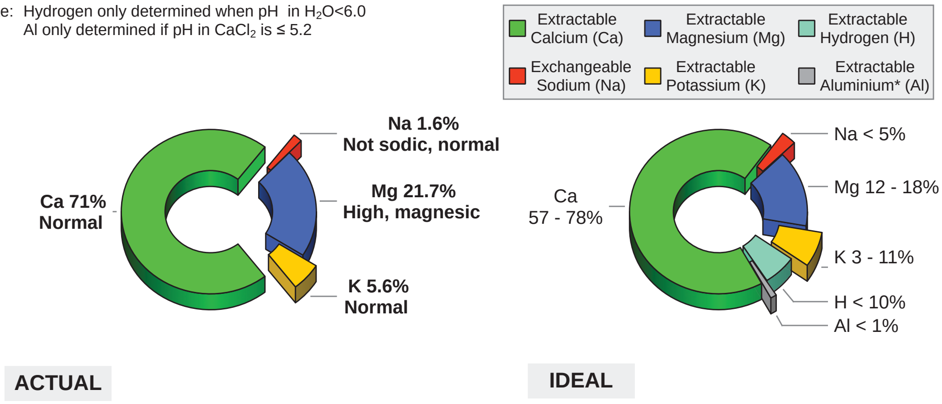




CATION BALANCE

EXCHANGEABLE CATION PERCENTAGE

Note: Hydrogen only determined when pH in H_2O<6.0
Al only determined if pH in $CaCl_2$ is ≤ 5.2



EFFECTIVE CATION EXCHANGE CAPACITY (eCEC)

CATION RATIOS

Ratio	Result	Target Range
Ca:Mg	3.3	4.1 – 6.0
Comment: Calcium low		
Mg:K	3.8	2.6 – 5.0
Comment: Balanced		
K/(Ca+Mg)	0.06	< 0.07
Comment: Acceptable		
K:Na	3.5	N/A

Sodium Absorption Ratio: 0 Low

Electrochemical Stability Index (ESI):
0.06 Moderate potential for dispersion and soil structure collapse

SOLUBLE CATIONS (meq/100g)

Na: K: Ca: Mg:

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Soil Chemistry Profile

Mehlich 3 - Multi-nutrient Extractant

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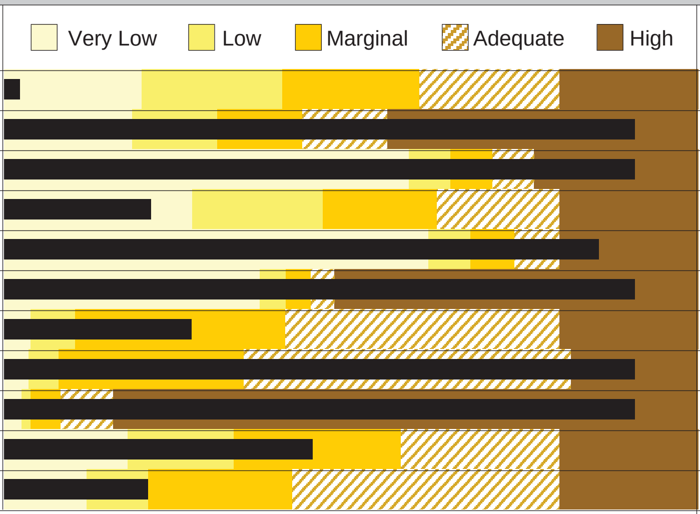
Batch N°: 33837 **Sample N°: 12** **Date Received: 3/3/15** **Report Status:** ○ Draft ● Final

PLANT AVAILABLE NUTRIENTS



Major Nutrients	Result (mg/kg)	Result (g/sqm)	Desirable (g/sqm)	Adjustment (g/sqm)
Nitrate-N (NO_3)	0.6	0.1	6	5.9
Phosphate-P (PO_4)	103.8	20.7	12.6	Drawdown
Potassium (K) †	362	72.2	60.6	Drawdown
Sulphate-S (SO_4)	18	3.6	13.6	10
Calcium (Ca) †	2318	462.4	431.7	Drawdown
Magnesium (Mg) †	430	85.8	44.9	Drawdown
Iron (Fe)	186.4	37.2	110.1	72.9
Manganese (Mn) †	49	9.8	8.8	Drawdown
Zinc (Zn) †	29	5.8	1	Drawdown
Copper (Cu)	3.5	0.7	1.3	0.6
Boron (B) †	0.7	0.1	0.5	0.4

Explanation of graph ranges:

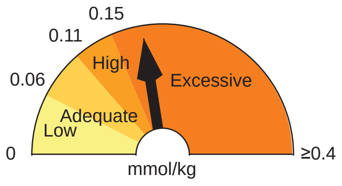
☐ Very Low	🟨 Low	🟧 Marginal	▨ Adequate	🟫 High
Growth is likely to be severely depressed and deficiency symptoms present. Large applications for soil building purposes are usually recommended. Potential response to nutrient addition is >90%.	Potential "hidden hunger", or sub-clinical deficiency. Potential response to nutrient addition is 60 to 90%.	Supply of this nutrient is barely adequate for the plant, and build-up is still recommended. Potential response to nutrient addition is 30 to 60%.	Supply of this nutrient is adequate for the plant, and and only maintenance application rates are recommended. Potential response to nutrient addition is 5 to 30%.	The level is excessive and may be detrimental to plant growth (i.e. phytotoxic) and may contribute to pollution of ground and surface waters. Drawdown is recommended. Potential response to nutrient addition is <2%.

NOTES: Adjustment recommendation calculates the elemental application to shift the soil test level to within the **Adequate** band, which maximises growth/yield, and economic efficiency, and minimises impact on the environment.

Drawdown: The objective nutrient management is to utilise residual soil nutrients. There is no agronomic reason to apply fertiliser when soil test levels exceed **Adequate**.

- g/sqm measurements are based on soil bulk density of 1.33 tonne/m^3 and selected soil depth.

Phosphorus Saturation Index



0.18

Excessive. Exceeds environmental threshold. Implement improved P management to reduce potential for nonpoint P pollution.

Exchangeable Acidity

Adams-Evans Buffer pH (BpH): -
Sum of Base Cations (meq/100g^{-1}): **16.3**
Eff. Cation Exch. Capacity (eCEC): **16.3**
Base Saturation (%): **100**
Exchangeable Acidity (meq/100g^{-1}): -
Exchangeable Acidity (%): -

Lime Application Rate

– to achieve pH 6.0 (g/sqm): **0**
– to neutralise Al (g/sqm): -

Gypsum Application Rate

– to achieve 67.5% exch. Ca (g/sqm): **0**

The CGAR is corrected for a soil depth of 150mm and any Lime addition to achieve pH 6.0.

Physical Description

Texture: -
Colour: -
Estimated clay content: **Did not test**
Size: -
Gravel content: -
Aggregate strength: -
Structural unit: **Did not test**
Potential infiltration rate: **Did Not Test**
Permeability (mm/hr): **Did not test**
Calculated EC_{SE} (dS/m): -

Requires EC and Soil Texture result.

Organic Carbon (OC%)†: **3 – Very high**
Organic Matter (OM%): **5.1**
Additional comments:

Consultant: Bronwyn Brennan

Authorised Signatory: Declan McDonald

Date Report Generated 15/03/2015

METHOD REFERENCES:
pH (1:5 H_2O) - Rayment & Higginson (1992) 4A1,
pH (1:5 $CaCl_2$) - Rayment & Higginson (1992) 4B1,
EC (1:5) - Rayment & Higginson (1992) 3A1,
Chloride - Rayment & Higginson (1992) 5A2,
Nitrate - Rayment & Higginson (1992) 7B1
Aluminium - SESL in-house,
PO_4, K, SO_4, Ca, Mg, Na, Fe, Mn, Zn, Cu, B - Mehlich 3 (1984),
Buffer pH and Hydrogen - Adams-Evans (1972)
Texture/Structure/Colour - PM0003 (Texture- "Northcote" (1992), Structure- "Murphy" (1991), Colour- "Munsell" (2000))

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Soil Chemistry Profile

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Batch N°: 33837 **Sample N°: 13** **Date Received: 3/3/15** **Report Status:** ○ Draft ● Final

Client Name: **AECOM - Newcastle**
Client Contact: **Matthieu Catteau**
Client Job N°:
Client Order N°:
Address: **PO Box 73**
HRMC NSW 2310

Project Name: **60340733 - C & A Rehabilitation Monitoring 2015**
MTW & HVO Mine Sites
SESL Quote N°: **Q4235**
Sample Name: **RHB-HVON Carrington**
Description: **Soil**
Test Type: **FSC, TOC_DC, M5**

RECOMMENDATIONS

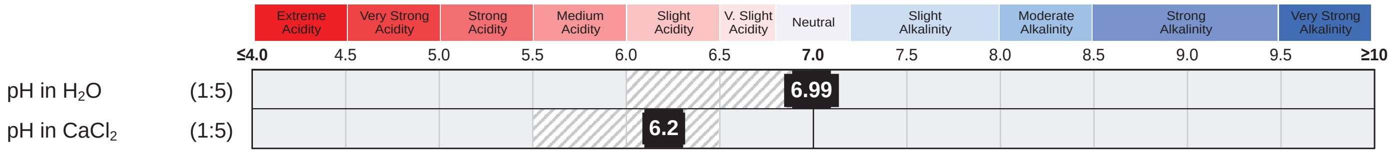
This soil sample submitted by the client was analysed for properties related to healthy plant growth, specifically the rehabilitation of soil to support pasture species. It is slightly acidic, not saline and not sodic. The cation balance is magnesic. The effective cation exchange capacity (eCEC) is moderate, indicating good nutrient retention and holding capacity.

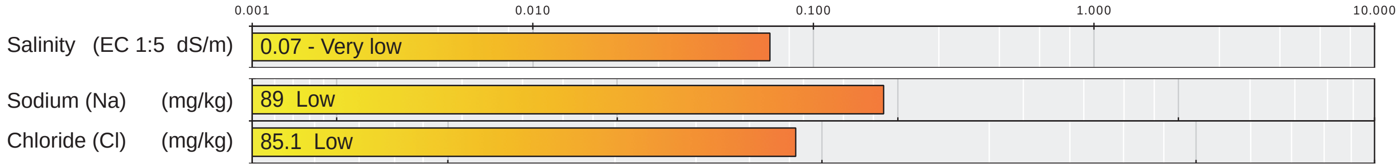
Of the plant available nutrients, N will prove most limiting to plant growth. This should be increased through split urea applications at 10 g/sqm (i.e. 2 x 10 g applications, or 200 kg/ha in total). P levels are also low. Apply super phosphate at 20 g/sqm (200 kg/ha). Applications of gypsum at 200 g/sqm (2 t/ha) will assist in balancing the cations and preventing any dispersion. These applications are considered the minimum to ensure pasture success.

Additionally, future application of a multi purpose NPK fertiliser (such as Dynamic Lifter or Pasture Starter) will ensure adequate nutrition as the pasture establishes.

SOIL SAMPLE DEPTH (mm): ○ 100 ● 150 ○ 200   FERTILITY RATING: ○ Low ● Moderate ○ High

pH and ELECTRICAL CONDUCTIVITY

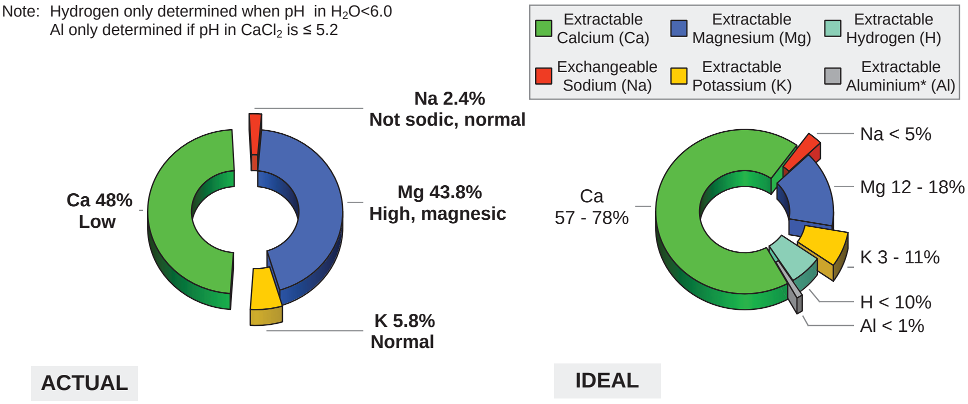




CATION BALANCE

EXCHANGEABLE CATION PERCENTAGE

Note: Hydrogen only determined when pH in H_2O<6.0
Al only determined if pH in $CaCl_2$ is ≤ 5.2



CATION RATIOS

Ratio	Result	Target Range
Ca:Mg	1.1	4.1 – 6.0
Comment: Calcium low		
Mg:K	7.5	2.6 – 5.0
Comment: Potassium low		
K/(Ca+Mg)	0.06	< 0.07
Comment: Acceptable		
K:Na	2.5	N/A

Sodium Absorption Ratio: 0 Low

Electrochemical Stability Index (ESI):
0.03 High potential for dispersion and soil structure collapse

EFFECTIVE CATION EXCHANGE CAPACITY (eCEC)

SOLUBLE CATIONS (meq/100g)

Na: K: Ca: Mg:

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Soil Chemistry Profile

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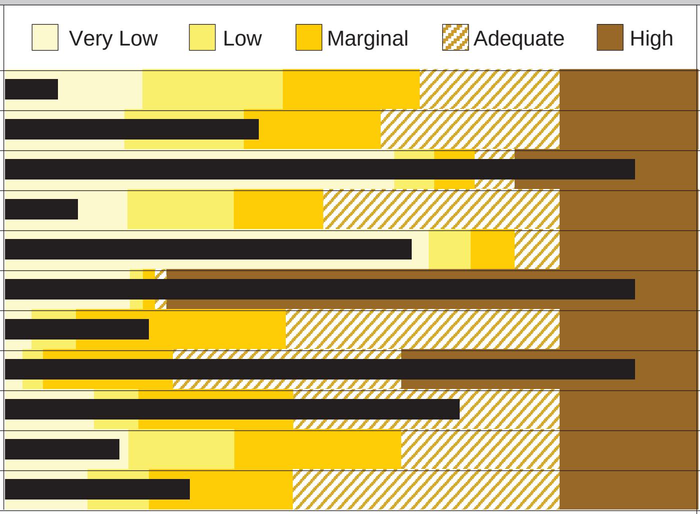
Batch N°: 33837 **Sample N°: 13** **Date Received: 3/3/15** **Report Status:** ○ Draft ● Final

PLANT AVAILABLE NUTRIENTS



Major Nutrients	Result (mg/kg)	Result (g/sqm)	Desirable (g/sqm)	Adjustment (g/sqm)
Nitrate-N (NO_3)	2	0.4	6	5.6
Phosphate-P (PO_4)	29.7	5.9	12.6	6.7
Potassium (K) †	376	75	60.6	Drawdown
Sulphate-S (SO_4)	8.9	1.8	13.6	11.8
Calcium (Ca) †	1586	316.4	431.7	115.3
Magnesium (Mg) †	879	175.4	44.9	Drawdown
Iron (Fe)	142.8	28.5	110.1	81.6
Manganese (Mn) †	70	14	8.8	Drawdown
Zinc (Zn) †	4.1	0.8	1	0.2
Copper (Cu)	1.3	0.3	1.3	1
Boron (B) †	0.9	0.2	0.5	0.3

Explanation of graph ranges:

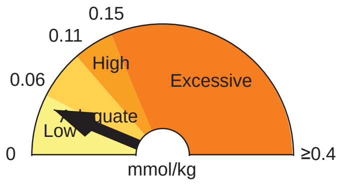
▢ **Very Low**	🟨 **Low**	🟧 **Marginal**	▨ **Adequate**	🟫 **High**
Growth is likely to be severely depressed and deficiency symptoms present. Large applications for soil building purposes are usually recommended. Potential response to nutrient addition is >90%.	Potential "hidden hunger", or sub-clinical deficiency. Potential response to nutrient addition is 60 to 90%.	Supply of this nutrient is barely adequate for the plant, and build-up is still recommended. Potential response to nutrient addition is 30 to 60%.	Supply of this nutrient is adequate for the plant, and and only maintenance application rates are recommended. Potential response to nutrient addition is 5 to 30%.	The level is excessive and may be detrimental to plant growth (i.e. phytotoxic) and may contribute to pollution of ground and surface waters. Drawdown is recommended. Potential response to nutrient addition is <2%.

NOTES: Adjustment recommendation calculates the elemental application to shift the soil test level to within the **Adequate** band, which maximises growth/yield, and economic efficiency, and minimises impact on the environment.

Drawdown: The objective nutrient management is to utilise residual soil nutrients. There is no agronomic reason to apply fertiliser when soil test levels exceed **Adequate**.

- g/sqm measurements are based on soil bulk density of 1.33 tonne/m^3 and selected soil depth.

Phosphorus Saturation Index



0.05

Low. Plant response to applied P is likely.

Exchangeable Acidity

Adams-Evans Buffer pH (BpH): -
Sum of Base Cations (meq/100g^{-1}): **16.5**
Eff. Cation Exch. Capacity (eCEC): **16.5**
Base Saturation (%): **100**
Exchangeable Acidity (meq/100g^{-1}): -
Exchangeable Acidity (%): -

Lime Application Rate

– to achieve pH 6.0 (g/sqm): **0**
– to neutralise Al (g/sqm): -

Gypsum Application Rate

– to achieve 67.5% exch. Ca (g/sqm): **552**
The CGAR is corrected for a soil depth of 150mm and any Lime addition to achieve pH 6.0.

Physical Description

Texture: -
Colour: -
Estimated clay content: **Did not test**
Size: -
Gravel content: -
Aggregate strength: -
Structural unit: **Did not test**
Potential infiltration rate: **Did Not Test**
Permeability (mm/hr): **Did not test**
Calculated EC_{SE} (dS/m): -
Requires EC and Soil Texture result.
Organic Carbon (OC%)†: **3.1 – Very high**
Organic Matter (OM%): **5.2**
Additional comments:

Consultant: Bronwyn Brennan

BWoodward.

Authorised Signatory: Declan McDonald

D McDonald.

Date Report Generated 15/03/2015

METHOD REFERENCES:
pH (1:5 H_2O) - Rayment & Higginson (1992) 4A1,
pH (1:5 $CaCl_2$) - Rayment & Higginson (1992) 4B1,
EC (1:5) - Rayment & Higginson (1992) 3A1,
Chloride - Rayment & Higginson (1992) 5A2,
Nitrate - Rayment & Higginson (1992) 7B1
Aluminium - SESL in-house,
PO_4, K, SO_4, Ca, Mg, Na, Fe, Mn, Zn, Cu, B - Mehlich 3 (1984),
Buffer pH and Hydrogen - Adams-Evans (1972)
Texture/Structure/Colour - PM0003 (Texture- "Northcote" (1992), Structure- "Murphy" (1991), Colour- "Munsell" (2000))

ASPAC

A member of the Australasian Soil and Plant Analysis Council
† This laboratory has been awarded a Certificate of Proficiency for specific soil and plant tissue analyses by the Australasian Soil and Plant Analysis Council (ASPAC). Tests for which proficiency has been demonstrated are highlighted in this report.

Soil Chemistry Profile

Mehlich 3 - Multi-nutrient Extractant

Sample Drop Off: 16 Chilvers Road
Thornleigh NSW 2120
Mailing Address: PO Box 357
Pennant Hills NSW 1715
Tel: 1300 30 40 80
Fax: 1300 64 46 89
Em: info@sesl.com.au
Web: www.sesl.com.au

Batch N°: 33837 **Sample N°: 14** **Date Received: 3/3/15** **Report Status:** ○ Draft ● Final

Client Name: **AECOM - Newcastle**
Client Contact: **Matthieu Catteau**
Client Job N°:
Client Order N°:
Address: **PO Box 73**
HRMC NSW 2310

Project Name: **60340733 - C & A Rehabilitation Monitoring 2015**
MTW & HVO Mine Sites
SESL Quote N°: **Q4235**
Sample Name: **RHB-HVOW Wilton**
Description: **Soil**
Test Type: **FSC, TOC_DC, M5**

RECOMMENDATIONS

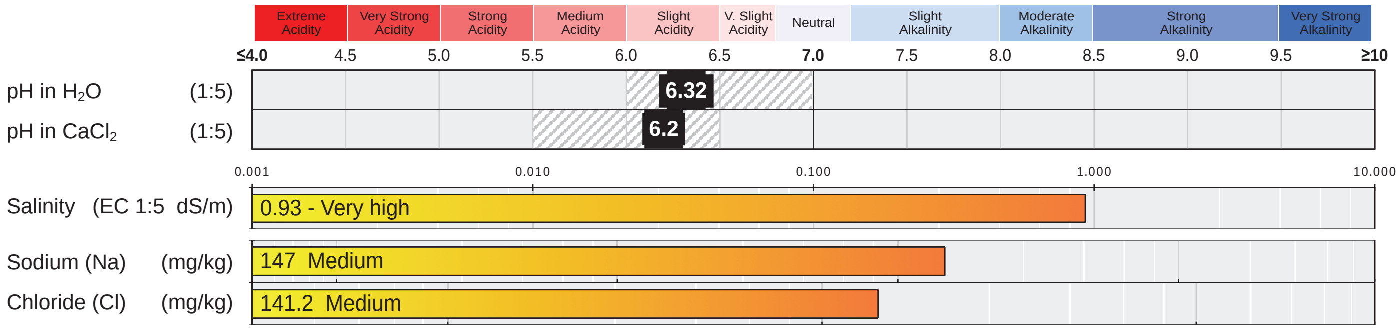
This soil sample submitted by the client was analysed for properties related to healthy plant growth, specifically the rehabilitation of soil to support pasture species. It is slightly acidic, highly saline and not sodic. The cation balance is magnesic. The effective cation exchange capacity (eCEC) is high, indicating excellent nutrient retention and holding capacity.

Of the plant available nutrients, N will prove most limiting to plant growth. This should be increased through split urea applications at 10 g/sqm (i.e. 2 x 10 g applications, or 200 kg/ha in total). P and K levels are also low. Apply super phosphate and muriate of potash, both at 20 g/sqm (200 kg/ha). Applications of gypsum at 300 g/sqm (3 t/ha) will assist in balancing the cations and preventing any dispersion. This will temporarily inflate the salinity, so leaching should be encouraged to reduce this. These applications are considered the minimum to ensure pasture success. Additionally, future application of a multi purpose NPK fertiliser (such as Dynamic Lifter or Pasture Starter) will ensure adequate nutrition as the pasture establishes.

SOIL SAMPLE DEPTH (mm): ○ 100 ● 150 ○ 200

FERTILITY RATING: ○ Low ● Moderate ○ High

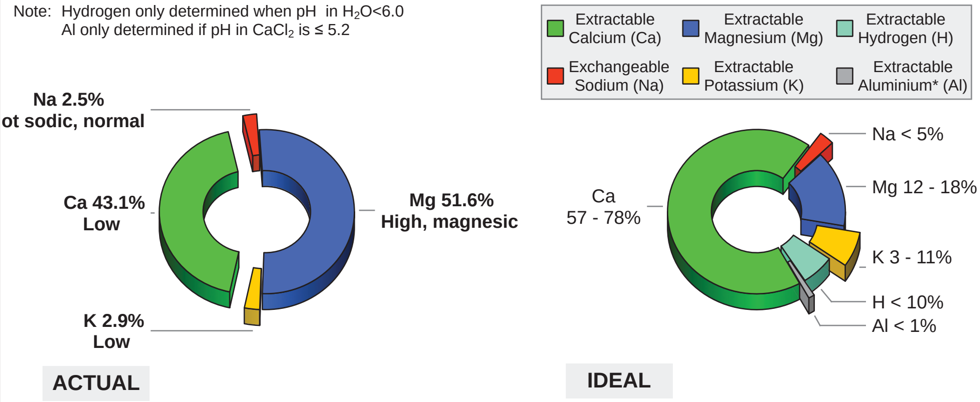
pH and ELECTRICAL CONDUCTIVITY



CATION BALANCE

EXCHANGEABLE CATION PERCENTAGE

Note: Hydrogen only determined when pH in H_2O<6.0
Al only determined if pH in $CaCl_2$ is ≤ 5.2



EFFECTIVE CATION EXCHANGE CAPACITY (eCEC)

CATION RATIOS

Ratio	Result	Target Range
Ca:Mg	0.8	4.1 – 6.0

Comment: Potential Calcium deficiency

Ratio	Result	Target Range
Mg:K	17.7	2.6 – 5.0

Comment: Potential Potassium deficiency

Ratio	Result	Target Range
K/(Ca+Mg)	0.03	< 0.07

Comment: Acceptable

Ratio	Result	Target Range
K:Na	1.2	N/A

Sodium Absorption Ratio: 0 Low

Electrochemical Stability Index (ESI):
0.37 Low potential for dispersion and soil structure collapse

SOLUBLE CATIONS (meq/100g)

Na: K: Ca: Mg:

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Soil Chemistry Profile

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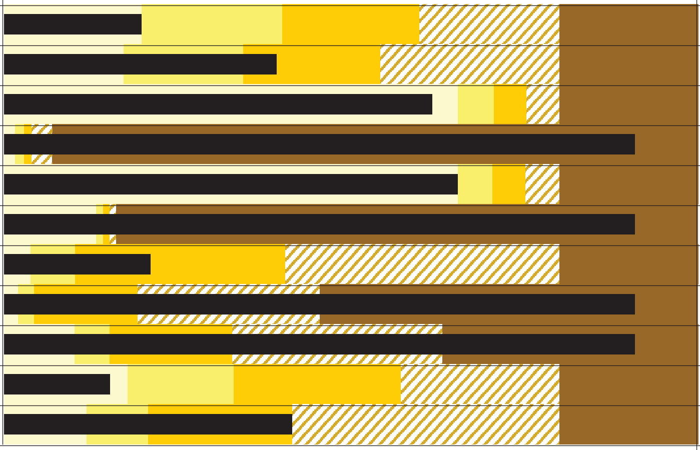
Batch N°: 33837 **Sample N°: 14** **Date Received: 3/3/15** **Report Status:** ○ Draft ● Final

PLANT AVAILABLE NUTRIENTS



Major Nutrients	**Result** (mg/kg)	☐ Very Low 🟨 Low 🟧 Marginal ▨ Adequate 🟫 High	**Result** (g/sqm)	**Desirable** (g/sqm)	**Adjustment** (g/sqm)
Nitrate-N (NO_3)	5.2		1	6	5
Phosphate-P (PO_4)	31.9		6.4	12.6	6.2
Potassium (K) †	299		59.7	77.4	17.7
Sulphate-S (SO_4)	894		178.4	13.6	Drawdown
Calcium (Ca) †	2257		450.3	551.2	100.9
Magnesium (Mg) †	1636		326.4	57.7	Drawdown
Iron (Fe)	145.7		29.1	110.1	81
Manganese (Mn) †	88		17.6	8.8	Drawdown
Zinc (Zn) †	7.2		1.4	1	Drawdown
Copper (Cu)	1.2		0.2	1.3	1.1
Boron (B) †	1.4		0.3	0.5	0.2

Explanation of graph ranges:

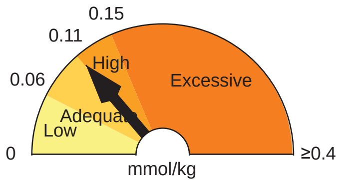
☐ **Very Low**	🟨 **Low**	🟧 **Marginal**	▨ **Adequate**	🟫 **High**
Growth is likely to be severely depressed and deficiency symptoms present. Large applications for soil building purposes are usually recommended. Potential response to nutrient addition is >90%.	Potential "hidden hunger", or sub-clinical deficiency. Potential response to nutrient addition is 60 to 90%.	Supply of this nutrient is barely adequate for the plant, and build-up is still recommended. Potential response to nutrient addition is 30 to 60%.	Supply of this nutrient is adequate for the plant, and and only maintenance application rates are recommended. Potential response to nutrient addition is 5 to 30%.	The level is excessive and may be detrimental to plant growth (i.e. phytotoxic) and may contribute to pollution of ground and surface waters. Drawdown is recommended. Potential response to nutrient addition is <2%.

NOTES: Adjustment recommendation calculates the elemental application to shift the soil test level to within the **Adequate** band, which maximises growth/yield, and economic efficiency, and minimises impact on the environment.

Drawdown: The objective nutrient management is to utilise residual soil nutrients. There is no agronomic reason to apply fertiliser when soil test levels exceed **Adequate**.

- g/sqm measurements are based on soil bulk density of 1.33 tonne/m^3 and selected soil depth.

Phosphorus Saturation Index



0.11

Adequate. Economic response to P unlikely. P application recommended maintaining current P level.

Exchangeable Acidity

Adams-Evans Buffer pH (BpH):	-
Sum of Base Cations (meq/100g^{-1}):	**26.1**
Eff. Cation Exch. Capacity (eCEC):	**26.1**
Base Saturation (%):	**100**
Exchangeable Acidity (meq/100g^{-1}):	-
Exchangeable Acidity (%):	-

Lime Application Rate

– to achieve pH 6.0 (g/sqm):	**0**
– to neutralise Al (g/sqm):	-

Gypsum Application Rate

– to achieve 67.5% exch. Ca (g/sqm):	**1092**

The CGAR is corrected for a soil depth of 150mm and any Lime addition to achieve pH 6.0.

Physical Description

Texture:	-
Colour:	-
Estimated clay content:	**Did not test**
Size:	-
Gravel content:	-
Aggregate strength:	-
Structural unit:	**Did not test**
Potential infiltration rate:	**Did Not Test**
Permeability (mm/hr):	**Did not test**
Calculated EC_{SE} (dS/m):	-

Requires EC and Soil Texture result.

Organic Carbon (OC%)†: **3.3 – Very high**

Organic Matter (OM%): **5.6**

Additional comments:

Consultant: Bronwyn Brennan

BWoodward.

Authorised Signatory: Declan McDonald

D McDonald.

Date Report Generated 15/03/2015

METHOD REFERENCES:
pH (1:5 H_2O) - Rayment & Higginson (1992) 4A1,
pH (1:5 $CaCl_2$) - Rayment & Higginson (1992) 4B1,
EC (1:5) - Rayment & Higginson (1992) 3A1,
Chloride - Rayment & Higginson (1992) 5A2,
Nitrate - Rayment & Higginson (1992) 7B1
Aluminium - SESL in-house,
PO_4, K, SO_4, Ca, Mg, Na, Fe, Mn, Zn, Cu, B - Mehlich 3 (1984),
Buffer pH and Hydrogen - Adams-Evans (1972)
Texture/Structure/Colour - PM0003 (Texture- "Northcote" (1992), Structure- "Murphy" (1991), Colour- "Munsell" (2000))

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Soil Chemistry Profile

Mehlich 3 - Multi-nutrient Extractant

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Pennant Hills NSW 1715
Tel: 1300 30 40 80
Fax: 1300 64 46 89
Em: info@sesl.com.au
Web: www.sesl.com.au

Batch N°: 33837 **Sample N°: 15** **Date Received: 3/3/15** **Report Status:** ○ **Draft** ● **Final**

Client Name: **AECOM - Newcastle**
Client Contact: **Matthieu Catteau**
Client Job N°:
Client Order N°:
Address: **PO Box 73**
HRMC NSW 2310

Project Name: **60340733 - C & A Rehabilitation Monitoring 2015**
MTW & HVO Mine Sites
SESL Quote N°: **Q4235**
Sample Name: **RHB-WML TD1**
Description: **Soil**
Test Type: **FSC, TOC_DC, M5**

RECOMMENDATIONS

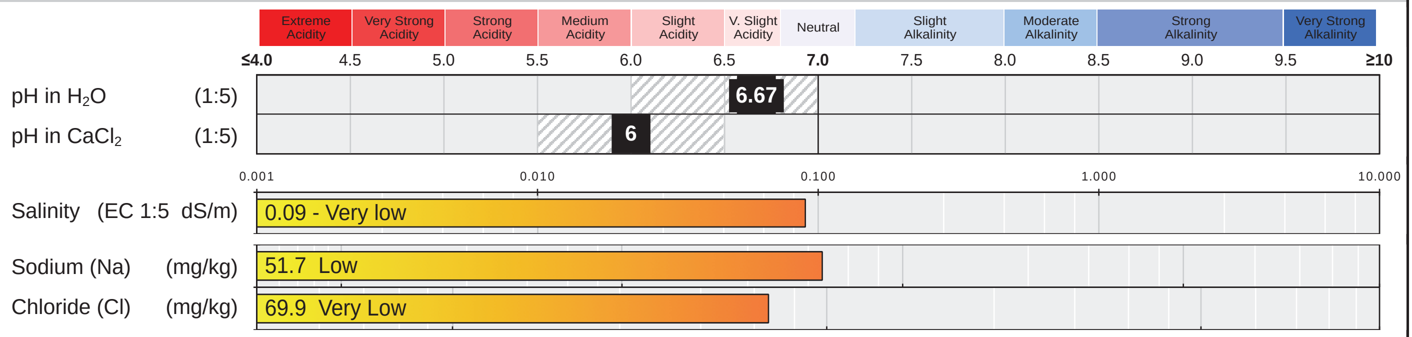
This soil sample submitted by the client was analysed for properties related to healthy plant growth, specifically the rehabilitation of soil to support pasture species. It is acidic, not saline and not sodic. The cation balance is magnesic. The effective cation exchange capacity (eCEC) is moderate, indicating good nutrient retention and holding capacity.

Of the plant available nutrients, N will prove most limiting to plant growth. This should be increased through split urea applications at 10 g/sqm (i.e. 2 x 10 g applications, or 200 kg/ha in total). P levels are also low. Apply super phosphate at 20 g/sqm (200 kg/ha). Applications of gypsum at 200 g/sqm (2 t/ha) will assist in balancing the cations and preventing any dispersion.

These applications are considered the minimum to ensure pasture success. Additionally, future application of a multi purpose NPK fertiliser (such as Dynamic Lifter or Pasture Starter) will ensure adequate nutrition as the pasture establishes.

SOIL SAMPLE DEPTH (mm): ○ **100** ● **150** ○ **200**   FERTILITY RATING: ○ Low ● Moderate ○ High

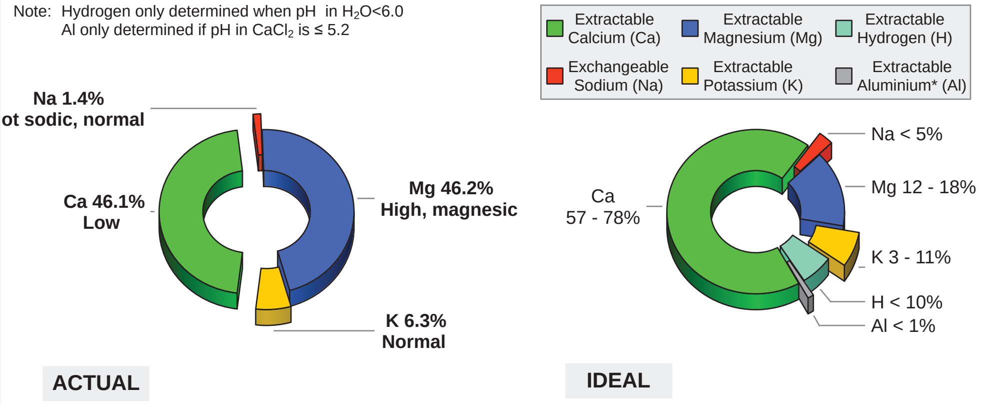
pH and ELECTRICAL CONDUCTIVITY



CATION BALANCE

EXCHANGEABLE CATION PERCENTAGE

Note: Hydrogen only determined when pH in H_2O<6.0
Al only determined if pH in $CaCl_2$ is ≤ 5.2



EFFECTIVE CATION EXCHANGE CAPACITY (eCEC)

CATION RATIOS

Ratio	Result	Target Range
Ca:Mg	1	4.1 – 6.0
Comment: Calcium low		
Mg:K	7.3	2.6 – 5.0
Comment: Potassium low		
K/(Ca+Mg)	0.07	< 0.07
Comment: High		
K:Na	4.5	N/A

Sodium Absorption Ratio: 0 Low

Electrochemical Stability Index (ESI):
0.06 Moderate potential for dispersion and soil structure collapse

SOLUBLE CATIONS (meq/100g)

Na: K: Ca: Mg:

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Soil Chemistry Profile

Mehlich 3 - Multi-nutrient Extractant

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Tel: 1300 30 40 80
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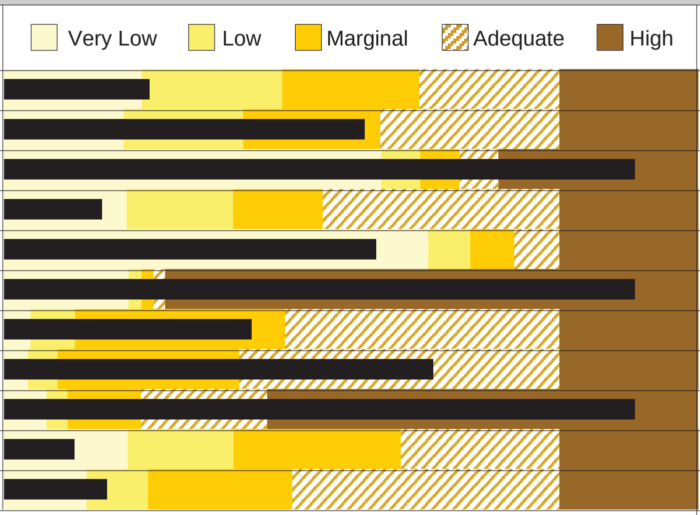
Web: www.sesl.com.au

Batch N°: 33837 **Sample N°: 15** **Date Received: 3/3/15** **Report Status:** ○ Draft ● Final

PLANT AVAILABLE NUTRIENTS



Major Nutrients	Result (mg/kg)	Result (g/sqm)	Desirable (g/sqm)	Adjustment (g/sqm)
Nitrate-N (NO_3)	5.5	1.1	6	4.9
Phosphate-P (PO_4)	42.2	8.4	12.6	4.2
Potassium (K) †	388	77.4	60.6	Drawdown
Sulphate-S (SO_4)	12	2.4	13.6	11.2
Calcium (Ca) †	1450	289.3	431.7	142.4
Magnesium (Mg) †	882	176	44.9	Drawdown
Iron (Fe)	246.1	49.1	110.1	61
Manganese (Mn) †	34	6.8	8.8	2
Zinc (Zn) †	12	2.4	1	Drawdown
Copper (Cu)	0.8	0.2	1.3	1.1
Boron (B) †	0.5	0.1	0.5	0.4

Explanation of graph ranges:

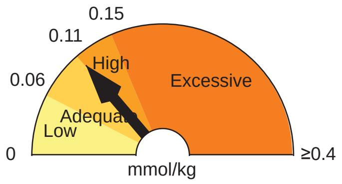
☐ Very Low	🟨 Low	🟧 Marginal	▨ Adequate	🟫 High
Growth is likely to be severely depressed and deficiency symptoms present. Large applications for soil building purposes are usually recommended. Potential response to nutrient addition is >90%.	Potential “hidden hunger”, or sub-clinical deficiency. Potential response to nutrient addition is 60 to 90%.	Supply of this nutrient is barely adequate for the plant, and build-up is still recommended. Potential response to nutrient addition is 30 to 60%.	Supply of this nutrient is adequate for the plant, and and only maintenance application rates are recommended. Potential response to nutrient addition is 5 to 30%.	The level is excessive and may be detrimental to plant growth (i.e. phytotoxic) and may contribute to pollution of ground and surface waters. Drawdown is recommended. Potential response to nutrient addition is <2%.

NOTES: Adjustment recommendation calculates the elemental application to shift the soil test level to within the **Adequate** band, which maximises growth/yield, and economic efficiency, and minimises impact on the environment.

Drawdown: The objective nutrient management is to utilise residual soil nutrients. There is no agronomic reason to apply fertiliser when soil test levels exceed **Adequate**.

- g/sqm measurements are based on soil bulk density of 1.33 tonne/m^3 and selected soil depth.

Phosphorus Saturation Index



0.11

Adequate. Economic response to P unlikely. P application recommended maintaining current P level.

Exchangeable Acidity

Adams-Evans Buffer pH (BpH): -
Sum of Base Cations (meq/100g^{-1}): **15.7**
Eff. Cation Exch. Capacity (eCEC): **15.7**
Base Saturation (%): **100**
Exchangeable Acidity (meq/100g^{-1}): -
Exchangeable Acidity (%): -

Lime Application Rate

– to achieve pH 6.0 (g/sqm): **0**
– to neutralise Al (g/sqm): -

Gypsum Application Rate

– to achieve 67.5% exch. Ca (g/sqm): **578**

The CGAR is corrected for a soil depth of 150mm and any Lime addition to achieve pH 6.0.

Physical Description

Texture: -
Colour: -
Estimated clay content: **Did not test**
Size: -
Gravel content: -
Aggregate strength: -
Structural unit: **Did not test**
Potential infiltration rate: **Did Not Test**
Permeability (mm/hr): **Did not test**
Calculated EC_{SE} (dS/m): -

Requires EC and Soil Texture result.

Organic Carbon (OC%)†: **5.3 – Very high**
Organic Matter (OM%): **8.9**
Additional comments:

Consultant: Bronwyn Brennan

Authorised Signatory: Declan McDonald

Date Report Generated 15/03/2015

METHOD REFERENCES:
pH (1:5 H_2O) - Rayment & Higginson (1992) 4A1,
pH (1:5 $CaCl_2$) - Rayment & Higginson (1992) 4B1,
EC (1:5) - Rayment & Higginson (1992) 3A1,
Chloride - Rayment & Higginson (1992) 5A2,
Nitrate - Rayment & Higginson (1992) 7B1
Aluminium - SESL in-house,
PO_4, K, SO_4, Ca, Mg, Na, Fe, Mn, Zn, Cu, B - Mehlich 3 (1984),
Buffer pH and Hydrogen - Adams-Evans (1972)
Texture/Structure/Colour - PM0003 (Texture- "Northcote" (1992), Structure- "Murphy" (1991), Colour- "Munsell" (2000))

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Environment & Soil Sciences

Soil Chemistry Profile

Mehlich 3 - Multi-nutrient Extractant

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Web: www.sesl.com.au

Batch N°: 33837 **Sample N°: 16** **Date Received: 3/3/15** **Report Status:** ○ **Draft** ● **Final**

Client Name: **AECOM - Newcastle**
Client Contact: **Matthieu Catteau**
Client Job N°:
Client Order N°:
Address: **PO Box 73**
HRMC NSW 2310

Project Name: **60340733 - C & A Rehabilitation Monitoring 2015**
MTW & HVO Mine Sites
SESL Quote N°: **Q4235**
Sample Name: **RHB-WML Swanlake**
Description: **Soil**
Test Type: **FSC, TOC_DC, M5**

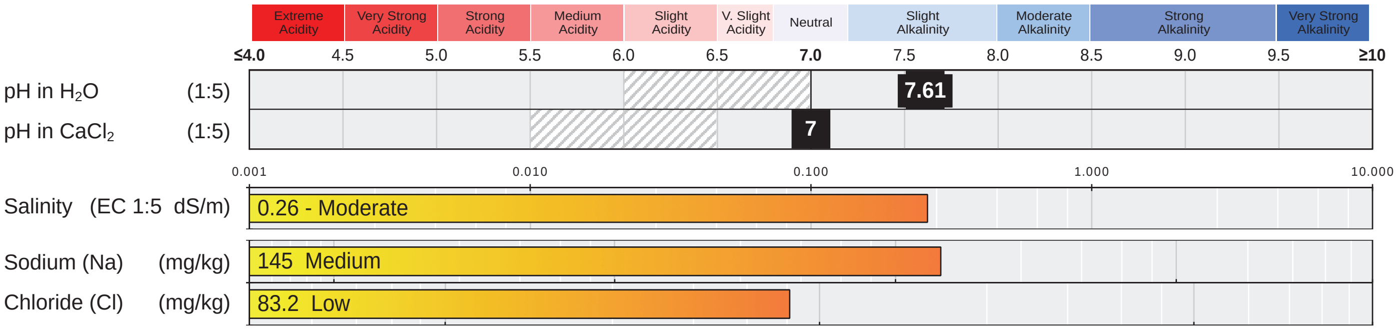
RECOMMENDATIONS

This soil sample submitted by the client was analysed for properties related to healthy plant growth, specifically the rehabilitation of soil to support pasture species. It is slightly alkaline, moderately saline and not sodic. The cation balance is magnesic. The effective cation exchange capacity (eCEC) is moderate, indicating good nutrient retention and holding capacity.

Of the plant available nutrients, N will prove most limiting to plant growth. This should be increased through split urea applications at 10 g/sqm (i.e. 2 x 10 g applications, or 200 kg/ha in total). P and K levels are also low. Apply super phosphate (DAP) and muriate of potash, both at 20 g/sqm (200 kg/ha). Applications of gypsum at 100 g/sqm (1 t/ha) will assist in balancing the cations and preventing any dispersion. This will temporarily inflate the salinity, so leaching should be encouraged to reduce this. These applications are considered the minimum to ensure pasture success. Additionally, futuree application of a multi purpose NPK fertiliser (such as Dynamic Lifter or Pasture Starter) will ensure adequate nutrition as the pasture establishes.

SOIL SAMPLE DEPTH (mm): ○ **100** ● **150** ○ **200**   FERTILITY RATING: ○ Low ● Moderate ○ High

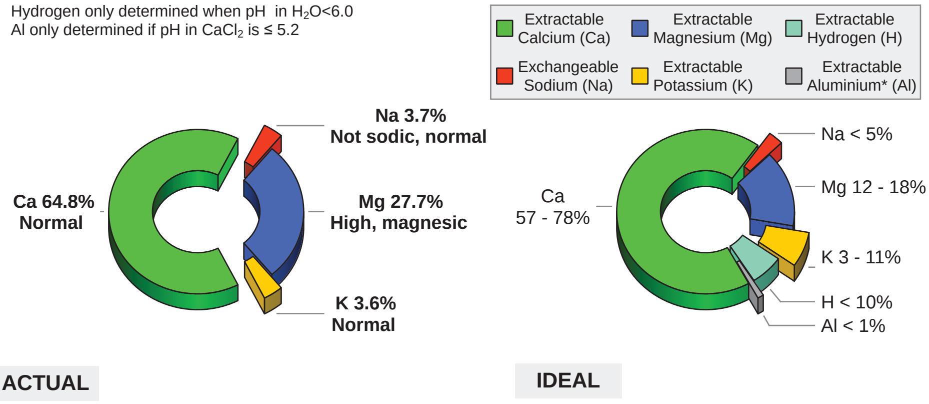
pH and ELECTRICAL CONDUCTIVITY



CATION BALANCE

EXCHANGEABLE CATION PERCENTAGE

Note: Hydrogen only determined when pH in H_2O<6.0
Al only determined if pH in $CaCl_2$ is ≤ 5.2



EFFECTIVE CATION EXCHANGE CAPACITY (eCEC)

CATION RATIOS

Ratio	Result	Target Range
Ca:Mg	**2.3**	4.1 – 6.0
Comment: Calcium low		
Mg:K	**7.7**	2.6 – 5.0
Comment: Potassium low		
K/(Ca+Mg)	**0.04**	< 0.07
Comment: Acceptable		
K:Na	**1**	N/A

Sodium Absorption Ratio: 0 Low

Electrochemical Stability Index (ESI):
0.07 Moderate potential for dispersion and soil structure collapse

SOLUBLE CATIONS (meq/100g)

Na: K: Ca: Mg:

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Soil Chemistry Profile

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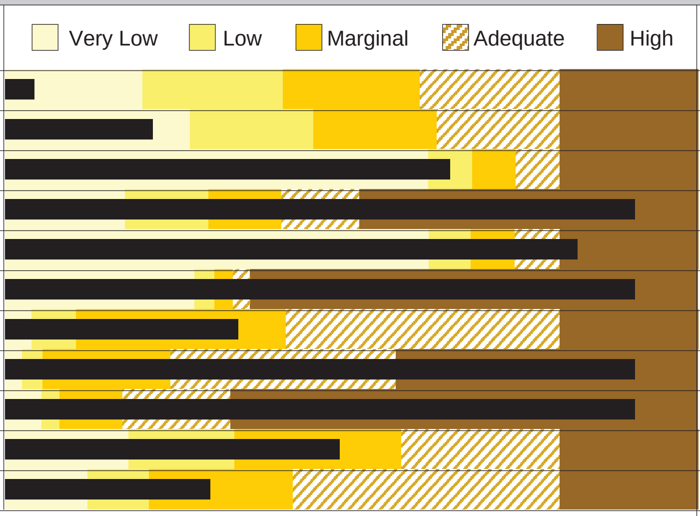
Web: www.sesl.com.au

Batch N°: 33837 **Sample N°: 16** **Date Received: 3/3/15** **Report Status:** ○ **Draft** ● **Final**

PLANT AVAILABLE NUTRIENTS

Major Nutrients	Result (mg/kg)	Result (g/sqm)	Desirable (g/sqm)	Adjustment (g/sqm)
Nitrate-N (NO_3)	1.1	0.2	6	5.8
Phosphate-P (PO_4)	16.8	3.4	12.6	9.2
Potassium (K) †	244	48.7	60.6	11.9
Sulphate-S (SO_4)	121	24.1	13.6	Drawdown
Calcium (Ca) †	2234	445.7	431.7	Drawdown
Magnesium (Mg) †	579	115.5	44.9	Drawdown
Iron (Fe)	231.9	46.3	110.1	63.8
Manganese (Mn) †	71	14.2	8.8	Drawdown
Zinc (Zn) †	14	2.8	1	Drawdown
Copper (Cu)	3.8	0.8	1.3	0.5
Boron (B) †	1	0.2	0.5	0.3



Explanation of graph ranges:

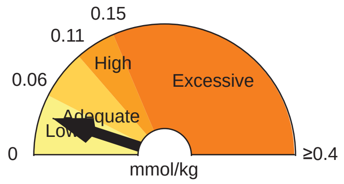
☐ Very Low	🟨 Low	🟧 Marginal	▨ Adequate	🟫 High
Growth is likely to be severely depressed and deficiency symptoms present. Large applications for soil building purposes are usually recommended. Potential response to nutrient addition is >90%.	Potential “hidden hunger”, or sub-clinical deficiency. Potential response to nutrient addition is 60 to 90%.	Supply of this nutrient is barely adequate for the plant, and build-up is still recommended. Potential response to nutrient addition is 30 to 60%.	Supply of this nutrient is adequate for the plant, and and only maintenance application rates are recommended. Potential response to nutrient addition is 5 to 30%.	The level is excessive and may be detrimental to plant growth (i.e. phytotoxic) and may contribute to pollution of ground and surface waters. Drawdown is recommended. Potential response to nutrient addition is <2%.

NOTES: Adjustment recommendation calculates the elemental application to shift the soil test level to within the **Adequate** band, which maximises growth/yield, and economic efficiency, and minimises impact on the environment.

Drawdown: The objective nutrient management is to utilise residual soil nutrients. There is no agronomic reason to apply fertiliser when soil test levels exceed **Adequate**.

- g/sqm measurements are based on soil bulk density of 1.33 tonne/m^3 and selected soil depth.

Phosphorus Saturation Index



0.04

Low. Plant response to applied P is likely.

Exchangeable Acidity

Adams-Evans Buffer pH (BpH): -
Sum of Base Cations (meq/100g^{-1}): **17.2**
Eff. Cation Exch. Capacity (eCEC): **17.2**
Base Saturation (%): **100**
Exchangeable Acidity (meq/100g^{-1}): -
Exchangeable Acidity (%): -

Lime Application Rate

– to achieve pH 6.0 (g/sqm): **0**
– to neutralise Al (g/sqm): -

Gypsum Application Rate

– to achieve 67.5% exch. Ca (g/sqm): **79**

The CGAR is corrected for a soil depth of 150mm and any Lime addition to achieve pH 6.0.

Physical Description

Texture: -
Colour: -
Estimated clay content: **Did not test**
Size: -
Gravel content: -
Aggregate strength: -
Structural unit: **Did not test**
Potential infiltration rate: **Did Not Test**
Permeability (mm/hr): **Did not test**
Calculated EC_{SE} (dS/m): -
Requires EC and Soil Texture result.
Organic Carbon (OC%)†: **3.4 – Very high**
Organic Matter (OM%): **5.7**
Additional comments:

Consultant: Bronwyn Brennan

BWoodward.

Authorised Signatory: Declan McDonald

D McDonald.

Date Report Generated 15/03/2015

METHOD REFERENCES:
pH (1:5 H_2O) - Rayment & Higginson (1992) 4A1,
pH (1:5 $CaCl_2$) - Rayment & Higginson (1992) 4B1,
EC (1:5) - Rayment & Higginson (1992) 3A1,
Chloride - Rayment & Higginson (1992) 5A2,
Nitrate - Rayment & Higginson (1992) 7B1
Aluminium - SESL in-house,
PO_4, K, SO_4, Ca, Mg, Na, Fe, Mn, Zn, Cu, B - Mehlich 3 (1984),
Buffer pH and Hydrogen - Adams-Evans (1972)
Texture/Structure/Colour - PM0003 (Texture- "Northcote" (1992), Structure- "Murphy" (1991), Colour- "Munsell" (2000))

A member of the Australasian Soil and Plant Analysis Council
† This laboratory has been awarded a Certificate of Proficiency for specific soil and plant tissue analyses by the Australasian Soil and Plant Analysis Council (ASPAC). Tests for which proficiency has been demonstrated are highlighted in this report.

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Biosolids Profile

Sample Drop Off: 16 Chilvers Road
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Batch N°: 33837 **Sample N°: 1** **Date Instructions Received: 3/3/15** **Report Status:** ○ Draft ● Final

Client Name: **AECOM - Newcastle**
Client Contact: **Matthieu Catteau**
Client Job N°:
Client Order N°:
Address: **PO Box 73**
HRMC NSW 2310

Project Name: **60340733 - C & A Rehabilitation Monitoring 2015**
MTW & HVO Mine Sites
SESL Quote N°: **Q4235**
Sample Name: **ANA-North CHPP**
Description: **Soil**
Test Type: **FSC, TOC_DC, M5**

Category	**Element**		**Results:**	**Contaminant Grade**				**Comments**
	Results given on a dry weight basis			A	B	C	D	
Chemical Contaminants (mg/kg)	Arsenic	(As)	-	≤20	≤20	≤20	≤30	Did not test
	Cadmium	(Cd)	1.2	≤3	≤5	≤20	≤32	Grade A - Unrestricted Use
	Chromium	(Cr)	-	≤100	≤250	≤500	≤600	Did not test
	Copper	(Cu)	13	≤100	≤375	≤2000	≤2000	Grade A - Unrestricted Use
	Lead	(Pb)	14.4	≤150	≤150	≤420	≤500	Grade A - Unrestricted Use
	Mercury	(Hg)	-	≤1	≤4	≤15	≤19	Did not test
	Nickel	(Ni)	19.3	≤60	≤125	≤270	≤300	Grade A - Unrestricted Use
	Selenium	(Se)	-	≤5	≤8	≤50	≤90	Did not test
	Zinc	(Zn)	56	≤200	≤700	≤2500	≤3500	Grade A - Unrestricted Use
Organic Contaminants (mg/kg)	DDT/DDD/DDE		-	≤0.5	≤0.5	≤1.0	≤1.0	Did not test
	Aldrin		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Dieldrin		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Chlordane		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Heptachlor		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	HCB		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Gamma BHC (Lindane)		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Alpha BHC		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
Note A: No detected PCB's at a limit of detection of 0.2mg PCB/kg biosolids.	PCBs		-	ND ^{A}	≤0.3	≤1.0	≤1.0	Did not test
Microbiological Standards (Stabilisation Grade)	E.coli		-	<100 MPN^{B}/g (dry weight)				Did not test
	Faecal coliforms		-	<1000 MPN^{B}/g (dry weight)				Did not test
	Salmonella sp.		-	Not detected/50g of final product				Did not test

Nitrogen Values	Solids Content % (SR)	-
	Moisture Content (%)	-
	Total Nitrogen (TN%)	-
	Total Kjeldahl N% (TKN)	-
	NO_2 present as N (dwb) mg/kg	-
	NO_3 present as N (dwb) mg/kg	-
	NH_4 present as N (dwb) mg/kg	-

Minimum quality grades			**Allowable land application use**							
Contaminant Grade	**Stabilisation Grade**	**Classification**	Home lawns & gardens	Public contact sites	Urban landscaping	Agriculture	Forestry	Soil & site rehabilitation	Landfill disposal	Surface land disposal*
A	A	Unrestricted Use	●	●	●	●	●	●	●	●
B	A	Restricted Use 1		●	●	●	●	●	●	●
C	B	Restricted Use 2				●	●	●	●	●
D	B	Restricted Use 3					●	●	●	●
E	C	Not Suitable For Use							●	●

* Restrictions apply to the selection of locations for surface land disposal.

Summary No restrictions to rehabilitation are noted.

Please see Soil Chemistry profile for recommendations.

Table 3.1 Contaminant Acceptance Concentration Thresholds, Table 3.6 Classification of Biosolids Products and Table 3.5 Stabilisation Grade A Microbiological Standards from the DEC NSW Environmental Guidelines: Use and disposal of biosolids products (1997) were used as the reference for chemical and organic contaminant acceptance concentration thresholds and classification. Other acceptance concentration thresholds and classification criterea may apply for other states.

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Consultant:
Bronwyn Brennan

Authorised Signatory:
Declan McDonald

Date Report Generated
15/03/2015

Biosolids Profile

Sample Drop Off: 16 Chilvers Road
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Batch N°: 33837 **Sample N°: 2** **Date Instructions Received: 3/3/15** **Report Status:** ○ Draft ● Final

Client Name:	**AECOM - Newcastle**	Project Name:	**60340733 - C & A Rehabilitation Monitoring 2015 MTW & HVO Mine Sites**
Client Contact:	**Matthieu Catteau**		
Client Job N°:		SESL Quote N°:	**Q4235**
Client Order N°:		Sample Name:	**ANA-Parnells**
Address:	**PO Box 73 HRMC NSW 2310**	Description:	**Soil**
		Test Type:	**FSC, TOC_DC, M5**

Category	**Element**		**Results:**	**Contaminant Grade**				**Comments**
	Results given on a dry weight basis			A	B	C	D	
Chemical Contaminants (mg/kg)	Arsenic	(As)	-	≤20	≤20	≤20	≤30	Did not test
	Cadmium	(Cd)	1.6	≤3	≤5	≤20	≤32	Grade A - Unrestricted Use
	Chromium	(Cr)	-	≤100	≤250	≤500	≤600	Did not test
	Copper	(Cu)	22	≤100	≤375	≤2000	≤2000	Grade A - Unrestricted Use
	Lead	(Pb)	21.5	≤150	≤150	≤420	≤500	Grade A - Unrestricted Use
	Mercury	(Hg)	-	≤1	≤4	≤15	≤19	Did not test
	Nickel	(Ni)	16.9	≤60	≤125	≤270	≤300	Grade A - Unrestricted Use
	Selenium	(Se)	-	≤5	≤8	≤50	≤90	Did not test
	Zinc	(Zn)	52	≤200	≤700	≤2500	≤3500	Grade A - Unrestricted Use
Organic Contaminants (mg/kg)	DDT/DDD/DDE		-	≤0.5	≤0.5	≤1.0	≤1.0	Did not test
	Aldrin		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Dieldrin		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Chlordane		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Heptachlor		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	HCB		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Gamma BHC (Lindane)		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Alpha BHC		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
Note A: No detected PCB's at a limit of detection of 0.2mg PCB/kg biosolids.	PCBs		-	ND ^{A}	≤0.3	≤1.0	≤1.0	Did not test
Microbiological Standards (Stabilisation Grade)	E.coli		-	<100 MPN^{B}/g (dry weight)				Did not test
	Faecal coliforms		-	<1000 MPN^{B}/g (dry weight)				Did not test
	Salmonella sp.		-	Not detected/50g of final product				Did not test

	Solids Content % (SR)	-
	Moisture Content (%)	-
	Total Nitrogen (TN%)	-
Nitrogen Values	Total Kjeldahl N% (TKN)	-
	NO$_2$ present as N (dwb) mg/kg	-
	NO$_3$ present as N (dwb) mg/kg	-
	NH$_4$ present as N (dwb) mg/kg	-

Minimum quality grades			**Allowable land application use**							
Contaminant Grade	**Stabilisation Grade**	**Classification**	Home lawns & gardens	Public contact sites	Urban landscaping	Agriculture	Forestry	Soil & site rehabilitation	Landfill disposal	Surface land disposal*
A	A	Unrestricted Use	●	●	●	●	●	●	●	●
B	A	Restricted Use 1		●	●	●	●	●	●	●
C	B	Restricted Use 2				●	●	●	●	●
D	B	Restricted Use 3					●	●	●	●
E	C	Not Suitable For Use							●	●

* Restrictions apply to the selection of locations for surface land disposal.

Summary No restrictions to rehabilitation are noted.

Please see Soil Chemistry profile for recommendations.

Table 3.1 Contaminant Acceptance Concentration Thresholds, Table 3.6 Classification of Biosolids Products and Table 3.5 Stabilisation Grade A Microbiological Standards from the DEC NSW Environmental Guidelines: Use and disposal of biosolids products (1997) were used as the reference for chemical and organic contaminant acceptance concentration thresholds and classification. Other acceptance concentration thresholds and classification criterea may apply for other states.

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Consultant:
Bronwyn Brennan

Authorised Signatory:
Declan McDonald

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15/03/2015

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Biosolids Profile

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Batch N°: 33837 **Sample N°: 3** **Date Instructions Received: 3/3/15** **Report Status:** ○ Draft ● Final

Client Name: **AECOM - Newcastle**
Client Contact: **Matthieu Catteau**
Client Job N°:
Client Order N°:
Address: **PO Box 73**
HRMC NSW 2310

Project Name: **60340733 - C & A Rehabilitation Monitoring 2015**
MTW & HVO Mine Sites
SESL Quote N°: **Q4235**
Sample Name: **ANA-Knodlers Lane**
Description: **Soil**
Test Type: **FSC, TOC_DC, M5**

Category	Element		Results:	Contaminant Grade				Comments
	Results given on a dry weight basis			A	B	C	D	
Chemical Contaminants (mg/kg)	Arsenic	(As)	-	≤20	≤20	≤20	≤30	Did not test
	Cadmium	(Cd)	0.9	≤3	≤5	≤20	≤32	Grade A - Unrestricted Use
	Chromium	(Cr)	-	≤100	≤250	≤500	≤600	Did not test
	Copper	(Cu)	7	≤100	≤375	≤2000	≤2000	Grade A - Unrestricted Use
	Lead	(Pb)	10.3	≤150	≤150	≤420	≤500	Grade A - Unrestricted Use
	Mercury	(Hg)	-	≤1	≤4	≤15	≤19	Did not test
	Nickel	(Ni)	16.3	≤60	≤125	≤270	≤300	Grade A - Unrestricted Use
	Selenium	(Se)	-	≤5	≤8	≤50	≤90	Did not test
	Zinc	(Zn)	23	≤200	≤700	≤2500	≤3500	Grade A - Unrestricted Use
Organic Contaminants (mg/kg)	DDT/DDD/DDE		-	≤0.5	≤0.5	≤1.0	≤1.0	Did not test
	Aldrin		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Dieldrin		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Chlordane		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Heptachlor		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	HCB		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Gamma BHC (Lindane)		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Alpha BHC		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
Note A: No detected PCB's at a limit of detection of 0.2mg PCB/kg biosolids.	PCBs		-	ND ^{A}	≤0.3	≤1.0	≤1.0	Did not test
Microbiological Standards (Stabilisation Grade)	E.coli		-	<100 MPN^B/g (dry weight)				Did not test
	Faecal coliforms		-	<1000 MPN^B/g (dry weight)				Did not test
	Salmonella sp.		-	Not detected/50g of final product				Did not test

Nitrogen Values	Solids Content % (SR)	-
	Moisture Content (%)	-
	Total Nitrogen (TN%)	-
	Total Kjeldahl N% (TKN)	-
	NO_2 present as N (dwb) mg/kg	-
	NO_3 present as N (dwb) mg/kg	-
	NH_4 present as N (dwb) mg/kg	-

Minimum quality grades			Allowable land application use							
Contaminant Grade	Stabilisation Grade	Classification	Home lawns & gardens	Public contact sites	Urban landscaping	Agriculture	Forestry	Soil & site rehabilitation	Landfill disposal	Surface land disposal*
A	A	Unrestricted Use	●	●	●	●	●	●	●	●
B	A	Restricted Use 1		●	●	●	●	●	●	●
C	B	Restricted Use 2				●	●	●	●	●
D	B	Restricted Use 3					●	●	●	●
E	C	Not Suitable For Use							●	●

* Restrictions apply to the selection of locations for surface land disposal.

Summary No restrictions to rehabilitation are noted.

Please see Soil Chemistry profile for recommendations.

Table 3.1 Contaminant Acceptance Concentration Thresholds, Table 3.6 Classification of Biosolids Products and Table 3.5 Stabilisation Grade A Microbiological Standards from the DEC NSW Environmental Guidelines: Use and disposal of biosolids products (1997) were used as the reference for chemical and organic contaminant acceptance concentration thresholds and classification. Other acceptance concentration thresholds and classification criterea may apply for other states.

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Consultant:
Bronwyn Brennan

Authorised Signatory: D McDonald
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Date Report Generated
15/03/2015

Biosolids Profile

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Batch N°: 33837 **Sample N°: 4** **Date Instructions Received: 3/3/15** **Report Status:** ○ Draft ● Final

Client Name: **AECOM - Newcastle**
Client Contact: **Matthieu Catteau**
Client Job N°:
Client Order N°:
Address: **PO Box 73**
HRMC NSW 2310

Project Name: **60340733 - C & A Rehabilitation Monitoring 2015**
MTW & HVO Mine Sites
SESL Quote N°: **Q4235**
Sample Name: **ANA Carrington Billabong**
Description: **Soil**
Test Type: **FSC, TOC_DC, M5**

Category	Element		Results:	Contaminant Grade				Comments
	Results given on a dry weight basis			A	B	C	D	
Chemical Contaminants (mg/kg)	Arsenic	(As)	-	≤20	≤20	≤20	≤30	Did not test
	Cadmium	(Cd)	1.7	≤3	≤5	≤20	≤32	Grade A - Unrestricted Use
	Chromium	(Cr)	-	≤100	≤250	≤500	≤600	Did not test
	Copper	(Cu)	29	≤100	≤375	≤2000	≤2000	Grade A - Unrestricted Use
	Lead	(Pb)	9.1	≤150	≤150	≤420	≤500	Grade A - Unrestricted Use
	Mercury	(Hg)	-	≤1	≤4	≤15	≤19	Did not test
	Nickel	(Ni)	60.5	≤60	≤125	≤270	≤300	Grade B - Restricted Use 1
	Selenium	(Se)	-	≤5	≤8	≤50	≤90	Did not test
	Zinc	(Zn)	64	≤200	≤700	≤2500	≤3500	Grade A - Unrestricted Use
Organic Contaminants (mg/kg)	DDT/DDD/DDE		-	≤0.5	≤0.5	≤1.0	≤1.0	Did not test
	Aldrin		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Dieldrin		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Chlordane		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Heptachlor		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	HCB		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Gamma BHC (Lindane)		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Alpha BHC		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
Note A: No detected PCB's at a limit of detection of 0.2mg PCB/kg biosolids.	PCBs		-	ND ^{A}	≤0.3	≤1.0	≤1.0	Did not test
Microbiological Standards (Stabilisation Grade)	E.coli		-	<100 MPN^{B}/g (dry weight)				Did not test
	Faecal coliforms		-	<1000 MPN^{B}/g (dry weight)				Did not test
	Salmonella sp.		-	Not detected/50g of final product				Did not test

Nitrogen Values	Solids Content % (SR)	-
	Moisture Content (%)	-
	Total Nitrogen (TN%)	-
	Total Kjeldahl N% (TKN)	-
	NO_2 present as N (dwb) mg/kg	-
	NO_3 present as N (dwb) mg/kg	-
	NH_4 present as N (dwb) mg/kg	-

Minimum quality grades			Allowable land application use							
Contaminant Grade	Stabilisation Grade	Classification	Home lawns & gardens	Public contact sites	Urban landscaping	Agriculture	Forestry	Soil & site rehabilitation	Landfill disposal	Surface land disposal*
A	A	Unrestricted Use	●	●	●	●	●	●	●	●
B	A	Restricted Use 1		●	●	●	●	●	●	●
C	B	Restricted Use 2				●	●	●	●	●
D	B	Restricted Use 3					●	●	●	●
E	C	Not Suitable For Use							●	●

* Restrictions apply to the selection of locations for surface land disposal.

Summary No restrictions to rehabilitation are noted.

Please see Soil Chemistry profile for recommendations.

Table 3.1 Contaminant Acceptance Concentration Thresholds, Table 3.6 Classification of Biosolids Products and Table 3.5 Stabilisation Grade A Microbiological Standards from the DEC NSW Environmental Guidelines: Use and disposal of biosolids products (1997) were used as the reference for chemical and organic contaminant acceptance concentration thresholds and classification. Other acceptance concentration thresholds and classification criterea may apply for other states.

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Consultant:
Bronwyn Brennan

Authorised Signatory:
Declan McDonald

Date Report Generated
15/03/2015

Biosolids Profile

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Batch N°: 33837 **Sample N°: 5** **Date Instructions Received: 3/3/15** **Report Status:** ○ **Draft** ● **Final**

Client Name: **AECOM - Newcastle**
Client Contact: **Matthieu Catteau**
Client Job N°:
Client Order N°:
Address: **PO Box 73**
HRMC NSW 2310

Project Name: **60340733 - C & A Rehabilitation Monitoring 2015**
MTW & HVO Mine Sites
SESL Quote N°: **Q4235**
Sample Name: **ANA-Newport**
Description: **Soil**
Test Type: **FSC, TOC_DC, M5**

Category	**Element**	**Results:**	**Contaminant Grade**				**Comments**
	Results given on a dry weight basis		A	B	C	D	
Chemical Contaminants (mg/kg)	Arsenic (As)	-	≤20	≤20	≤20	≤30	Did not test
	Cadmium (Cd)	1.8	≤3	≤5	≤20	≤32	Grade A - Unrestricted Use
	Chromium (Cr)	-	≤100	≤250	≤500	≤600	Did not test
	Copper (Cu)	7	≤100	≤375	≤2000	≤2000	Grade A - Unrestricted Use
	Lead (Pb)	24	≤150	≤150	≤420	≤500	Grade A - Unrestricted Use
	Mercury (Hg)	-	≤1	≤4	≤15	≤19	Did not test
	Nickel (Ni)	11.3	≤60	≤125	≤270	≤300	Grade A - Unrestricted Use
	Selenium (Se)	-	≤5	≤8	≤50	≤90	Did not test
	Zinc (Zn)	43	≤200	≤700	≤2500	≤3500	Grade A - Unrestricted Use
Organic Contaminants (mg/kg)	DDT/DDD/DDE	-	≤0.5	≤0.5	≤1.0	≤1.0	Did not test
	Aldrin	-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Dieldrin	-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Chlordane	-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Heptachlor	-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	HCB	-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Gamma BHC (Lindane)	-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Alpha BHC	-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
Note A: No detected PCB's at a limit of detection of 0.2mg PCB/kg biosolids.	PCBs	-	ND ^{A}	≤0.3	≤1.0	≤1.0	Did not test
Microbiological Standards (Stabilisation Grade)	E.coli	-	<100 MPN^B/g (dry weight)				Did not test
	Faecal coliforms	-	<1000 MPN^B/g (dry weight)				Did not test
	Salmonella sp.	-	Not detected/50g of final product				Did not test

Nitrogen Values	Solids Content % (SR)	-
	Moisture Content (%)	-
	Total Nitrogen (TN%)	-
	Total Kjeldahl N% (TKN)	-
	NO_2 present as N (dwb) mg/kg	-
	NO_3 present as N (dwb) mg/kg	-
	NH_4 present as N (dwb) mg/kg	-

Minimum quality grades			**Allowable land application use**							
Contaminant Grade	**Stabilisation Grade**	**Classification**	Home lawns & gardens	Public contact sites	Urban landscaping	Agriculture	Forestry	Soil & site rehabilitation	Landfill disposal	Surface land disposal*
A	A	Unrestricted Use	●	●	●	●	●	●	●	●
B	A	Restricted Use 1		●	●	●	●	●	●	●
C	B	Restricted Use 2				●	●	●	●	●
D	B	Restricted Use 3					●	●	●	●
E	C	Not Suitable For Use							●	●

* Restrictions apply to the selection of locations for surface land disposal.

Summary No restrictions to rehabilitation are noted.

Please see Soil Chemistry profile for recommendations.

Table 3.1 Contaminant Acceptance Concentration Thresholds, Table 3.6 Classification of Biosolids Products and Table 3.5 Stabilisation Grade A Microbiological Standards from the DEC NSW Environmental Guidelines: Use and disposal of biosolids products (1997) were used as the reference for chemical and organic contaminant acceptance concentration thresholds and classification. Other acceptance concentration thresholds and classification criterea may apply for other states.

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Consultant:
Bronwyn Brennan

Authorised Signatory:
Declan McDonald

Date Report Generated
15/03/2015

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Biosolids Profile

Sample Drop Off: 16 Chilvers Road
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Batch N°: 33837 **Sample N°: 6** **Date Instructions Received: 3/3/15** **Report Status:** ○ Draft ● Final

Client Name: **AECOM - Newcastle**
Client Contact: **Matthieu Catteau**
Client Job N°:
Client Order N°:
Address: **PO Box 73**
HRMC NSW 2310

Project Name: **60340733 - C & A Rehabilitation Monitoring 2015**
MTW & HVO Mine Sites
SESL Quote N°: **Q4235**
Sample Name: **ANA-Cheshunt**
Description: **Soil**
Test Type: **FSC, TOC_DC, M5**

Category	**Element**		**Results:**	**Contaminant Grade**				**Comments**
	Results given on a dry weight basis			A	B	C	D	
Chemical Contaminants (mg/kg)	Arsenic	(As)	-	≤20	≤20	≤20	≤30	Did not test
	Cadmium	(Cd)	1.7	≤3	≤5	≤20	≤32	Grade A - Unrestricted Use
	Chromium	(Cr)	-	≤100	≤250	≤500	≤600	Did not test
	Copper	(Cu)	24	≤100	≤375	≤2000	≤2000	Grade A - Unrestricted Use
	Lead	(Pb)	8.7	≤150	≤150	≤420	≤500	Grade A - Unrestricted Use
	Mercury	(Hg)	-	≤1	≤4	≤15	≤19	Did not test
	Nickel	(Ni)	54.4	≤60	≤125	≤270	≤300	Grade A - Unrestricted Use
	Selenium	(Se)	-	≤5	≤8	≤50	≤90	Did not test
	Zinc	(Zn)	63	≤200	≤700	≤2500	≤3500	Grade A - Unrestricted Use
Organic Contaminants (mg/kg)	DDT/DDD/DDE		-	≤0.5	≤0.5	≤1.0	≤1.0	Did not test
	Aldrin		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Dieldrin		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Chlordane		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Heptachlor		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	HCB		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Gamma BHC (Lindane)		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Alpha BHC		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
Note A: No detected PCB's at a limit of detection of 0.2mg PCB/kg biosolids.	PCBs		-	ND ^{A}	≤0.3	≤1.0	≤1.0	Did not test
Microbiological Standards (Stabilisation Grade)	E.coli		-	<100 MPN^B/g (dry weight)				Did not test
	Faecal coliforms		-	<1000 MPN^B/g (dry weight)				Did not test
	Salmonella sp.		-	Not detected/50g of final product				Did not test

Nitrogen Values	Solids Content % (SR)	-
	Moisture Content (%)	-
	Total Nitrogen (TN%)	-
	Total Kjeldahl N% (TKN)	-
	NO_2 present as N (dwb) mg/kg	-
	NO_3 present as N (dwb) mg/kg	-
	NH_4 present as N (dwb) mg/kg	-

Minimum quality grades			**Allowable land application use**							
Contaminant Grade	**Stabilisation Grade**	**Classification**	Home lawns & gardens	Public contact sites	Urban landscaping	Agriculture	Forestry	Soil & site rehabilitation	Landfill disposal	Surface land disposal*
A	A	Unrestricted Use	●	●	●	●	●	●	●	●
B	A	Restricted Use 1		●	●	●	●	●	●	●
C	B	Restricted Use 2				●	●	●	●	●
D	B	Restricted Use 3					●	●	●	●
E	C	Not Suitable For Use							●	●

* Restrictions apply to the selection of locations for surface land disposal.

Summary No restrictions to rehabilitation are noted.

Please see Soil Chemistry profile for recommendations.

Table 3.1 Contaminant Acceptance Concentration Thresholds, Table 3.6 Classification of Biosolids Products and Table 3.5 Stabilisation Grade A Microbiological Standards from the DEC NSW Environmental Guidelines: Use and disposal of biosolids products (1997) were used as the reference for chemical and organic contaminant acceptance concentration thresholds and classification. Other acceptance concentration thresholds and classification criterea may apply for other states.

Tests are performed under a quality system certified as complying with ISO 9001: 2008. Results and conclusions assume that sampling is representative. This document shall not be reproduced except in full.

Consultant:
Bronwyn Brennan

Authorised Signatory:
Declan McDonald

Date Report Generated
15/03/2015

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Biosolids Profile

Sample Drop Off: 16 Chilvers Road
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Batch N°: 33837 **Sample N°: 7** **Date Instructions Received: 3/3/15** **Report Status:** ○ Draft ● Final

Client Name: **AECOM - Newcastle**
Client Contact: **Matthieu Catteau**
Client Job N°:
Client Order N°:
Address: **PO Box 73**
HRMC NSW 2310

Project Name: **60340733 - C & A Rehabilitation Monitoring 2015**
MTW & HVO Mine Sites
SESL Quote N°: **Q4235**
Sample Name: **ANA-Howick**
Description: **Soil**
Test Type: **FSC, TOC_DC, M5**

Category	**Element**		**Results:**	**Contaminant Grade**				**Comments**
	Results given on a dry weight basis			A	B	C	D	
Chemical Contaminants (mg/kg)	Arsenic	(As)	-	≤20	≤20	≤20	≤30	Did not test
	Cadmium	(Cd)	3.1	≤3	≤5	≤20	≤32	Grade B - Restricted Use 1
	Chromium	(Cr)	-	≤100	≤250	≤500	≤600	Did not test
	Copper	(Cu)	22	≤100	≤375	≤2000	≤2000	Grade A - Unrestricted Use
	Lead	(Pb)	30.1	≤150	≤150	≤420	≤500	Grade A - Unrestricted Use
	Mercury	(Hg)	-	≤1	≤4	≤15	≤19	Did not test
	Nickel	(Ni)	19.5	≤60	≤125	≤270	≤300	Grade A - Unrestricted Use
	Selenium	(Se)	-	≤5	≤8	≤50	≤90	Did not test
	Zinc	(Zn)	84	≤200	≤700	≤2500	≤3500	Grade A - Unrestricted Use
Organic Contaminants (mg/kg)	DDT/DDD/DDE		-	≤0.5	≤0.5	≤1.0	≤1.0	Did not test
	Aldrin		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Dieldrin		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Chlordane		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Heptachlor		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	HCB		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Gamma BHC (Lindane)		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Alpha BHC		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
Note A: No detected PCB's at a limit of detection of 0.2mg PCB/kg biosolids.	PCBs		-	ND ^{A}	≤0.3	≤1.0	≤1.0	Did not test
Microbiological Standards (Stabilisation Grade)	E.coli		-	<100 MPN^B/g (dry weight)				Did not test
	Faecal coliforms		-	<1000 MPN^B/g (dry weight)				Did not test
	Salmonella sp.		-	Not detected/50g of final product				Did not test

Nitrogen Values	Solids Content % (SR)	-
	Moisture Content (%)	-
	Total Nitrogen (TN%)	-
	Total Kjeldahl N% (TKN)	-
	NO_2 present as N (dwb) mg/kg	-
	NO_3 present as N (dwb) mg/kg	-
	NH_4 present as N (dwb) mg/kg	-

Minimum quality grades			**Allowable land application use**							
Contaminant Grade	**Stabilisation Grade**	**Classification**	Home lawns & gardens	Public contact sites	Urban landscaping	Agriculture	Forestry	Soil & site rehabilitation	Landfill disposal	Surface land disposal*
A	A	Unrestricted Use	●	●	●	●	●	●	●	●
B	A	Restricted Use 1		●	●	●	●	●	●	●
C	B	Restricted Use 2				●	●	●	●	●
D	B	Restricted Use 3					●	●	●	●
E	C	Not Suitable For Use							●	●

* Restrictions apply to the selection of locations for surface land disposal.

Summary No restrictions to rehabilitation are noted.

Please see Soil Chemistry profile for recommendations.

Table 3.1 Contaminant Acceptance Concentration Thresholds, Table 3.6 Classification of Biosolids Products and Table 3.5 Stabilisation Grade A Microbiological Standards from the DEC NSW Environmental Guidelines: Use and disposal of biosolids products (1997) were used as the reference for chemical and organic contaminant acceptance concentration thresholds and classification. Other acceptance concentration thresholds and classification criterea may apply for other states.

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Bronwyn Brennan

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Date Report Generated
15/03/2015

Biosolids Profile

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Batch N°: 33837 **Sample N°: 8** **Date Instructions Received: 3/3/15** **Report Status:** ○ Draft ● Final

Client Name: **AECOM - Newcastle**
Client Contact: **Matthieu Catteau**
Client Job N°:
Client Order N°:
Address: **PO Box 73**
HRMC NSW 2310

Project Name: **60340733 - C & A Rehabilitation Monitoring 2015**
MTW & HVO Mine Sites
SESL Quote N°: **Q4235**
Sample Name: **ANA-Lemington Rd**
Description: **Soil**
Test Type: **FSC, TOC_DC, M5**

Category	**Element**	**Results:**	**Contaminant Grade**				**Comments**
	Results given on a dry weight basis		A	B	C	D	
Chemical Contaminants (mg/kg)	Arsenic (As)	-	≤20	≤20	≤20	≤30	Did not test
	Cadmium (Cd)	1.7	≤3	≤5	≤20	≤32	Grade A - Unrestricted Use
	Chromium (Cr)	-	≤100	≤250	≤500	≤600	Did not test
	Copper (Cu)	24	≤100	≤375	≤2000	≤2000	Grade A - Unrestricted Use
	Lead (Pb)	8.9	≤150	≤150	≤420	≤500	Grade A - Unrestricted Use
	Mercury (Hg)	-	≤1	≤4	≤15	≤19	Did not test
	Nickel (Ni)	54.6	≤60	≤125	≤270	≤300	Grade A - Unrestricted Use
	Selenium (Se)	-	≤5	≤8	≤50	≤90	Did not test
	Zinc (Zn)	62	≤200	≤700	≤2500	≤3500	Grade A - Unrestricted Use
Organic Contaminants (mg/kg)	DDT/DDD/DDE	-	≤0.5	≤0.5	≤1.0	≤1.0	Did not test
	Aldrin	-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Dieldrin	-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Chlordane	-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Heptachlor	-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	HCB	-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Gamma BHC (Lindane)	-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Alpha BHC	-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
Note A: No detected PCB's at a limit of detection of 0.2mg PCB/kg biosolids.	PCBs	-	ND [A]	≤0.3	≤1.0	≤1.0	Did not test
Microbiological Standards (Stabilisation Grade)	E.coli	-	<100 MPN[B]/g (dry weight)				Did not test
	Faecal coliforms	-	<1000 MPN[B]/g (dry weight)				Did not test
	Salmonella sp.	-	Not detected/50g of final product				Did not test

Nitrogen Values	Solids Content % (SR)	-
	Moisture Content (%)	-
	Total Nitrogen (TN%)	-
	Total Kjeldahl N% (TKN)	-
	NO_2 present as N (dwb) mg/kg	-
	NO_3 present as N (dwb) mg/kg	-
	NH_4 present as N (dwb) mg/kg	-

Minimum quality grades			**Allowable land application use**							
Contaminant Grade	**Stabilisation Grade**	**Classification**	Home lawns & gardens	Public contact sites	Urban landscaping	Agriculture	Forestry	Soil & site rehabilitation	Landfill disposal	Surface land disposal*
A	A	Unrestricted Use	●	●	●	●	●	●	●	●
B	A	Restricted Use 1		●	●	●	●	●	●	●
C	B	Restricted Use 2				●	●	●	●	●
D	B	Restricted Use 3					●	●	●	●
E	C	Not Suitable For Use							●	●

* Restrictions apply to the selection of locations for surface land disposal.

Summary No restrictions to rehabilitation are noted.

Please see Soil Chemistry profile for recommendations.

Table 3.1 Contaminant Acceptance Concentration Thresholds, Table 3.6 Classification of Biosolids Products and Table 3.5 Stabilisation Grade A Microbiological Standards from the DEC NSW Environmental Guidelines: Use and disposal of biosolids products (1997) were used as the reference for chemical and organic contaminant acceptance concentration thresholds and classification. Other acceptance concentration thresholds and classification criterea may apply for other states.

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Date Report Generated
15/03/2015

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Biosolids Profile

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Batch N°: 33837 **Sample N°: 9** **Date Instructions Received: 3/3/15** **Report Status:** ○ **Draft** ● **Final**

Client Name: **AECOM - Newcastle**
Client Contact: **Matthieu Catteau**
Client Job N°:
Client Order N°:
Address: **PO Box 73**
HRMC NSW 2310

Project Name: **60340733 - C & A Rehabilitation Monitoring 2015**
MTW & HVO Mine Sites
SESL Quote N°: **Q4235**
Sample Name: **RHB-MTO South CHPP**
Description: **Soil**
Test Type: **FSC, TOC_DC, M5**

Category	**Element**		**Results:**	**Contaminant Grade**				**Comments**
	Results given on a dry weight basis			A	B	C	D	
Chemical Contaminants (mg/kg)	Arsenic	(As)	-	≤20	≤20	≤20	≤30	Did not test
	Cadmium	(Cd)	1.7	≤3	≤5	≤20	≤32	Grade A - Unrestricted Use
	Chromium	(Cr)	-	≤100	≤250	≤500	≤600	Did not test
	Copper	(Cu)	31	≤100	≤375	≤2000	≤2000	Grade A - Unrestricted Use
	Lead	(Pb)	20.3	≤150	≤150	≤420	≤500	Grade A - Unrestricted Use
	Mercury	(Hg)	-	≤1	≤4	≤15	≤19	Did not test
	Nickel	(Ni)	18	≤60	≤125	≤270	≤300	Grade A - Unrestricted Use
	Selenium	(Se)	-	≤5	≤8	≤50	≤90	Did not test
	Zinc	(Zn)	61	≤200	≤700	≤2500	≤3500	Grade A - Unrestricted Use
Organic Contaminants (mg/kg)	DDT/DDD/DDE		-	≤0.5	≤0.5	≤1.0	≤1.0	Did not test
	Aldrin		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Dieldrin		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Chlordane		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Heptachlor		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	HCB		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Gamma BHC (Lindane)		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Alpha BHC		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
Note A: No detected PCB's at a limit of detection of 0.2mg PCB/kg biosolids.	PCBs		-	ND [A]	≤0.3	≤1.0	≤1.0	Did not test
Microbiological Standards (Stabilisation Grade)	E.coli		-	<100 MPN[B]/g (dry weight)				Did not test
	Faecal coliforms		-	<1000 MPN[B]/g (dry weight)				Did not test
	Salmonella sp.		-	Not detected/50g of final product				Did not test

Nitrogen Values	Solids Content % (SR)	-
	Moisture Content (%)	-
	Total Nitrogen (TN%)	-
	Total Kjeldahl N% (TKN)	-
	NO_2 present as N (dwb) mg/kg	-
	NO_3 present as N (dwb) mg/kg	-
	NH_4 present as N (dwb) mg/kg	-

Minimum quality grades			**Allowable land application use**							
Contaminant Grade	**Stabilisation Grade**	**Classification**	Home lawns & gardens	Public contact sites	Urban landscaping	Agriculture	Forestry	Soil & site rehabilitation	Landfill disposal	Surface land disposal*
A	A	Unrestricted Use	●	●	●	●	●	●	●	●
B	A	Restricted Use 1		●	●	●	●	●	●	●
C	B	Restricted Use 2				●	●	●	●	●
D	B	Restricted Use 3					●	●	●	●
E	C	Not Suitable For Use							●	●

* Restrictions apply to the selection of locations for surface land disposal.

Summary No restrictions to rehabilitation are noted.

Please see Soil Chemistry profile for recommendations.

Table 3.1 Contaminant Acceptance Concentration Thresholds, Table 3.6 Classification of Biosolids Products and Table 3.5 Stabilisation Grade A Microbiological Standards from the DEC NSW Environmental Guidelines: Use and disposal of biosolids products (1997) were used as the reference for chemical and organic contaminant acceptance concentration thresholds and classification. Other acceptance concentration thresholds and classification criterea may apply for other states.

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Date Report Generated
15/03/2015

Biosolids Profile

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Batch N°: 33837 **Sample N°: 10** **Date Instructions Received: 3/3/15** **Report Status:** ○ Draft ● Final

Client Name: **AECOM - Newcastle**
Client Contact: **Matthieu Catteau**
Client Job N°:
Client Order N°:
Address: **PO Box 73**
HRMC NSW 2310

Project Name: **60340733 - C & A Rehabilitation Monitoring 2015**
MTW & HVO Mine Sites
SESL Quote N°: **Q4235**
Sample Name: **RHB-HVOW Plane Dump**
Description: **Soil**
Test Type: **FSC, TOC_DC, M5**

Category	Element		Results:	Contaminant Grade				Comments
	Results given on a dry weight basis			A	B	C	D	
Chemical Contaminants (mg/kg)	Arsenic	(As)	-	≤20	≤20	≤20	≤30	Did not test
	Cadmium	(Cd)	1.7	≤3	≤5	≤20	≤32	Grade A - Unrestricted Use
	Chromium	(Cr)	-	≤100	≤250	≤500	≤600	Did not test
	Copper	(Cu)	26	≤100	≤375	≤2000	≤2000	Grade A - Unrestricted Use
	Lead	(Pb)	20	≤150	≤150	≤420	≤500	Grade A - Unrestricted Use
	Mercury	(Hg)	-	≤1	≤4	≤15	≤19	Did not test
	Nickel	(Ni)	17.5	≤60	≤125	≤270	≤300	Grade A - Unrestricted Use
	Selenium	(Se)	-	≤5	≤8	≤50	≤90	Did not test
	Zinc	(Zn)	61	≤200	≤700	≤2500	≤3500	Grade A - Unrestricted Use
Organic Contaminants (mg/kg)	DDT/DDD/DDE		-	≤0.5	≤0.5	≤1.0	≤1.0	Did not test
	Aldrin		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Dieldrin		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Chlordane		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Heptachlor		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	HCB		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Gamma BHC (Lindane)		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Alpha BHC		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
Note A: No detected PCB's at a limit of detection of 0.2mg PCB/kg biosolids.	PCBs		-	ND [A]	≤0.3	≤1.0	≤1.0	Did not test
Microbiological Standards (Stabilisation Grade)	E.coli		-	<100 MPN[B]/g (dry weight)				Did not test
	Faecal coliforms		-	<1000 MPN[B]/g (dry weight)				Did not test
	Salmonella sp.		-	Not detected/50g of final product				Did not test

Nitrogen Values		
	Solids Content % (SR)	-
	Moisture Content (%)	-
	Total Nitrogen (TN%)	-
	Total Kjeldahl N% (TKN)	-
	NO_2 present as N (dwb) mg/kg	-
	NO_3 present as N (dwb) mg/kg	-
	NH_4 present as N (dwb) mg/kg	-

Minimum quality grades			Allowable land application use							
Contaminant Grade	Stabilisation Grade	Classification	Home lawns & gardens	Public contact sites	Urban landscaping	Agriculture	Forestry	Soil & site rehabilitation	Landfill disposal	Surface land disposal*
A	A	Unrestricted Use	●	●	●	●	●	●	●	●
B	A	Restricted Use 1		●	●	●	●	●	●	●
C	B	Restricted Use 2				●	●	●	●	●
D	B	Restricted Use 3					●	●	●	●
E	C	Not Suitable For Use							●	●

* Restrictions apply to the selection of locations for surface land disposal.

Summary No restrictions to rehabilitation are noted.

Please see Soil Chemistry profile for recommendations.

Table 3.1 Contaminant Acceptance Concentration Thresholds, Table 3.6 Classification of Biosolids Products and Table 3.5 Stabilisation Grade A Microbiological Standards from the DEC NSW Environmental Guidelines: Use and disposal of biosolids products (1997) were used as the reference for chemical and organic contaminant acceptance concentration thresholds and classification. Other acceptance concentration thresholds and classification criterea may apply for other states.

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Bronwyn Brennan

Authorised Signatory:
Declan McDonald

Date Report Generated
15/03/2015

SESL
AUSTRALIA
Environment & Soil Sciences

Biosolids Profile

Sample Drop Off: 16 Chilvers Road
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Batch N°: 33837 **Sample N°: 11** **Date Instructions Received: 3/3/15** **Report Status:** ○ Draft ● Final

Client Name: **AECOM - Newcastle**
Client Contact: **Matthieu Catteau**
Client Job N°:
Client Order N°:
Address: **PO Box 73**
HRMC NSW 2310

Project Name: **60340733 - C & A Rehabilitation Monitoring 2015**
MTW & HVO Mine Sites
SESL Quote N°: **Q4235**
Sample Name: **RHB-MTO North Dump**
Description: **Soil**
Test Type: **FSC, TOC_DC, M5**

Category	Element		Results:	Contaminant Grade				Comments
	Results given on a dry weight basis			A	B	C	D	
Chemical Contaminants (mg/kg)	Arsenic	(As)	-	≤20	≤20	≤20	≤30	Did not test
	Cadmium	(Cd)	1.2	≤3	≤5	≤20	≤32	Grade A - Unrestricted Use
	Chromium	(Cr)	-	≤100	≤250	≤500	≤600	Did not test
	Copper	(Cu)	10	≤100	≤375	≤2000	≤2000	Grade A - Unrestricted Use
	Lead	(Pb)	12.4	≤150	≤150	≤420	≤500	Grade A - Unrestricted Use
	Mercury	(Hg)	-	≤1	≤4	≤15	≤19	Did not test
	Nickel	(Ni)	11.7	≤60	≤125	≤270	≤300	Grade A - Unrestricted Use
	Selenium	(Se)	-	≤5	≤8	≤50	≤90	Did not test
	Zinc	(Zn)	68	≤200	≤700	≤2500	≤3500	Grade A - Unrestricted Use
Organic Contaminants (mg/kg)	DDT/DDD/DDE		-	≤0.5	≤0.5	≤1.0	≤1.0	Did not test
	Aldrin		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Dieldrin		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Chlordane		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Heptachlor		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	HCB		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Gamma BHC (Lindane)		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Alpha BHC		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
Note A: No detected PCB's at a limit of detection of 0.2mg PCB/kg biosolids.	PCBs		-	ND [A]	≤0.3	≤1.0	≤1.0	Did not test
Microbiological Standards (Stabilisation Grade)	E.coli		-	<100 MPN[B]/g (dry weight)				Did not test
	Faecal coliforms		-	<1000 MPN[B]/g (dry weight)				Did not test
	Salmonella sp.		-	Not detected/50g of final product				Did not test

Nitrogen Values	Solids Content % (SR)	-
	Moisture Content (%)	-
	Total Nitrogen (TN%)	-
	Total Kjeldahl N% (TKN)	-
	NO_2 present as N (dwb) mg/kg	-
	NO_3 present as N (dwb) mg/kg	-
	NH_4 present as N (dwb) mg/kg	-

Minimum quality grades			Allowable land application use							
Contaminant Grade	Stabilisation Grade	Classification	Home lawns & gardens	Public contact sites	Urban landscaping	Agriculture	Forestry	Soil & site rehabilitation	Landfill disposal	Surface land disposal*
A	A	Unrestricted Use	●	●	●	●	●	●	●	●
B	A	Restricted Use 1		●	●	●	●	●	●	●
C	B	Restricted Use 2				●	●	●	●	●
D	B	Restricted Use 3					●	●	●	●
E	C	Not Suitable For Use							●	●

* Restrictions apply to the selection of locations for surface land disposal.

Summary No restrictions to rehabilitation are noted.

Please see Soil Chemistry profile for recommendations.

Table 3.1 Contaminant Acceptance Concentration Thresholds, Table 3.6 Classification of Biosolids Products and Table 3.5 Stabilisation Grade A Microbiological Standards from the DEC NSW Environmental Guidelines: Use and disposal of biosolids products (1997) were used as the reference for chemical and organic contaminant acceptance concentration thresholds and classification. Other acceptance concentration thresholds and classification criterea may apply for other states.

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Bronwyn Brennan

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SESL AUSTRALIA
Environmental & Soil Sciences

Biosolids Profile

Sample Drop Off: 16 Chilvers Road
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Batch N°: 33837 **Sample N°: 12** **Date Instructions Received: 3/3/15** **Report Status:** ○ Draft ● Final

Client Name: **AECOM - Newcastle**
Client Contact: **Matthieu Catteau**
Client Job N°:
Client Order N°:
Address: **PO Box 73**
HRMC NSW 2310

Project Name: **60340733 - C & A Rehabilitation Monitoring 2015**
MTW & HVO Mine Sites
SESL Quote N°: **Q4235**
Sample Name: **RHB-HVOS Riverview**
Description: **Soil**
Test Type: **FSC, TOC_DC, M5**

Category	**Element**		**Results:**	**Contaminant Grade**				**Comments**
	Results given on a dry weight basis			A	B	C	D	
Chemical Contaminants (mg/kg)	Arsenic	(As)	-	≤20	≤20	≤20	≤30	Did not test
	Cadmium	(Cd)	1.3	≤3	≤5	≤20	≤32	Grade A - Unrestricted Use
	Chromium	(Cr)	-	≤100	≤250	≤500	≤600	Did not test
	Copper	(Cu)	29	≤100	≤375	≤2000	≤2000	Grade A - Unrestricted Use
	Lead	(Pb)	32.2	≤150	≤150	≤420	≤500	Grade A - Unrestricted Use
	Mercury	(Hg)	-	≤1	≤4	≤15	≤19	Did not test
	Nickel	(Ni)	17.4	≤60	≤125	≤270	≤300	Grade A - Unrestricted Use
	Selenium	(Se)	-	≤5	≤8	≤50	≤90	Did not test
	Zinc	(Zn)	82	≤200	≤700	≤2500	≤3500	Grade A - Unrestricted Use
Organic Contaminants (mg/kg)	DDT/DDD/DDE		-	≤0.5	≤0.5	≤1.0	≤1.0	Did not test
	Aldrin		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Dieldrin		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Chlordane		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Heptachlor		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	HCB		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Gamma BHC (Lindane)		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Alpha BHC		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
Note A: No detected PCB's at a limit of detection of 0.2mg PCB/kg biosolids.	PCBs		-	ND [A]	≤0.3	≤1.0	≤1.0	Did not test
Microbiological Standards (Stabilisation Grade)	E.coli		-	<100 MPN[B]/g (dry weight)				Did not test
	Faecal coliforms		-	<1000 MPN[B]/g (dry weight)				Did not test
	Salmonella sp.		-	Not detected/50g of final product				Did not test

Nitrogen Values	Solids Content % (SR)	-
	Moisture Content (%)	-
	Total Nitrogen (TN%)	-
	Total Kjeldahl N% (TKN)	-
	NO_3 present as N (dwb) mg/kg	-
	NO_2 present as N (dwb) mg/kg	-
	NH_4 present as N (dwb) mg/kg	-

Minimum quality grades			**Allowable land application use**							
Contaminant Grade	**Stabilisation Grade**	**Classification**	Home lawns & gardens	Public contact sites	Urban landscaping	Agriculture	Forestry	Soil & site rehabilitation	Landfill disposal	Surface land disposal*
A	A	Unrestricted Use	●	●	●	●	●	●	●	●
B	A	Restricted Use 1		●	●	●	●	●	●	●
C	B	Restricted Use 2				●	●	●	●	●
D	B	Restricted Use 3					●	●	●	●
E	C	Not Suitable For Use							●	●

* Restrictions apply to the selection of locations for surface land disposal.

Summary No restrictions to rehabilitation are noted.

Please see Soil Chemistry profile for recommendations.

Table 3.1 Contaminant Acceptance Concentration Thresholds, Table 3.6 Classification of Biosolids Products and Table 3.5 Stabilisation Grade A Microbiological Standards from the DEC NSW Environmental Guidelines: Use and disposal of biosolids products (1997) were used as the reference for chemical and organic contaminant acceptance concentration thresholds and classification. Other acceptance concentration thresholds and classification criterea may apply for other states.

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Authorised Signatory:
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Date Report Generated
15/03/2015

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Environmental & Soil Sciences

Biosolids Profile

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Batch N°: 33837 **Sample N°: 13** **Date Instructions Received: 3/3/15** **Report Status:** ○ Draft ● Final

Client Name: **AECOM - Newcastle**
Client Contact: **Matthieu Catteau**
Client Job N°:
Client Order N°:
Address: **PO Box 73**
HRMC NSW 2310

Project Name: **60340733 - C & A Rehabilitation Monitoring 2015**
MTW & HVO Mine Sites
SESL Quote N°: **Q4235**
Sample Name: **RHB-HVON Carrington**
Description: **Soil**
Test Type: **FSC, TOC_DC, M5**

Category	**Element**		**Results:**	**Contaminant Grade**				**Comments**
	Results given on a dry weight basis			A	B	C	D	
Chemical Contaminants (mg/kg)	Arsenic	(As)	-	≤20	≤20	≤20	≤30	Did not test
	Cadmium	(Cd)	1	≤3	≤5	≤20	≤32	Grade A - Unrestricted Use
	Chromium	(Cr)	-	≤100	≤250	≤500	≤600	Did not test
	Copper	(Cu)	11	≤100	≤375	≤2000	≤2000	Grade A - Unrestricted Use
	Lead	(Pb)	9.3	≤150	≤150	≤420	≤500	Grade A - Unrestricted Use
	Mercury	(Hg)	-	≤1	≤4	≤15	≤19	Did not test
	Nickel	(Ni)	26.6	≤60	≤125	≤270	≤300	Grade A - Unrestricted Use
	Selenium	(Se)	-	≤5	≤8	≤50	≤90	Did not test
	Zinc	(Zn)	32	≤200	≤700	≤2500	≤3500	Grade A - Unrestricted Use
Organic Contaminants (mg/kg)	DDT/DDD/DDE		-	≤0.5	≤0.5	≤1.0	≤1.0	Did not test
	Aldrin		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Dieldrin		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Chlordane		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Heptachlor		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	HCB		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Gamma BHC (Lindane)		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Alpha BHC		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
Note A: No detected PCB's at a limit of detection of 0.2mg PCB/kg biosolids.	PCBs		-	ND ^{A}	≤0.3	≤1.0	≤1.0	Did not test
Microbiological Standards (Stabilisation Grade)	E.coli		-	<100 MPN^{B}/g (dry weight)				Did not test
	Faecal coliforms		-	<1000 MPN^{B}/g (dry weight)				Did not test
	Salmonella sp.		-	Not detected/50g of final product				Did not test

Nitrogen Values	Solids Content % (SR)	-
	Moisture Content (%)	-
	Total Nitrogen (TN%)	-
	Total Kjeldahl N% (TKN)	-
	NO_2 present as N (dwb) mg/kg	-
	NO_3 present as N (dwb) mg/kg	-
	NH_4 present as N (dwb) mg/kg	-

Minimum quality grades			**Allowable land application use**							
Contaminant Grade	**Stabilisation Grade**	**Classification**	Home lawns & gardens	Public contact sites	Urban landscaping	Agriculture	Forestry	Soil & site rehabilitation	Landfill disposal	Surface land disposal*
A	A	Unrestricted Use	●	●	●	●	●	●	●	●
B	A	Restricted Use 1		●	●	●	●	●	●	●
C	B	Restricted Use 2				●	●	●	●	●
D	B	Restricted Use 3					●	●	●	●
E	C	Not Suitable For Use							●	●

* Restrictions apply to the selection of locations for surface land disposal.

Summary No restrictions to rehabilitation are noted.

Please see Soil Chemistry profile for recommendations.

Table 3.1 Contaminant Acceptance Concentration Thresholds, Table 3.6 Classification of Biosolids Products and Table 3.5 Stabilisation Grade A Microbiological Standards from the DEC NSW Environmental Guidelines: Use and disposal of biosolids products (1997) were used as the reference for chemical and organic contaminant acceptance concentration thresholds and classification. Other acceptance concentration thresholds and classification criterea may apply for other states.

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Date Report Generated
15/03/2015

Biosolids Profile

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Batch N°: 33837 **Sample N°: 14** **Date Instructions Received: 3/3/15** **Report Status:** ○ Draft ● Final

Client Name: **AECOM - Newcastle**
Client Contact: **Matthieu Catteau**
Client Job N°:
Client Order N°:
Address: **PO Box 73**
HRMC NSW 2310

Project Name: **60340733 - C & A Rehabilitation Monitoring 2015**
MTW & HVO Mine Sites
SESL Quote N°: **Q4235**
Sample Name: **RHB-HVOW Wilton**
Description: **Soil**
Test Type: **FSC, TOC_DC, M5**

Category	Element	Results:	Contaminant Grade				Comments
	Results given on a dry weight basis		A	B	C	D	
Chemical Contaminants (mg/kg)	Arsenic (As)	-	≤20	≤20	≤20	≤30	Did not test
	Cadmium (Cd)	1.2	≤3	≤5	≤20	≤32	Grade A - Unrestricted Use
	Chromium (Cr)	-	≤100	≤250	≤500	≤600	Did not test
	Copper (Cu)	17	≤100	≤375	≤2000	≤2000	Grade A - Unrestricted Use
	Lead (Pb)	22.1	≤150	≤150	≤420	≤500	Grade A - Unrestricted Use
	Mercury (Hg)	-	≤1	≤4	≤15	≤19	Did not test
	Nickel (Ni)	12.4	≤60	≤125	≤270	≤300	Grade A - Unrestricted Use
	Selenium (Se)	-	≤5	≤8	≤50	≤90	Did not test
	Zinc (Zn)	71	≤200	≤700	≤2500	≤3500	Grade A - Unrestricted Use
Organic Contaminants (mg/kg)	DDT/DDD/DDE	-	≤0.5	≤0.5	≤1.0	≤1.0	Did not test
	Aldrin	-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Dieldrin	-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Chlordane	-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Heptachlor	-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	HCB	-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Gamma BHC (Lindane)	-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Alpha BHC	-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
Note A: No detected PCB's at a limit of detection of 0.2mg PCB/kg biosolids.	PCBs	-	ND [A]	≤0.3	≤1.0	≤1.0	Did not test
Microbiological Standards (Stabilisation Grade)	E.coli	-	<100 MPN[B]/g (dry weight)				Did not test
	Faecal coliforms	-	<1000 MPN[B]/g (dry weight)				Did not test
	Salmonella sp.	-	Not detected/50g of final product				Did not test

Nitrogen Values		
	Solids Content % (SR)	-
	Moisture Content (%)	-
	Total Nitrogen (TN%)	-
	Total Kjeldahl N% (TKN)	-
	NO_2 present as N (dwb) mg/kg	-
	NO_3 present as N (dwb) mg/kg	-
	NH_4 present as N (dwb) mg/kg	-

Minimum quality grades			Allowable land application use							
Contaminant Grade	Stabilisation Grade	Classification	Home lawns & gardens	Public contact sites	Urban landscaping	Agriculture	Forestry	Soil & site rehabilitation	Landfill disposal	Surface land disposal*
A	A	Unrestricted Use	●	●	●	●	●	●	●	●
B	A	Restricted Use 1		●	●	●	●	●	●	●
C	B	Restricted Use 2				●	●	●	●	●
D	B	Restricted Use 3					●	●	●	●
E	C	Not Suitable For Use							●	●

* Restrictions apply to the selection of locations for surface land disposal.

Summary No restrictions to rehabilitation are noted.

Please see Soil Chemistry profile for recommendations.

Table 3.1 Contaminant Acceptance Concentration Thresholds, Table 3.6 Classification of Biosolids Products and Table 3.5 Stabilisation Grade A Microbiological Standards from the DEC NSW Environmental Guidelines: Use and disposal of biosolids products (1997) were used as the reference for chemical and organic contaminant acceptance concentration thresholds and classification. Other acceptance concentration thresholds and classification criterea may apply for other states.

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Date Report Generated
15/03/2015

Biosolids Profile

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Batch N°: 33837 **Sample N°: 15** **Date Instructions Received: 3/3/15** **Report Status:** ○ Draft ● Final

Client Name: **AECOM - Newcastle**
Client Contact: **Matthieu Catteau**
Client Job N°:
Client Order N°:
Address: **PO Box 73**
HRMC NSW 2310

Project Name: **60340733 - C & A Rehabilitation Monitoring 2015**
MTW & HVO Mine Sites
SESL Quote N°: **Q4235**
Sample Name: **RHB-WML TD1**
Description: **Soil**
Test Type: **FSC, TOC_DC, M5**

Category	Element	Results:	Contaminant Grade				Comments
	Results given on a dry weight basis		A	B	C	D	
Chemical Contaminants (mg/kg)	Arsenic (As)	-	≤20	≤20	≤20	≤30	Did not test
	Cadmium (Cd)	1.1	≤3	≤5	≤20	≤32	Grade A - Unrestricted Use
	Chromium (Cr)	-	≤100	≤250	≤500	≤600	Did not test
	Copper (Cu)	12	≤100	≤375	≤2000	≤2000	Grade A - Unrestricted Use
	Lead (Pb)	13.9	≤150	≤150	≤420	≤500	Grade A - Unrestricted Use
	Mercury (Hg)	-	≤1	≤4	≤15	≤19	Did not test
	Nickel (Ni)	17.2	≤60	≤125	≤270	≤300	Grade A - Unrestricted Use
	Selenium (Se)	-	≤5	≤8	≤50	≤90	Did not test
	Zinc (Zn)	48	≤200	≤700	≤2500	≤3500	Grade A - Unrestricted Use
Organic Contaminants (mg/kg)	DDT/DDD/DDE	-	≤0.5	≤0.5	≤1.0	≤1.0	Did not test
	Aldrin	-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Dieldrin	-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Chlordane	-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Heptachlor	-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	HCB	-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Gamma BHC (Lindane)	-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Alpha BHC	-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
Note A: No detected PCB's at a limit of detection of 0.2mg PCB/kg biosolids.	PCBs	-	ND [A]	≤0.3	≤1.0	≤1.0	Did not test
Microbiological Standards (Stabilisation Grade)	E.coli	-	<100 MPN[B]/g (dry weight)				Did not test
	Faecal coliforms	-	<1000 MPN[B]/g (dry weight)				Did not test
	Salmonella sp.	-	Not detected/50g of final product				Did not test

Nitrogen Values	Solids Content % (SR)	-
	Moisture Content (%)	-
	Total Nitrogen (TN%)	-
	Total Kjeldahl N% (TKN)	-
	NO_2 present as N (dwb) mg/kg	-
	NO_3 present as N (dwb) mg/kg	-
	NH_4 present as N (dwb) mg/kg	-

Minimum quality grades			Allowable land application use							
Contaminant Grade	Stabilisation Grade	Classification	Home lawns & gardens	Public contact sites	Urban landscaping	Agriculture	Forestry	Soil & site rehabilitation	Landfill disposal	Surface land disposal*
A	A	Unrestricted Use	●	●	●	●	●	●	●	●
B	A	Restricted Use 1		●	●	●	●	●	●	●
C	B	Restricted Use 2				●	●	●	●	●
D	B	Restricted Use 3					●	●	●	●
E	C	Not Suitable For Use							●	●

* Restrictions apply to the selection of locations for surface land disposal.

Summary No restrictions to rehabilitation are noted.

Please see Soil Chemistry profile for recommendations.

Table 3.1 Contaminant Acceptance Concentration Thresholds, Table 3.6 Classification of Biosolids Products and Table 3.5 Stabilisation Grade A Microbiological Standards from the DEC NSW Environmental Guidelines: Use and disposal of biosolids products (1997) were used as the reference for chemical and organic contaminant acceptance concentration thresholds and classification. Other acceptance concentration thresholds and classification criterea may apply for other states.

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Biosolids Profile

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Batch N°: 33837 **Sample N°: 16** **Date Instructions Received: 3/3/15** **Report Status:** ○ **Draft** ● **Final**

Client Name: **AECOM - Newcastle**
Client Contact: **Matthieu Catteau**
Client Job N°:
Client Order N°:
Address: **PO Box 73**
HRMC NSW 2310

Project Name: **60340733 - C & A Rehabilitation Monitoring 2015**
MTW & HVO Mine Sites
SESL Quote N°: **Q4235**
Sample Name: **RHB-WML Swanlake**
Description: **Soil**
Test Type: **FSC, TOC_DC, M5**

Category	**Element**		**Results:**	**Contaminant Grade**				**Comments**
	Results given on a dry weight basis			A	B	C	D	
Chemical Contaminants (mg/kg)	Arsenic	(As)	-	≤20	≤20	≤20	≤30	Did not test
	Cadmium	(Cd)	1.1	≤3	≤5	≤20	≤32	Grade A - Unrestricted Use
	Chromium	(Cr)	-	≤100	≤250	≤500	≤600	Did not test
	Copper	(Cu)	16	≤100	≤375	≤2000	≤2000	Grade A - Unrestricted Use
	Lead	(Pb)	19.9	≤150	≤150	≤420	≤500	Grade A - Unrestricted Use
	Mercury	(Hg)	-	≤1	≤4	≤15	≤19	Did not test
	Nickel	(Ni)	11.4	≤60	≤125	≤270	≤300	Grade A - Unrestricted Use
	Selenium	(Se)	-	≤5	≤8	≤50	≤90	Did not test
	Zinc	(Zn)	67	≤200	≤700	≤2500	≤3500	Grade A - Unrestricted Use
Organic Contaminants (mg/kg)	DDT/DDD/DDE		-	≤0.5	≤0.5	≤1.0	≤1.0	Did not test
	Aldrin		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Dieldrin		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Chlordane		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Heptachlor		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	HCB		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Gamma BHC (Lindane)		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
	Alpha BHC		-	≤0.02	≤0.2	≤0.5	≤1.0	Did not test
Note A: No detected PCB's at a limit of detection of 0.2mg PCB/kg biosolids.	PCBs		-	ND ^{A}	≤0.3	≤1.0	≤1.0	Did not test
Microbiological Standards (Stabilisation Grade)	E.coli		-	<100 MPN^{B}/g (dry weight)				Did not test
	Faecal coliforms		-	<1000 MPN^{B}/g (dry weight)				Did not test
	Salmonella sp.		-	Not detected/50g of final product				Did not test

Nitrogen Values	Solids Content % (SR)	-
	Moisture Content (%)	-
	Total Nitrogen (TN%)	-
	Total Kjeldahl N% (TKN)	-
	NO_2 present as N (dwb) mg/kg	-
	NO_3 present as N (dwb) mg/kg	-
	NH_4 present as N (dwb) mg/kg	-

Minimum quality grades			**Allowable land application use**							
Contaminant Grade	**Stabilisation Grade**	**Classification**	Home lawns & gardens	Public contact sites	Urban landscaping	Agriculture	Forestry	Soil & site rehabilitation	Landfill disposal	Surface land disposal*
A	A	Unrestricted Use	●	●	●	●	●	●	●	●
B	A	Restricted Use 1		●	●	●	●	●	●	●
C	B	Restricted Use 2				●	●	●	●	●
D	B	Restricted Use 3					●	●	●	●
E	C	Not Suitable For Use							●	●

* Restrictions apply to the selection of locations for surface land disposal.

Summary No restrictions to rehabilitation are noted.

Please see Soil Chemistry profile for recommendations.

Table 3.1 Contaminant Acceptance Concentration Thresholds, Table 3.6 Classification of Biosolids Products and Table 3.5 Stabilisation Grade A Microbiological Standards from the DEC NSW Environmental Guidelines: Use and disposal of biosolids products (1997) were used as the reference for chemical and organic contaminant acceptance concentration thresholds and classification. Other acceptance concentration thresholds and classification criterea may apply for other states.

Tests are performed under a quality system certified as complying with ISO 9001: 2008. Results and conclusions assume that sampling is representative. This document shall not be reproduced except in full.

Consultant:
Bronwyn Brennan

Authorised Signatory: D Mc Donald
Declan McDonald

Date Report Generated
15/03/2015

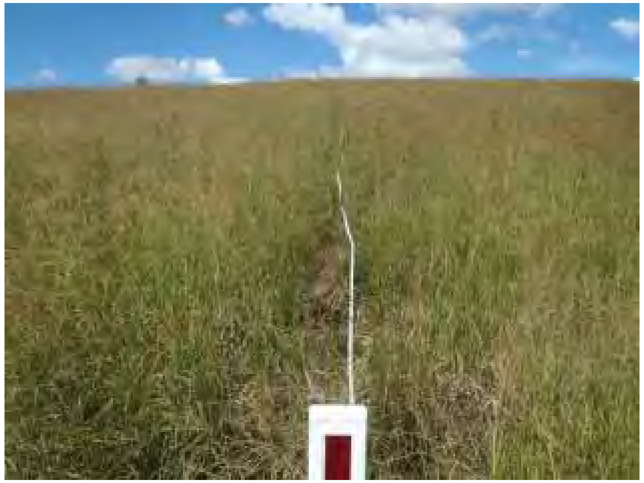
Appendix C

Photographic Monitoring Results

Appendix C Photographic Monitoring Results

Monitoring site: RHB_HVON_Carrington			
View from start of transect			
View from end of transect			

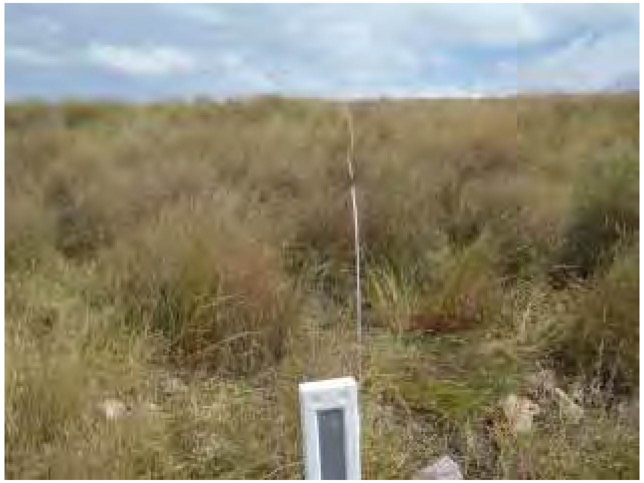
Monitoring site: RHB_HVOS_Riverview			
View from start of transect			
View from start of transect			

Monitoring site: RHB_HVOW_Plane_Dump			
View from start of transect			
View from start of transect			

Monitoring site: RHB_HVOW_Wilton			
View from start of transect			
View from start of transect			

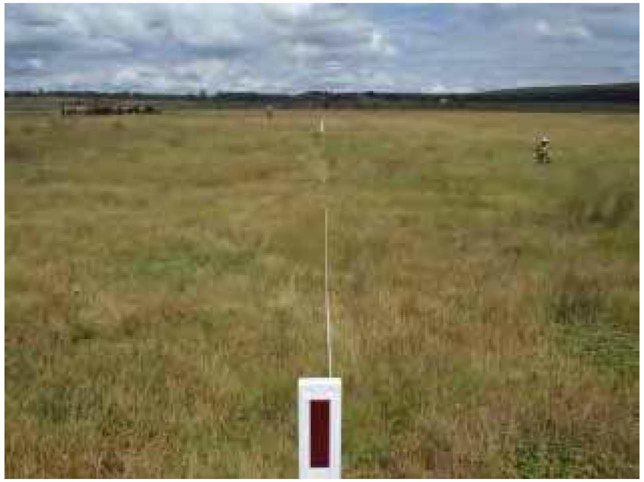
Monitoring site: RHB_MTO_North_Dump			
View from start of transect			
View from start of transect			

Monitoring site: RHB_MTO_South_CHPP			
View from start of transect			
View from start of transect			

Monitoring site: RHB_WML_Swanlake			
View from start of transect			
View from start of transect			

Monitoring site: RHB_WML_TD1			
View from start of transect			
View from start of transect			

Monitoring site: ANA_Carrington_Billabong			
View from start of transect			
View from start of transect			

Monitoring site: ANA_Cheshunt			
View from start of transect			
View from start of transect			

Monitoring site: ANA_Lemington_Rd			
View from start of transect			
View from start of transect			

Monitoring site: ANA_Howick			
View from start of transect			
View from start of transect			

<table>
<tr><th colspan="4">Monitoring site: ANA_Parnells</th></tr>
<tr><td>View from start of transect</td><td></td><td></td><td></td></tr>
<tr><td>View from start of transect</td><td></td><td></td><td></td></tr>
</table>

Monitoring site: ANA_Knodlers_Lane			
View from start of transect			
View from start of transect			

Monitoring site: ANA_Newport

View from start of transect			
View from start of transect			

Monitoring site: ANA_North_CHPP			
View from start of transect			
View from start of transect