CARRINGTON WEST WING

Environmental Assessment

Prepared for Coal & Allied Operations Pty Limited | October 2010

Volume 2 - Supporting Appendices

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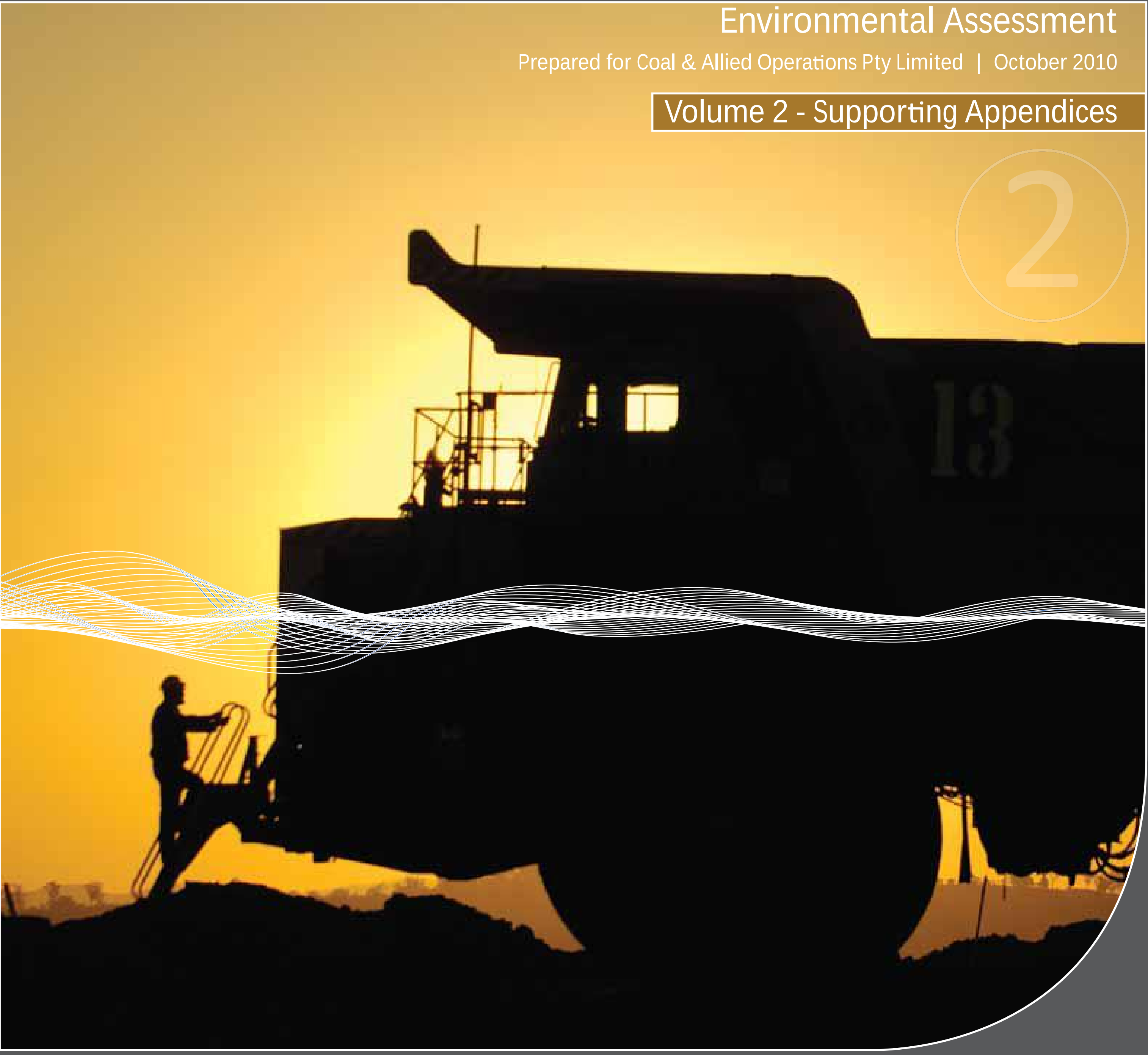

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Appendix A

Environmental Assessment Requirements

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NSW GOVERNMENT | Planning

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Mr Anthony Russo
Principal Advisor Project Approvals
Coal & Allied Operations Pty Limited
PO Box 315
SINGLETON NSW 2330

Dear Mr Russo

Hunter Valley Operations North –
Carrington West Wing Modification (DA 450-10-2003 MOD 3)
Director-General's Requirements

The Department has received your application for the proposed Carrington West Wing Modification.

I have attached a copy of the Director-General's requirements for the modification. These requirements have been prepared in consultation with the Department of Industry and Investment (DII), Department of Environment, Climate Change and Water (DECCW), the NSW Office of Water (NOW) and Singleton Council, and are based on the information you have provided to date. I have also attached a copy of the agency comments for your information.

Please note that the Director-General may alter these requirements at any time.

If your proposal is likely to have a significant impact on matters of National Environmental Significance, it will require an approval under the Commonwealth *Environment Protection Biodiversity Conservation Act 1999* (EPBC Act). This approval is in addition to any approvals required under NSW legislation. It is your responsibility to contact the Department of Environment, Water, Heritage and the Arts in Canberra (6274 1111 or http://www.environment.gov.au) to determine if the proposal requires an approval under the EPBC Act. The Commonwealth Government has accredited the NSW environmental assessment process, so if it is determined that an approval is required under the EPBC Act, please contact the Department immediately as supplementary Director-General's requirements may need to be issued.

I would appreciate it if you would contact the Department at least two weeks before you propose to submit your Environmental Assessment for the modification. This will enable the Department to:

- confirm the applicable fee (see Division 1A, Part 15 of the *Environmental Planning and Assessment Regulation 2000*); and
- determine the number of copies (hard-copy and CD-ROM) of the Environmental Assessment that will be required for exhibition purposes.

Once the Department receives the Environmental Assessment, the Department will review it in consultation with the relevant agencies to determine if it adequately addresses the Director-General's requirements, and may require you to revise it prior to public exhibition.

The Department is required to make all the relevant information associated with the modification publicly available on its website. Consequently, I would appreciate it if you would ensure that all the documents you subsequently submit to the Department are in a suitable format for the web, and arrange for an electronic version of the Environmental Assessment to be hosted on a suitable website during the exhibition period.

If you have any enquiries about these requirements, please contact Alison O'Reilly on 9228 6339 or alison.oreilly@planning.nsw.gov.au.

Yours sincerely

David Kitto
Director
Mining & Industry Projects
As delegate for the Director-General

Director-General's Requirements

Section 75W of the *Environmental Planning and Assessment Act 1979*

Application number	DA 450-10-2003 MOD 3
Modification	Modifying the Hunter Valley Operations North coal mine, involving: • expanding the existing Carrington Pit to the south west (Carrington West Wing), covering an area of approximately 142 hectares; • extracting approximately 17 million tonnes of run-of-mine coal from the Broonie, Bayswater, Piercefield and Vaux seams for a period of up to 5 years, using truck and shovel mining methods; • out-of-pit overburden emplacement on land immediately north of the proposal; • extending the approved Carrington Pit evaporative sink; • diverting a drainage line located across the pit extension; • constructing a levee and groundwater barrier wall; and • modifying the existing development consent boundary to include Carrington West Wing.
Location	Approximately 24 kilometres (km) north west of Singleton.
Proponent	Coal & Allied Operations Pty Limited.
Date of Issue	31 May 2010
General Requirements	The Environmental Assessment of the modification must include: • an executive summary; • a detailed description of: - historical operations on the site; - existing and approved mining operations/facilities, including any statutory approvals that apply to these operations/facilities; and - the existing environmental management and monitoring regime on site; • a detailed description of the modification, including the: - need for the modification; - alternatives considered, including a justification for the proposed mine plan/s and coal rejects disposal strategy on economic, social and environmental grounds; - likely interactions between existing and approved mining operations; - likely staging of the modification; and - plans of any proposed building works; • a risk assessment of the potential environmental impacts of the modification, identifying the key issues for further assessment; • a detailed assessment of the key issues specified below, and any other significant issues identified in the risk assessment (see above), which includes: - a description of the existing environment, using sufficient baseline data; - an assessment of the potential impacts of all stages of the modification, including any cumulative impacts associated with the concurrent operation of the modification with any other existing or approved mining or gas production operations in the region, taking into consideration any relevant policies, guidelines, plans and statutory provisions (see below); and - a description of the measures that would be implemented to avoid, minimise, mitigate and/or offset the potential impacts of the modification, including detailed contingency plans for managing any significant risks to the environment; • a statement of commitments, outlining all the proposed environmental management and monitoring measures; • a conclusion justifying the modification on economic, social and environmental grounds, taking into consideration whether the modification

	is consistent with the objects of the *Environmental Planning & Assessment Act 1979*; and • a signed statement from the author of the Environmental Assessment, certifying that the information contained within the document is neither false nor misleading.
Key Issues	• **Soil and Water** – including: o a detailed assessment of the potential impacts of the modification, using appropriate quantitative modelling on: - the quantity and quality of both surface and ground water resources, with particular reference to the Hunter River, alluvial groundwater and the evaporative sink extension; - water users, both in the vicinity of and downstream of the modification; - the riparian and ecological values of the watercourses both on site and downstream of the proposal; - environmental flows; and - flooding; o a comparison of these impact predictions against those associated with the existing mine plan, including detailed explanations for any differences; o plans for the proposed diversion of the unnamed drainage line, including: - detailed design and completion criteria; - timeframes; and - a detailed assessment of the environmental, hydrogeological, hydrological and geomorphic considerations of the final alignments; and o a revised site water balance for the mine; • **Noise & Blasting** – including: o a quantitative assessment of the potential construction and operational noise impacts, in conjunction with the cumulative noise impacts from other sources, including the surrounding mines and other operations at the mine; o noise modelling should be based on applicable meteorological and stability category temperature inversion conditions to be developed in consultation with DECCW; and o blasting impacts of the project on people, livestock, property and roads; • **Air Quality** – including a detailed consideration of the potential construction and operational impacts on the local air shed, in conjunction with the cumulative air impacts from other sources, including the surrounding mines and other operations at the mine; • **Biodiversity** – including: o accurate estimates of any vegetation clearing or other impacts; o an assessment of the potential impacts of the project on any terrestrial or aquatic threatened species or populations, their habitats, endangered ecological communities, riparian vegetation or groundwater dependent ecosystems; and o a description of the measures that would be implemented to maintain or improve the biodiversity values of the surrounding region in the medium to long term; • **Heritage** – including the potential impacts of the project on Aboriginal and non-Aboriginal heritage; • **Greenhouse Gas** – including: o a quantitative assessment of the potential scope 1, 2 and 3 greenhouse gas emissions of the project, and qualitative assessment of the potential impacts of these emissions on the environment; and o a detailed description of the measures that would be implemented to minimise, reuse, recycle and dispose of any waste produced on site to ensure that the project is energy efficient;

	• **Visual** – including a detailed description of the measures that would be implemented to minimise the potential visual impacts of the project;
	• **Transport** – including a detailed assessment of any potential impacts of the project on the safety and performance of the road network, including any potential impacts to Lemington Road;
	• **Waste** – including:
	  o estimates of the quantity and nature of the potential waste streams of the project; and
	  o a detailed description of the measures that would be implemented on site to ensure that the project is energy efficient;
	• **Hazards** – paying particular attention to public safety;
	• **Socio & Economic** – including:
	  o an assessment of the potential impacts of the project on the local and regional community; and
	  o a detailed assessment of the costs and benefits of the project as a whole, and whether it would result in a net benefit for the NSW community; and
	• **Rehabilitation** – including a description of the proposed rehabilitation strategy for the mine, taking into consideration and relevant strategic land use planning or resource management plans or policies, including:
	  o the costs of rehabilitation, remediation and repair, including the diversion of the drainage line;
	  o identifying post-mining land use options;
	  o clearly defining project rehabilitation objectives;
	  o outlining general rehabilitation methods and procedures; and
	  o a conceptual final landform design.

References	While not exhaustive, the following attachment contains a list of guidelines, policies and plans that may be relevant to the environmental assessment of the modification.
Consultation	During the preparation of the Environmental Assessment, you should consult with the relevant local, State or Commonwealth government authorities, service providers, community groups or affected landowners. In particular you should consult with: • Department of Environment, Climate Change and Water; • Department of Industry and Investment; • NSW Office of Water; and • Singleton Shire Council. The consultation process, and the issues raised during this process, must be described in the Environmental Assessment.
Deemed refusal period	90 days

Policies, Guidelines & Plans

Aspect	Policy /Methodology
Risk Assessment	
	AS/NZS 4360:2004 Risk Management (Standards Australia)
	HB 203: 203:2006 Environmental Risk Management – Principles & Process (Standards Australia)
	Risk Management Handbook for the Mining Industry (DPI)
Soil and Water	
Soil	Rural Land Capability Mapping (DLWC)
	Agricultural Land Classification (DPI)
	Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites (ANZECC & NHMRC)
	National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPC)
	State Environmental Planning Policy No. 55 – Remediation of Land
	Managing Land Contamination – Planning Guidelines SEPP 55 – Remediation of Land (DOP)
Surface Water	Australian Drinking Water Guidelines 2004 (NWQMS)
	National Water Quality Management Strategy: Water quality management – an outline of the policies (ANZACC/ARMCANZ)
	National Water Quality Management Strategy: Policies and principles – a reference document (ANZACC/ARMCANZ)
	National Water Quality Management Strategy: Implementation Guidelines (ANZACC/ARMCANZ)
	National Water Quality Management Strategy: Australian Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ)
	National Water Quality Management Strategy: Australian Guidelines for Water Quality Monitoring and Reporting (ANZECC/ARMCANZ)
	National Water Quality Management Strategy: Guidelines for Sewerage Systems – Effluent Management (ARMCANZ/ANZECC)
	National Water Quality Management Strategy: Guidelines for Sewerage Systems – Use of Reclaimed Water (ARMCANZ/ANZECC)
	Using the ANZECC Guideline and Water Quality Objectives in NSW (DEC)
	State Water Management Outcomes Plan
	NSW Government Water Quality and River Flow Environmental Objectives (DECC)
	Approved Methods for the Sampling and Analysis of Water Pollutants in NSW (DEC)
	Managing Urban Stormwater: Soils & Construction (Landcom)
	Managing Urban Stormwater: Treatment Techniques (DECC)
	Managing Urban Stormwater: Source Control (DECC)
	Floodplain Management Manual (DNR)
	Floodplain Risk Management Guideline (DEC)
	A Rehabilitation Manual for Australian Streams (LWRRDC and CRCCH)
	Technical Guidelines: Bunding & Spill Management (DECC)
	Environmental Guidelines: Use of Effluent by Irrigation
	State Water Management Outcomes Plan
Groundwater	National Water Quality Management Strategy Guidelines for Groundwater Protection in Australia (ARMCANZ/ANZECC)
	NSW State Groundwater Policy Framework Document (DLWC)
	NSW State Groundwater Quality Protection Policy (DLWC)

	NSW State Groundwater Quantity Management Policy (DLWC) Draft
	NSW State Groundwater Dependent Ecosystems Policy (2002)
	Guidelines for Groundwater Protection in Australia (1995)
	Draft Guidelines for the Assessment & Management of Groundwater Contamination (DECC)
Flora & Fauna	
	Draft Guidelines for Threatened Species Assessment under Part 3A of the *Environmental Planning and Assessment Act 1979* (DEC)
	NSW Groundwater Dependent Ecosystem Policy (DLWC)
	Policy & Guidelines - Aquatic Habitat Management and Fish Conservation (NSW Fisheries)
	Policy & Guidelines - Fish Friendly Waterway Crossings (NSW Fisheries)
	State Environmental Planning Policy No. 44 – Koala Habitat Protection
	Draft Threatened Biodiversity Survey and Assessment Guidelines for Developments and Activities (2004)
	Green Offsets for Sustainable Regional Development: Concept Paper (NSW Government, May 2002)
Heritage	
Aboriginal	Draft Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation (DEC)
	Aboriginal Cultural Heritage Standards and Guidelines Kit
	Interim Community Consultation Requirements for Applicants
Non- Aboriginal	NSW Heritage Manual (NSW Heritage Office & DUAP)
	The Burra Charter (The Australia ICOMOS charter for places of cultural significance)
Noise	
	NSW Industrial Noise Policy (DECC)
	Environmental Criteria for Road Traffic Noise (NSW EPA)
	Environmental Noise Control Manual (DECC)
Air Quality	
	Protection of the Environment Operations (Clean Air) Regulation 2002
	Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (DEC)
	Approved Methods for the Sampling and Analysis of Air pollutants in NSW (DEC)
Greenhouse Gas	
	AGO Factors and Methods Workbook (AGO)
	Draft Guidelines: Energy and Greenhouse in EIA, NSW Department of Planning, 2002
	The Greenhouse gas Protocol: Corporate Standard, World Council for Sustainable Business Development & World Resources Institute
	National Greenhouse Accounts (NGA) Factors, Australian department of Climate Change, 2008
	Guidelines for Energy Savings Action Plans (DEUS, 2005)
Transport	
	Guide to Traffic Generating Development (RTA)
	Road Design Guide (RTA)
Waste	
	Waste Avoidance and Resource Recovery Strategy 2007 (DECC)
	Environmental Guidelines: Solid Waste Landfills (EPA)
	Environmental Guidelines: Assessment, Classification, and Management of Non-Liquid and Liquid Waste (EPA)
Hazards	
	State Environmental Planning Policy No. 33 – Hazardous and Offensive Development

	Applying SEPP 33 – Hazardous and Offensive Development Application Guidelines (DUAP)
	Hazardous Industry Planning Advisory Paper No. 6 – Guidelines for Hazard Analysis
Social & Economic	
	Draft Economic Evaluation in Environmental Impact Assessment (DOP)
	Techniques for Effective Social Impact Assessment: A Practical Guide (Office of Social Policy, NSW Government Social Policy Directorate)
Rehabilitation	
	Mine Rehabilitation – Leading Practice Sustainable Development Program for the Mining Industry (Commonwealth of Australia)
	Mine Closure and Completion – Leading Practice Sustainable Development Program for the Mining Industry (Commonwealth of Australia)
	Strategic Framework for Mine Closure (ANZMEC)

Appendix B

Development Consent No. DA 450-10-2003

Development Consent

Section 80 of the *Environmental Planning and Assessment Act 1979*

I, the Minister for Infrastructure, Planning and Natural Resources, approve the Development Application referred to in schedule 1, subject to the conditions in schedules 3 to 6.

These conditions are required to:
- prevent, minimise, and/or offset adverse environmental impacts;
- set standards and performance measures for acceptable environmental performance;
- require regular monitoring and reporting; and
- provide for the on-going environmental management of the development.

Craig Knowles MP
Minister for Infrastructure and Planning
Minister for Natural Resources

Sydney, 2004 File No: S02/02690

SCHEDULE 1

Development Application:	DA 450-10-2003.
Applicant:	Coal & Allied Operations Pty Ltd.
Consent Authority:	Minister for Infrastructure and Planning.
Land:	See Appendix 1.
Proposed Development:	The extension of open cut coal mine operations at the West Pit of Hunter Valley Operations in general accordance with the Environmental Impact Statement for the *Hunter Valley Operations - West Pit Extension and Minor Modifications*, which includes: • extending open cut mining operations to the east of currently approved development; • using existing mining methods and equipment; • using existing coal preparation facilities at the West Pit to process up to 6 million tonnes per annum (Mtpa) of coal and use of related coal reject disposal facilities; • continuing coal production at the rate of 12 Mtpa at West Pit; • increasing the approved production capacity of the Carrington Pit from 6 Mtpa to 10 Mtpa; • increasing approved coal haulage from mining areas south of the Hunter River to the Hunter Valley Coal Preparation Plant from 8 Mtpa to 16 Mtpa; • upgrading the capacity of the Hunter Valley Coal Preparation Plant from 13 Mtpa to 20 Mtpa; • upgrading the Belt Line Conveyor from the Hunter Valley Coal Preparation Plant to the Hunter Valley Loading Point; • constructing a conveyor between the Hunter Valley Loading Point and the Newdell Loading Point; • hauling coal, on an intermittent basis, between the Hunter Valley Loading Point and Newdell Loading Point and the Ravensworth Coal Terminal;

- hauling coal, on an intermittent basis, between the Hunter Valley Coal Preparation Plant and the Hunter Valley Loading Point along a private haul road;
- moving coal and coal rejects between mining areas and facilities of the Hunter Valley Operations, including mining areas and facilities located south of the Hunter River;
- constructing temporary crossings of the Hunter River to allow the relocation of heavy mining equipment; and
- consolidating 15 existing development approvals, applying to Hunter Valley Operations north of the Hunter River, into a single consent.

State Significant Development: The proposal is classified as State significant development, under section 76A(7) of the *Environmental Planning and Assessment Act 1979*, because it involves coal-mining related development that requires a new mining lease under section 63 of the *Mining Act 1992*.

Integrated Development: The proposal is classified as integrated development, under section 91 of the *Environmental Planning and Assessment Act 1979*, because it requires additional approvals under the:

- *Protection of the Environment Operations Act 1997*;
- *National Parks and Wildlife Act 1974*;
- *Water Act 1912*;
- *Rivers and Foreshores Improvement Act 1948*;
- *Roads Act 1993*; and
- *Mine Subsidence Compensation Act 1961*.

Designated Development: The proposal is classified as designated development, under section 77A of the *Environmental Planning and Assessment Act 1979*, because it is for a coal mine that would "*produce or process more than 500 tonnes of coal a day*", and consequently meets the criteria for designated development in schedule 3 of the *Environmental Planning and Assessment Regulation 2000*.

BCA Classification: Class 10b: Coal conveyor

Note:
1) *To find out when this consent becomes effective, see section 83 of the Environmental Planning and Assessment Act 1979 (EP&A Act);*
2) *To find out when this consent is liable to lapse, see section 95 of the EP&A Act; and*
3) *To find out about appeal rights, see section 97 of the EP&A Act.*

SCHEDULE 2
DEFINITIONS

AEMR	Annual Environmental Management Report
Applicant	Coal & Allied Operations Pty Ltd
BCA	Building Code of Australia
Bore	Any bore or well or excavation or other work connected or proposed to be connected with sources of sub-surface water, and used or proposed to be used or capable of being used to obtain supplies of such water whether the water flows naturally at all times or has to be raised whether wholly or at times by pumping or other artificial means
CCC	Community Consultative Committee
Council	Singleton Shire Council
DA	Development Application
Day	Day is defined as the period from 7am to 6pm on Monday to Saturday, and 8am to 6pm on Sundays and Public Holidays
DEC	The Department of Environment and Conservation
Department	Department of Planning
Director-General	Director-General of the Department of Planning, or delegate
DNR	Department of Natural Resources
DPI (MR)	Department of Primary Industries (Mineral Resources)
EIS	Environmental Impact Statement
EP&A Act	*Environmental Planning and Assessment Act 1979*
EP&A Regulation	*Environmental Planning and Assessment Regulation 2000*
EPL	Environment Protection Licence
EPL 640	Environment Protection Licence No. 640 issued for HVO's operations north of the Hunter River or any subsequent replacement for, or variation of, EPL 640
Evening	Evening is defined as the period from 6pm to 10pm
GTA	General Term of Approval
HVO	Hunter Valley Operations
Land	Land means the whole of a lot in a current plan registered at the Land Titles Office at the date of this consent
MOP	Mining Operations Plan
MSC	Muswellbrook Shire Council
MSB	Mine Subsidence Board
Night	Night is defined as the period from 10pm to 7am on Monday to Saturday, and 10pm to 8am on Sundays and Public Holidays
NP&W Act	*National Parks and Wildlife Act 1974*
PCA	Principal Certifying Authority appointed under Section 109E of the Act
Privately-owned land	Land excluding land owned by a mining company, where • A private agreement does not exist between the Applicant and the land owner; and • There are no land acquisition provisions requiring the Applicant to purchase the land upon request from the land owner
ROM coal	Run-of-mine coal
RTA	Roads and Traffic Authority
Site	Land to which the DA applies
Vacant land	Vacant land is defined as the whole of the lot in a current plan registered at the Land Titles Office that does not have a dwelling situated on the lot and is permitted to have a dwelling on that lot at the date of this consent.

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Red type represents August 2005 modification
Blue type represents June 2006 modification

SCHEDULE 3
ADMINISTRATIVE CONDITIONS

Obligation to Minimise Harm to the Environment

1. The Applicant shall implement all practicable measures to prevent and/or minimise any harm to the environment that may result from the construction, operation, or rehabilitation of the development.

Terms of Approval

2. The Applicant shall carry out the development generally in accordance with the:
   (a) DA 450-10-2003;
   (b) EIS titled *Hunter Valley Operations – West Pit Extension and Minor Modifications*, volumes 1 – 4, dated October 2003, and prepared by Environmental Resources Management Australia;
   (c) the section 96(1A) modification application for the Hunter Valley Loading Point, dated 30 June 2005, and prepared by Matrix Consulting;
   (d) *Carrington Pit Extended Statement of Environmental Effects* volumes 1 & 2, dated October 2005, and prepared by Environmental Resources Management Australia;
   (e) *Carrington Pit Extension Response to Submissions Report*, dated May 2006, and prepared by Environmental Resources Management Australia;
   (f) Summary of Commitments for Carrington Pit as Extended, dated 28 May 2006 and prepared by the Applicant; and
   (g) conditions of this consent.

3. If there is any inconsistency between the above documents, the latter document shall prevail over the former to the extent of the inconsistency. However, the conditions of this consent shall prevail over all other documents to the extent of any inconsistency.

4. The Applicant shall comply with any reasonable requirement/s of the Director-General arising from the Department's assessment of:
   (a) any reports, plans or correspondence that are submitted in accordance with this consent; and
   (b) the implementation of any actions or measures contained in these reports, plans or correspondence.

Surrender of Consents

5. Within 3 months of the submission of the revised West Pit extension MOP to the DPI(MR), the Applicant shall surrender all existing development consents and existing use rights associated with Hunter Valley Operations' (HVO's) mining operations and related facilities north of the Hunter River in accordance with clause 97 of the *EP&A Regulation*.

Limits on Approval

6. This consent expires 21 years after the date it commences.

   Note: This condition does not affect the operation of section 95 of the EP&A Act.

7. The Applicant shall not extract more than 12 million tonnes per annum (Mtpa) of ROM coal from the West Pit and 10 Mtpa of ROM coal from the Carrington Pit.

8. The Applicant shall ensure that the Hunter Valley Coal Preparation Plant does not receive more than 16 Mtpa of coal from mining operations south of the Hunter River, and process more than 20 Mtpa of coal.

9. The Applicant shall ensure that the West Pit Coal Preparation Plant does not process more than 6 Mtpa of coal.

Structural Adequacy

10. The Applicant shall ensure that all new buildings and structures, and any alterations or additions to existing buildings and structures, are constructed in accordance with the relevant requirements of the BCA.

    Notes:
    1) Under Part 4A of the EP&A Act, the Applicant is required to obtain construction and occupation certificates for the proposed building works.

2) *Part 8 of the EP&A Regulation sets out the requirements for the certification of development.*
3) [1]*The development is located in the Patrick Plains Mine Subsidence District. Under section 15 of the Mine Subsidence Compensation Act 1961, the Applicant is required to obtain the Mine Subsidence Board's approval before constructing or relocating any improvements on the site.*

Demolition

11. The Applicant shall ensure that any demolition work is carried out in accordance with *AS 2601-2001: The Demolition of Structures*, or its latest version.

Operation of Plant and Equipment

12. The Applicant shall ensure that all plant and equipment used at the site, or to transport coal off-site, are:
    (a) maintained in a proper and efficient condition; and
    (b) operated in a proper and efficient manner.

Community Enhancement Contribution

13. Before carrying out any development, or as agreed otherwise by Council, the Applicant shall pay Council $15,000 for the provision of stream improvement works in the Hunter River or its tributaries. If Council has not carried out these enhancement works within 12 months of payment, the Applicant may retrieve the funds from Council.

[1] Incorporates MSB GTA.

SCHEDULE 4
SPECIFIC ENVIRONMENTAL CONDITIONS

ACQUISITION UPON REQUEST

1. Upon receiving a written request for acquisition from any landowner of the land listed in Table 1, the Applicant shall acquire the land in accordance with the procedures in conditions 9-11 of schedule 5 and condition 7 of schedule 5 for property 8.

8 - Holz	10 - Moses
9 - Dallas	12 - Barry

Table 1: Land subject to acquisition upon request

Note: For more information on the numbering and identification of properties used in this consent, see Figure 24, volume 4 of the EIS for the Hunter Valley Operations – West Pit and Minor Modifications

2. While the land listed in condition 1 is privately-owned, the Applicant shall implement all practicable measures to ensure that the impacts of the development comply with the predictions in the EIS, to the satisfaction of the Director-General.

AIR QUALITY

Impact Assessment Criteria

3. The Applicant shall ensure that the air pollution generated by the development does not exceed the criteria listed in Tables 2, 3, and 4 at any privately-owned land, excluding the land in Table 1.

Pollutant	Averaging period	Criterion
Total suspended particulate (TSP) matter	Annual	90 $\mu g/m^3$
Particulate matter < 10 µm (PM_{10})	Annual	30 $\mu g/m^3$

Table 2: Long-term impact assessment criteria for particulate matter

Pollutant	Averaging period	Criterion
Particulate matter < 10 µm (PM_{10})	24 hour	50 $\mu g/m^3$

Table 3: Short-term impact assessment criterion for particulate matter

Pollutant	Averaging period	Maximum increase in deposited dust level	Maximum total deposited dust level
Deposited dust	Annual	2 g/m^2/month	4 g/m^2/month

Table 4: Long-term impact assessment criteria for deposited dust

Note: Deposited dust is assessed as insoluble solids as defined by Standards Australia, 1991, AS 3580.10.1-1991: Methods for Sampling and Analysis of Ambient Air - Determination of Particulates - Deposited Matter - Gravimetric Method.

Land Acquisition Criteria

4. If the air pollution generated by the development exceeds the criteria in Tables 5, 6, and 7 at any privately-owned land, the Applicant shall, upon receiving a written request for acquisition from the landowner, acquire the land in accordance with the procedures in conditions 9-11 of schedule 5.

Pollutant	Averaging period	Criterion
Total suspended particulate (TSP) matter	Annual	90 µg/m³
Particulate matter < 10 µm (PM_{10})	Annual	30 µg/m³

Table 5: Long-term land acquisition criteria for particulate matter

Pollutant	Averaging period	Criterion	Percentile[1]	Basis
Particulate matter < 10 µm (PM_{10})	24 hour	150 µg/m³	99[2]	Total[3]
Particulate matter < 10 µm (PM_{10})	24 hour	50 µg/m³	98.6	Increment[4]

Table 6: Short-term land acquisition criteria for particulate matter

[1]*Based on the number of block 24 hour averages in an annual period.*
[2]*Excludes extraordinary events such as bushfires, prescribed burning, dust storms, sea fog, fire incidents, illegal activities or any other activity agreed by the Director-General in consultation with the DEC.*
[3]*Background PM_{10} concentrations due to all other sources plus the incremental increase in PM_{10} concentrations due to the mine alone.*
[4]*Incremental increase in PM_{10} concentrations due to the mine alone.*

Pollutant	Averaging period	Maximum increase in deposited dust level	Maximum total deposited dust level
Deposited dust	Annual	2 g/m²/month	4 g/m²/month

Table 7: Long term land acquisition criteria for deposited dust

Note: Deposited dust is assessed as insoluble solids as defined by Standards Australia, 1991, AS 3580.10.1-1991: Methods for Sampling and Analysis of Ambient Air - Determination of Particulates - Deposited Matter - Gravimetric Method.

[2]Monitoring

5. The Applicant shall establish air quality monitoring stations (or obtain free and unencumbered access to data from existing air quality monitoring stations) at a minimum of 6 locations around the site, including the residences on properties 10 (Moses), 4 (Muller) and 8 (Holz) whilst privately-owned or at alternative locations as approved by the Director-General, and including locations representative of the most-affected residences in Jerrys Plains and Maison Dieu, to monitor (by sampling and obtaining results by analysis) the concentration of each pollutant in Table 8 to the satisfaction of DEC and the Director-General, using the specified averaging period, frequency, and sampling method:

Pollutant	Units of Measure	Averaging Period	Frequency	Sampling method[1]
PM_{10}	µg/m³	24 hour, annual	Continuous	AS3580.9.8 – 2001[2]
TSP	µg/m³	24 hour, annual	1 day in 6	AM-15
Dust Deposition	g/m²/month	Month, annual	Continuous	AM-19
Siting	-	-	-	AM-1

Table 8: Air quality monitoring

[2] Incorporates DEC GTA

[1] *NSW EPA, 2001, Approved Methods for the Sampling and Analysis of Air Pollutants in NSW.*
[2] *Standards Australia, 2001, AS3580.9.8-2001, Method for Sampling and Analysis of Ambient Air - Determination of Suspended Particulate Matter - PM_{10} Continuous Direct Mass Method using a Tapered Element Oscillating Microbalance Analyser, or any other method that is approved by the Director-General, in consultation with the DEC.*

6 Within 6 months of the date of this consent, the Applicant shall prepare and implement an Air Quality Monitoring Program, to the satisfaction of the Director-General.

[3]NOISE

Noise Impact Assessment Criteria

7. The Applicant shall ensure that the noise generated by the development does not exceed the noise impact assessment criteria presented in Table 9 at any privately-owned land.

Day/Evening/Night $L_{Aeq(15 minute)}$	*Night* $L_{A1(1 minute)}$	*Land Number*
40	*46*	*4 – Muller (from year 1 to year 7)* *7 – Stapleton* *Jerrys Plains Village – represented by residence locations 13 and 14 on Figure 24, volume 4 of the EIS (years 20 & 21)* *1 – Hayes (years 20 & 21)* *18 – Bennet (years 20 & 21)* *51 – Nicholls (years 20 & 21)* *52 – Old – (years 20 & 21)*
39	*46*	*2 – Skinner* *3 – Elisnore* *11 – Fisher* *19 – Biralee Feeds* *31 – Cooper* *36 – Garland* *54 – Skinner*
38	*46*	*1 – Hayes (from year 1 to year 19)* *18 – Bennet (from year 1 to year 19)* *51 – Nicholls (from year 1 to year 19)* *52 – Old (from year 1 to year 19)*
36	*46*	*4 – Muller (from year 8 to year 21)*
35	*46*	*All other residential or sensitive receptors, excluding the receptors listed in condition 1 above.*

Table 9: Noise impact assessment criteria dB(A)

Notes:

(a) *The years referenced in Table 9 are to be considered as the position of mining operations as set out in the EIS for that year. If mining operations are delayed or accelerated from the planned location as shown in the EIS for a particular year, then the noise assessment criteria will be adjusted in accordance with the location of actual mining operations. The location of actual mining operations in relation to locations predicted in the EIS, will be indicated in the AEMR (see schedule 6, condition 5).*

(b) *The noise limits in Table 9 are for the noise contribution of the West Pit extension and all Hunter Valley Operations north of the Hunter River and coal haulage identified in the EIS from the south side of the Hunter River.*

(c) *Noise from the development is to be measured at the most affected point within the residential boundary, or at the most affected point within 30 metres of a dwelling (rural situations) where the dwelling is more than 30 metres from the boundary, to determine compliance with the $L_{Aeq(15 minute)}$ noise limits in the above table.*

(d) *To determine compliance with the $L_{Aeq(15 minute)}$ noise limits in the above table. Where it can be demonstrated that direct measurement of noise from the development is impractical, the DEC may accept alternative means of determining compliance (see Chapter 11 of the NSW Industrial Noise Policy). The modification factors in Section 4 of the NSW Industrial Noise Policy shall also be applied to the measured noise levels where applicable.*

(e) *Noise from the development is to be measured at 1 metre from the dwelling façade to determine compliance with the $L_{A1(1 minute)}$ noise limits in the above table.*

(f) *The noise emission limits identified in the above table do not apply under meteorological conditions of:*
   - *i* *wind speeds in excess 3 m/s at 10 metres above ground level; and/or*
   - *ii* *temperature inversion conditions in excess of 3°C/100m, and wind speeds in excess of 2 m/s at 10 metres above ground level.*

[3] Incorporates DEC GTAs

Land Acquisition Criteria

8. If the noise generated by the development exceeds the criteria in Table 10, the Applicant shall, upon receiving a written request for acquisition from the landowner, acquire the land in accordance with the procedures in conditions 9-11 of schedule 5.

Day/Evening/Night $L_{Aeq(15\ minute)}$	*Property*
43	*11 – Fisher*
42	*7 - Stapleton*
41	*All residential or sensitive receptors, excluding the receptors listed in condition 1 above*

Table 10: Land acquisition criteria dB(A)

Monitoring

9. The Applicant shall establish at least 5 permanent real-time noise monitoring stations at representative locations around the mine including residences on the land numbered 1 (Hayes) and 4 (Muller) in the EIS, while privately-owned, or at alternative locations approved by the Director-General, and at least 3 other locations (or obtain free and unencumbered access to data from existing real-time noise monitoring stations) approved by the DEC, and to the satisfaction of the Director-General. These stations shall monitor the noise generated by the development in general accordance with the *NSW Industrial Noise Policy* and *AS 1055: Acoustics – Description and Measurement of Environmental Noise*.

10. Within 6 months of the date of this consent, the Applicant shall prepare and implement a Noise Monitoring Program for the development to the satisfaction of the Director-General, which includes a noise monitoring protocol for evaluating compliance with the criteria in conditions 7 and 8.

METEOROLOGICAL MONITORING

11. The Applicant shall maintain a permanent meteorological station at a location approved by the DEC, and to the satisfaction of the Director-General, to monitor the parameters specified in Table 11, using the specified units of measure, averaging period, frequency, and sampling method in the table.

Parameter	*Units of measure*	*Averaging period*	Frequency	*Sampling method*[1]
Lapse rate	*°C/100m*	*1 hour*	Continuous	*Note*[2]
Rainfall	*mm/hr*	*1 hour*	Continuous	*AM-4*
Sigma Theta @ 10 m	*°*	*1 hour*	*Continuous*	*AM-2*
Siting	*-*	*-*	-	*AM-1*
Temperature @ 10 m	*K*	*1 hour*	*Continuous*	*AM-4*
Temperature @ 2 m	*K*	*1 hour*	*Continuous*	*AM-4*
Total Solar Radiation @ 2m	*W/m^2*	*1 hour*	*Continuous*	*AM-4*
Wind Direction @ 10 m	*°*	*1 hour*	*Continuous*	*AM-2*
Wind Speed @ 10 m	*m/s*	*1 hour*	Continuous	*AM-2*

Table 11: Meteorological monitoring

[1] NSW EPA, 2001, Approved Methods for the Sampling and Analysis of Air Pollutants in NSW.
[2] The Applicant shall calculate lapse rate from measurements made at 2m and 10m or any improved system of the determination of inversions.

BLASTING & VIBRATION

Airblast Overpressure Limits

12. The Applicant shall ensure that the airblast overpressure level from blasting at the development does not exceed the criteria in Table 12 at any residence on privately-owned land.

Airblast overpressure level (dB(Lin Peak))	Allowable exceedance
115	5% of the total number of blasts in a 12 month period
120	0%

Table 12: Airblast overpressure impact assessment criteria

Ground Vibration Impact Assessment Criteria

13. The Applicant shall ensure that the ground vibration level from blasting at the development does not exceed the criteria in Table 13 at any residence on privately-owned land.

Peak particle velocity (mm/s)	Allowable exceedance
5	5% of the total number of blasts in a 12 month period
10	0%

Table 13: Ground vibration impact assessment criteria

Blasting Hours

14. The Applicant shall only carry out blasting at the development between 7 am and 6 pm Monday to Saturday inclusive. No blasting is allowed on Sundays, Public Holidays or any other time without the written approval of DEC.

Interactions With Adjoining Mines

15. Prior to carrying out any mining or associated development within 500 metres of active mining areas at Ravensworth Operations, the Applicant shall enter into an agreement with Ravensworth Operations Pty Ltd (or its assigns or successors in title) to address the potential interactions between the two mines. If during the course of entering into this agreement, or subsequently implementing this agreement, there is a dispute between the parties about any aspect of the agreement, then either party may refer the matter to the Director-General for resolution.

16. Prior to carrying out any mining or associated development within 500 metres of active mining areas at Cumnock No. 1 Colliery, the Applicant shall enter into an agreement with Cumnock No. 1 Colliery Pty Ltd (or its assigns or successors in title) to address the potential interactions between the two mines. If during the course of entering into this agreement, or subsequently implementing this agreement, there is a dispute between the parties about any aspect of the agreement, then either party may refer the matter to the Director-General for resolution.

Monitoring

17. The Applicant shall monitor the airblast overpressure and ground vibration impacts of the development at residences on the land numbered 9 (Dallas) and 10 (Moses) whilst privately-owned, or at alternative locations approved by the Director-General, using the units of measurement, frequency, sampling method, and locations specified in Table 14.

Parameter	Units of Measure	Frequency	Sampling Method	Measurement Location
Airblast overpressure	dB(Lin Peak)	During every blast	AS2187.2-1993[1]	Not less than 3.5 m from a building or structure
Peak particle velocity	mm/s	During every blast	AS2187.2-1993	Not more than 30 m from a building or structure

Table 14: Airblast overpressure and ground vibration monitoring

[1]Standards Australia, 1993, AS2187.2-1993 Explosives - Storage, Transport and Use - Use of Explosives.

18. Within 6 months of the date of this consent, the Applicant shall prepare and implement a detailed Blasting Monitoring Program for the development to the satisfaction of the Director-General. The Applicant shall not carry out any development in the West Pit Extension area before the Director-General has approved this program.

Property Investigations

19. If any landowner within a 2 km radius of the site claims that his/her property, including vibration-sensitive infrastructure such as underground irrigation mains, has been damaged as a result of blasting at the development, the Applicant shall:
    (a) within 14 days of receiving this claim in writing, commission a suitably qualified person whose appointment has been approved by the Director-General to investigate the claim; and
    (b) provide the landowner a copy of the property investigation report within 14 days of receiving the report.

    If this independent investigation confirms the landowner's claim, and both parties agree with these findings, then the Applicant shall repair the damages to the satisfaction of the Director-General.

    If the Applicant or landowner disagrees with the findings of the independent property investigation, then either party may refer the matter to the Director-General for resolution.

    If the matter cannot be resolved within 21 days, the Director-General shall refer the matter to an Independent Dispute Resolution Process (See Appendix 2).

[4]SURFACE & GROUND WATER

Note: The Applicant is required to obtain or modify licences or permits for the development under the Water Act 1912, the Rivers and Foreshores Improvement Act 1948 and the Protection of the Environment Operations Act 1997.

Pollution of Waters

20. Except as may be expressly provided by a DEC licence, the Applicant shall comply with section 120 of the *Protection of the Environment Operations Act 1997* during the carrying out of the development.

Discharge Limits

21. Except as may be expressly provided by a DEC licence or the *Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Regulation 2002 (or any subsequent version of the Regulation)*, the Applicant shall:
    (a) not discharge more than 237 ML/day from the licensed discharge points at HVO north of the Hunter River;
    (b) ensure that the discharges from licensed discharge points comply with the limits in Table 15:

Pollutant	Units of measure	100 percentile concentration limit
pH	pH	6.5 ≤ pH ≤ 9.5
Non-filterable residue	mg/litre	NFR ≤ 120

Table 15: Discharge Limits

Note: This condition does not authorise the pollution of waters by any other pollutants.

[5]Water Licensing

22. Prior to the renewal of a licence obtained under the *Water Act*, or 5 years after the issue date (whichever is first), the Applicant must undertake a comparison of predicted impacts, on water resources, in the EIS against actual impacts, to the satisfaction of the DNR.

Groundwater Barrier

22A. Within 2 years of commencing mining in the Carrington Pit Southern Extension, or as otherwise agreed with the Director-General, the Applicant shall construct a groundwater barrier wall across the eastern arm of the palaeochannel of the Hunter River, to the satisfaction of the Director-General and at a location no further south than shown in the figure "*Carrington River Red Gums, Billabong and*

[4] Incorporates DEC GTA
[5] Incorporates DNR GTAs

Associated Infrastructure" included in the *Carrington Pit Extension Response to Submissions Report*, dated May 2006.

22B. By 31 December 2006, or as otherwise agreed with the Director-General, the Applicant shall submit a report to the Department and the DNR that:
   (a) examines all reasonable and feasible options for the design and construction of the groundwater barrier wall (including matters such as materials, timing and method of construction, costs, projected initial and longterm effectiveness) to the satisfaction of the Director-General; and
   (b) recommends a preferred option for the approval of the Director-General.

Site Water Management Plan

23. Before carrying out any development in the West Pit Extension area, the Applicant shall prepare a Site Water Management Plan for the development to the satisfaction of the Director-General. This plan must include:
   (a) the predicted site water balance;
   (b) an Erosion and Sediment Control Plan;
   (c) a Surface Water Monitoring Program;
   (d) a Groundwater Management Program; and
   (e) a strategy for the decommissioning of water management structures on the site.

24. [6]Each year, the Applicant shall:
   (a) review the site water balance for the development against the predictions in the EIS;
   (b) re-calculate the site water balance for the development; and
   (c) report the results of this review in the AEMR.

25. The Erosion and Sediment Control Plan shall:
   (a) be consistent with the requirements of the Department of Housing's *Managing Urban Stormwater: Soils and Construction* manual;
   (b) identify activities that could cause soil erosion and generate sediment;
   (c) describe the location, function, and capacity of erosion and sediment control structures;
   (d) describe measures to minimise soil erosion and the potential for the migration of sediments to downstream waters; and
   (e) include a program to monitor the effectiveness of the Erosion and Sediment Control Plan.

26. The Surface Water Monitoring Program shall include:
   (a) surface water impact assessment criteria; and
   (b) a program to monitor surface water flows and quality in Emu, Farrell's and Parnell's Creeks and the Hunter River.

27. [7]The Groundwater Management Plan (GMP) must cover the full cycle of operation from pre-mining to completion of rehabilitation/restoration of all groundwater. This plan must include:
   (a) clearly defined objectives for the GMP;
   (b) release criteria applicable to the objectives of the GMP;
   (c) identification of monitoring bores and piezometers which are representative of those areas likely to be impacted within and around the operational area;
   (d) pre-mining and post-mining, for a period of 10 years, monitoring of watertable levels and water quality;
   (e) analytes to be monitored;
   (f) procedures for sampling and monitoring;
   (g) frequency of readings in relation to all specified parameters;
   (h) levels of readings indicating contamination/impacts of the groundwater;
   (i) procedures for investigation of detected contamination/impacts; and
   (j) trigger levels, contingency criteria and contingency plans to address potential groundwater impacts.

Note: After reviewing the relevant documentation the Department may require the licence holder to undertake particular measures or perform particular work within a specified time, in order to restore any groundwater systems or groundwater dependant ecosystems impacted by mining activities located outside of the coal measures.

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[6] This should differentiate between licensed extracted water (from surface or groundwater sources), incidental water encountered in mining operations, and Harvestable Right water, which may not be exported from the site. These calculations must exclude the clean water system, including any sediment control structures, and any dams in the mine lease area which fall under the Maximum Harvestable Right Dam Capacity; include any dams that are licensable under Section 205 of the Water Act 1912, and water harvested from any non-harvestable rights dam on the mine lease area; address balances of inflows, licenced water extractions, and transfers of water from the site to other sites; include an accounting system for water budgets; and include a salt budget.

[7] Incorporates DNR GTAs.

Final Void Management Plan

28. At least 5 years before the cessation of open cut coal extraction that will result in the creation of a final void, or as otherwise agreed with the Director-General, the Applicant shall prepare and implement a Final Void Management Plan for each void, in consultation with DPI(MR) and DNR, and to the satisfaction of the Director-General. Each plan must:
    (a) assess locational, design and future use options;
    (b) be integrated with the Site Water Management Plan and the Landscape and Rehabilitation Management Strategy;
    (c) assess short term and long term groundwater and other impacts associated with each option; and
    (d) describe the measures to be would be implemented to avoid, minimise, manage and monitor potential adverse impacts of the final void over time.

[8]Temporary Crossing of the Hunter River

29. Prior to the commencement of any work within 40 metres of the Hunter River, a permit under Part 3A of the *Rivers and Foreshores Improvement Act 1948* shall be obtained from the DNR. All works shall be:
    (a) undertaken in accordance with the permit application, except as otherwise provided by conditions of the permit;
    (c) designed and constructed such that the works do not cause sedimentation, erosion or permanent diversion of the Hunter River;
    (d) constructed in accordance with section 10.8 (Temporary Crossing of the Hunter River), volume 1 of the EIS, dated October 2003; and titled *"Hunter Valley Operations – West Pit Extension and Minor Modifications"*; and
    (e) constructed in accordance with the Statement of Environmental Effects, prepared by Coal & Allied, dated August 2001, titled *"Proposed relocation of a dragline and electric rope shovel - Ravensworth and Hunter Valley Operations."*

Notes:
(a) Should Crown land, as defined under the Crown Lands Act 1989, be included in the temporary crossing, there is a requirement to seek approval from the Department of Lands under the Crown Lands Act; and
(b) Any works on Crown public roads require the Department of Lands' approval and must satisfy the statutory requirements of the Roads Act 1993.

FAUNA & FLORA

Rehabilitation/Regeneration Strategy

30. The Applicant shall not destroy or disturb more than 1 mature river red gum in the river red gum population associated with the Carrington billabong, and ensure that the mining highwall is located at least 150 metres from the standing water line of the billabong.

31. By 30 June 2007, the Applicant shall prepare and implement a comprehensive Rehabilitation and Restoration Strategy for the Carrington billabong and river red gum population, in consultation with DNR, and to the satisfaction of the Director-General. This strategy must be prepared by suitably qualified expert/s, and must include:
    (a) the rehabilitation and restoration objectives for the billabong and associated river red gum population;
    (b) a description of the short, medium and long term measures that would be implemented to rehabilitate and restore the billabong and associated river red gum population (including measures to address matters which affect the long term health and sustainability of the billabong and river red gums such as surface and ground water supply, and controlling weeds, livestock and feral animals); and
    (c) detailed assessment and completion criteria for the rehabilitation and restoration of the billabong and associated river red gum population.

    Note. The billabong, standing water line and river red gum population referred to are the billabong, standing water line and endangered population of river red gums located on land owned by the Applicant between the Hunter River and Levee 5, as shown in the figure "Carrington River Red Gums, Billabong and Associated Infrastructure" included in the Carrington Pit Extension Response to Submissions Report, dated May 2006.

32. By 30 June 2007, the Applicant shall prepare and implement a conceptual Landscape and Rehabilitation Management Strategy, in consultation with affected agencies, to the satisfaction of the Director-General. The strategy must:

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[8] Incorporates DNR GTAs

(a) include objectives for landscape management and rehabilitation of the site and a justification for the proposed strategy;
(b) present a conceptual plan for landscape management and rehabilitation of the site;
(c) be integrated with the relevant requirements of the Mining Operations Plan;
(d) describe the measures that would be implemented to achieve the objectives (including an indicative timetable for mine closure);
(e) include proposals to offset the flora and fauna impacts of the development (including proposals resulting from condition 30A above), and an outline of how the strategy would integrate with existing and planned corridors of native vegetation in areas surrounding the development; and
(f) outline how the proposed strategy would be integrated with the landscape management and rehabilitation of the other operations within Hunter Valley Operations (both north and south of the Hunter River) and other coal mines in the vicinity.

Strategic Study Contribution

33. If, during the development, the Department or the DEC commissions a strategic study into the regional vegetation corridor stretching from the Wollemi National Park to the Barrington Tops National Park, then the Applicant shall contribute a reasonable amount, up to $10,000, towards the completion of this study.

Operating Conditions

34. The Applicant shall salvage and reuse as much material as possible from the land that will be mined, such as soil, seeds, tree hollows, rocks and logs. Cleared vegetation must be reused or recycled to the greatest extent practicable. No burning of cleared vegetation shall be permitted. Reuse options including removing millable logs, recovering fence posts, mulching and chipping unusable vegetation waste for on-site use are to be implemented.

Flora and Fauna Management

35. The Applicant shall prepare and implement procedures for the management of flora and fauna for the development. These procedures shall:
(a) provide details on:
- delineating areas of disturbance;
- protecting areas outside of the disturbance areas;
- identifying when pre-clearance surveys are required for fauna;
- determining the best time to clear vegetation to avoid nesting/breeding activities of threatened fauna;
- capturing and releasing fauna;
- relocating bat roosts;
- salvaging habitat resources and collecting seed;
- controlling weeds in regeneration/rehabilitation areas; and
- controlling access to the regeneration/rehabilitation areas;

(b) describe how the land in regeneration areas would be revegetated;
(c) describe how the mined areas would be rehabilitated for grazing and biodiversity values;
(d) identify actions to minimise the potential impacts of the development on threatened fauna;
(e) describe how the performance of the revegetation/rehabilitation strategies would be monitored over time including, as a minimum, the parameters in Table 16; and
(f) identify who is responsible for monitoring, reviewing, and implementing the procedures.

The Applicant shall submit a copy of these procedures to the Director-General for approval within 6 months of the date of this consent.

Parameter	*Units of measure*
Density of vegetation	*Plants/m²*
	Understorey
	Ground cover
Diversity of flora	*Species/m²*
Age/maturity of flora	*Vegetation height/diameter/form*
Vegetation health	-
Disturbance	*Weeds/m²*
	Erosion
	Feral animals
	Stock
Density of fauna	*Fauna (Avian/Mammals/Reptiles-Amphibians)/m²*
Diversity of fauna	*Species/m²*
Density of fauna habitat	*Hollow-bearing trees/nesting sites/ logs/dams, etc.*
	Habitat Complexity Score
Ecosystem Function	*Landscape Function Analysis*

Table 16: Parameters and Units of Measure for Fauna and Flora Monitoring

Annual Review

36. The Applicant shall
    (a) review the performance of the flora & fauna management procedures annually, and, if necessary,
    (b) revise these documents to take into account any recommendations from the annual review.

[9]ABORIGINAL CULTURAL HERITAGE

Note: The Applicant is required to obtain consent from the DEC under the National Parks and Wildlife Act 1974 to destroy Aboriginal sites and objects on the site. The DEC has issued General Terms of Approval for the sites listed in condition 37.

West Pit Extension - Consents to Destroy

37. The Applicant shall obtain consent from DEC to destroy the following sites:

- WPE 1
- WPE 2
- WPE 3
- WPE 4
- WPE 5
- WPE 6
- WPE 7
- WPE 8
- WPE 9
- WPE 10
- WPE 11
- 37-2-1964
- 37-2-1965
- 37-2-1966
- 37-2-1967
- 37-2-0038
- 37-2-0144
- 37-2-0894
- 37-2-0896
- 37-2-0805

West Pit Extension - Salvage

38. Before making application for section 90 consents under NP&W Act, the Applicant shall prepare a salvage program for the sites listed in condition 37 in consultation with the DEC and Aboriginal communities, and to the satisfaction of the DEC.

Other Areas

39. The Applicant shall apply to the DEC for section 90 consents to destroy under the NP&W Act for the following sites:

- 37-2-0145
- 37-2-0147
- 37-2-0148
- 37-2-0523
- 37-2-0524
- 37-2-0525
- 37-2-0526
- 37-2-0527
- 37-2-0528
- 37-2-0562
- 37-2-0777
- 37-2-0778
- 37-2-0779
- 37-2-0780
- 37-2-0781
- 37-2-0782
- 37-2-0783
- 37-2-0784
- 37-2-0785
- 37-2-0786
- 37-2-0787
- 37-2-0788
- 37-2-0789
- 37-2-0790
- 37-2-0791
- 37-2-0792
- 37-2-0793

[9] Incorporates DEC GTAs.

• 37-2-0794	• 37-2-1872	• 37-2-1962
• 37-2-0795	• IF1	• 37-2-1963
• 37-2-0796	• TD	• 37-5-0061
• 37-2-0895	• TG	• 37-2-1861
• 37-2-1865	• 37-2-1504	• 37-2-1862
• 37-2-1866	• 37-2-1522	• 37-2-1873
• 37-2-1867	• 37-2-1535	• 37-2-1860
• 37-2-1868	• 37-2-1864	• 37-5-0131
• 37-2-1869	• 37-2-1874	• 37-3-0286
• 37-2-1870	• 37-2-1875	• 37-5-0061
• 37-2-1871	• 37-2-1876	• 37-1-0399
• 37-2-2078 (C1)	• 37-5-0494 (C4)	• 37-2-2085 (C10)
• 37-2-2079 (C2)	• 37-2-2083 (C8)	• 37-2-1962 (CM45)
• 37-2-2080 (C3)	• 37-2-2084 (C9)	• 37-2-1963 (CM46)

40. The Applicant shall continue the Cultural Heritage Indigenous Management Agreement developed in consultation with, and to the satisfaction of, the Wonnarua Tribal Council, particularly in relation to the management of Aboriginal site 37-2-1877 (ie CM-CD1) and Older Stratum as shown in Drawing 002 – Revision A which may include consideration of permanent conservation status for the site CM-CD1, and also sites 37-2-1504 (ie CM1), part of 37-2-1505 (CM2), 37-2-1522 (CM19), and 37-2-1535 (CM32). Details of any agreement shall be provided to the Director-General within 14 days of any final agreement(s).

41. The Applicant shall not mine within 15 metres of the Aboriginal site 37-2-1877 (CM-CD1) and the Older Stratum, as measured from the margin of the predicted maximum extent of those deposits as identified in Drawing 002-Revision A, dated 4 August 2000.

41A. Prior to disturbance by mining, the Applicant shall ensure that the scarred tree 37-2-2080 (C3) is removed and relocated to a site where it will be protected from future development, in consultation with the Wonnarua Tribal Council, and to the satisfaction of the Director-General.

Note. In conditions 37 – 41A, all seven-figure numbers refer to Aboriginal site listings in DEC's Aboriginal Heritage Information Management System (AHIMS). All other numbers are site numbers used by the Applicant in on-site Aboriginal heritage studies. Site numbers beginning with C or CM are associated with the Carrington Pit, as shown in Fig 5.1 of Annex G of the Carrington Pit Extended Statement of Environmental Effects.

Trust Fund Contribution

42. Before carrying out the development, or as agreed otherwise by the Director-General, the Applicant shall contribute $20,000 to the Hunter Aboriginal Cultural Heritage Trust Fund for further investigations into Aboriginal cultural heritage, as defined by the Trust Deed.

TRAFFIC & TRANSPORT

New Access Intersection to Hunter Valley Loading Point

Note: The Applicant requires Council approval under the Roads Act 1993 for the new road entry from Liddell Station Road to the Hunter Valley Loading Point.

43. [10]The Applicant shall design, construct and maintain for the duration of this consent, the proposed new access intersection from Liddell Station Road to the Hunter Valley Loading Point to the satisfaction of the Council.

Road Closure

Note: The Applicant requires MSC approval under the Roads Act 1993 prior to closing a section of Pikes Gully Road.

44. Within 12 months of the date of this consent, unless otherwise agreed by the Director-General, the Applicant is to complete the relevant requirements to enable the section of Pikes Gully Road situated in the Muswellbrook local government area to be closed as a public road.

45. The Applicant shall not blast within 500 metres of a public road while the road is open to the public. Any road closures with respect of blasting shall be subject to a plan of management approved by Council.

[10] Incorporates Council GTA

Lemington Road

46. The Applicant shall reimburse Council for any road upgrading works undertaken on Lemington Road, to a maximum amount of $30,000.

47. The Applicant shall alter or cease mining operations if driver visibility or traffic safety on Lemington Road is adversely affected by dust, in accordance with the requirements of Council.

48. The Applicant shall be responsible for the full cost of the maintenance of the Lemington Road deviation undertaken for the Carrington Pit until March 2011, in accordance with the standards and requirements of Council.

Intersection of Lemington Road and the Golden Highway

49. Within 2 years of the date of this consent, the Applicant shall upgrade the intersection of the Golden Highway (SH 27) and Lemington Road to a type "BAR" intersection with a sealed shoulder to the satisfaction of the RTA.

Road Safety Audit

49A.
- (a) By 31 December 2006, the Applicant shall prepare and submit a road safety audit to the RTA and Council for all public roads used by mine employees and service vehicles in the vicinity of the development, including an audit of the existing intersections of all mine access roads with public roads;
- (b) any improvement to meet accepted road safety standards required by the relevant road manager (ie the RTA or Council) for public roads as a result of impacts related to the development as identified by the audit shall be undertaken at the Applicant's cost and to the satisfaction of the road manager;
- (c) any dispute between the Applicant and the relevant road manager in relation to the audit findings and the requirements of the road manager for improvements of public roads is to be determined by the Director-General; and
- (d) any maintenance of line marking and sign posting required by the relevant road manager at existing intersections of mine access roads with public roads shall be undertaken at the Applicant's cost and to the satisfaction of the road manager.

Coal Haulage

50. [11]The Applicant shall ensure that spillage of coal from coal haulage vehicles is minimised and that sediment-laden runoff from roads is effectively managed, to the satisfaction of the Director-General. Measures that shall be implemented include:
- (a) covering all loads where loaded coal trucks leave the site and enter public roads;
- (b) ensuring the gunwhales of all loaded trucks are clean of coal;
- (c) providing effective wheel wash facilities at all coal load and unload facilities prior to vehicles entering public roads; and
- (d) sweeping, at regular intervals and at the completion of campaign hauls, public roads used for the transportation of coal.

51. The Applicant shall enter into an agreement with Council for the maintenance of the sections of Pikes Gully Road and Liddell Station Road whilst used by the Applicant for the haulage of coal, and during the period the roads are owned by Council.

Monitoring

52. The Applicant shall maintain and include in each AEMR records of the:
- (a) amount of coal transported from the site each year;
- (b) amount of coal received from Hunter Valley Operations south of the Hunter River;
- (c) amount of coal hauled by road to the Hunter Valley Loading Point;
- (d) amount of coal hauled by road to the Newdell Loading Point;
- (e) amount of coal hauled by road from the Newdell Loading Point to the Ravensworth coal Terminal;
- (f) amount of coal hauled by road from the Hunter Valley Loading Point to the Ravensworth Coal Terminal; and
- (g) number of coal haulage truck movements generated by the development.

[11] This may include the use of sediment dams or the incorporation of runoff into the mine water management system.

VISUAL IMPACT

Visual Amenity

53. The Applicant shall implement measures to mitigate visual impacts including:
    (a) design and construction of development infrastructure in a manner that minimises visual contrasts; and
    (b) progressive rehabilitation of mine waste rock emplacements (particularly outer batters), including partial rehabilitation of temporarily inactive areas.

54. The Applicant shall plant trees to provide an effective visual screen from Lemington Road in the vicinity of the Belt Line Road and adjacent to the Mitchell pit area. The plan for this tree planting is to:
    (a) provide for tree planting within 2 years of the date of this consent;
    (b) achieve an 80% survival rate by the 5th year;
    (c) be submitted to the DPI(MR) and Director-General for review and approval; and
    (d) provide an assessment of whether visual bunds are required to supplement the vegetative visual screen.

Lighting Emissions

55. The Applicant shall take all practicable measures to mitigate off-site lighting impacts from the development.

56. All external lighting associated with the development shall comply with *Australian Standard AS4282 (INT) 1995 – Control of Obtrusive Effects of Outdoor Lighting*.

WASTE MINIMISATION

57. The Applicant shall minimise the amount of waste generated by the development to the satisfaction of the Director-General.

HAZARDS MANAGEMENT

Spontaneous Combustion

58. The Applicant shall:
    (a) take the necessary measures to prevent, as far as is practical, spontaneous combustion on the site; and
    (b) manage any spontaneous combustion on-site to the satisfaction of DPI(MR).

Dangerous Goods

59. The Applicant shall ensure that the storage, handling, and transport of:
    (a) dangerous goods is done in accordance with the relevant *Australian Standards*, particularly *AS1940* and *AS1596*, and the *Dangerous Goods Code*; and
    (b) explosives are managed in accordance with the requirements of DPI(MR).

BUSHFIRE MANAGEMENT

60. The Applicant shall:
    (a) ensure that the development is suitably equipped to respond to any fires on-site; and
    (b) assist the Rural Fire Service and emergency services as much as possible if there is a fire on-site during the development.

61. The Applicant shall ensure that the Bushfire Management Plan for the site, is to the satisfaction of Council and the Rural Fire Service.

REHABILITATION

62. The Applicant shall:
    (a) rehabilitate all mining areas in accordance with the requirements of any mining lease granted by the Minister for Mineral Resources, having regard to the *Synoptic Plan – Integrated Landscapes for Mine Site Rehabilitation*; and
    (b) ensure that the progressive rehabilitation is carried out to the satisfaction of the DPI(MR).

MINE EXIT STRATEGY

63. Within 5 years of the date of this consent, the Applicant shall work with the Council and MSC to investigate the minimisation of adverse socio-economic effects of a significant reduction in local employment levels and closure of the development at the end of its life.

SCHEDULE 5
ADDITIONAL PROCEDURES FOR AIR QUALITY & NOISE MANAGEMENT

Notify Landowners

1. If the air dispersion and/or noise model predictions in the documents listed in condition 2 of schedule 3 identify that the air pollution and/or noise generated by the development are likely to be greater than the air quality and/or noise impact assessment criteria in conditions 3 and 7 of schedule 4, then the Applicant shall notify the relevant landowners and/or existing or potential tenants (including tenants of mine-owned properties) accordingly before it carries out any development.

2. If the results of the air quality and/or noise monitoring required in schedule 4 identify that the air pollution and/or noise generated by the development are greater than the air quality and/or noise impact assessment criteria in schedule 4, then the Applicant shall notify the relevant landowners and/or existing or future tenants (including tenants of mine-owned properties) at the end of each quarter.

3. Before carrying out any development in the West Pit Extension Area, the Applicant shall develop a procedure in consultation with DEC and NSW Health, for notifying landowners and tenants referred to in condition 1. This procedure must ensure that:
   (a) all existing and future tenants are advised in writing about:
      - air quality impacts likely to occur at the residence during the operational life of the mine; and
      - likely health and amenity impacts associated with exposure to particulate matter;
   (b) the written advice in (a) is based on current air quality monitoring data, dispersion modelling results, research and literature; and
   (c) there is an ongoing process for providing current air quality monitoring data, dispersion modelling results, research and literature to the tenants.

Independent Review

4. If a landowner considers the development to be exceeding the air quality and/or noise impact assessment criteria listed in schedule 4 at his/her dwelling, or at any proposed dwelling on his/her vacant land, then he/she may ask the Applicant for an independent review of the air pollution and/or noise impacts of the development on his/her dwelling, or proposed dwelling.

   If the Director-General is satisfied that an independent review is warranted, the Applicant shall:
   (a) consult with the landowner to determine his/her concerns; and
   (b) commission a suitably qualified person – whose appointment has been approved by the Director-General – to conduct air quality and/or noise monitoring at the relevant dwelling to determine whether the development is complying with the relevant impact assessment criteria, and identify the source(s) and scale of any air quality and/or noise impact at the dwelling, and the development's contribution to this impact.

   Within 14 days of receiving the results of this independent review, the Applicant shall give a copy of these results to the Director-General and landowner.

5. If the independent review (referred to in condition 4) determines that the development is complying with the relevant impact assessment criteria listed in schedule 4 at the dwelling, then the Applicant may discontinue the independent review with the approval of the Director-General.

6. If the independent review (referred to in condition 4) determines that the development is not complying with the relevant impact assessment criteria listed in schedule 4 at the dwelling, and that the development is primarily responsible for this non-compliance, then the Applicant shall:
   (a) take all practicable measures, in consultation with the landowner, to ensure that the development complies with the relevant impact assessment criteria; and conduct further air quality and/or noise monitoring at the dwelling to determine whether these measures ensure compliance; or
   (b) secure a written agreement with the landowner to allow exceedances of the air quality and/or noise impact assessment criteria listed in schedule 4.

   If the additional monitoring referred to above subsequently determines that the development is complying with the relevant impact assessment criteria listed in schedule 4 at the dwelling, then the Applicant may discontinue the independent review with the approval of the Director-General.

   If the measures referred to in (a) do not ensure compliance with the air quality and/or noise land acquisition criteria listed in schedule 4 at the dwelling, and the Applicant cannot secure a written agreement with the landowner to allow exceedances of the air quality and/or noise impact assessment criteria listed in schedule 4, then the Applicant shall, upon receiving a written request from the landowner, acquire all or part of the landowner's land in accordance with the procedures in conditions 9-11 below.

7. If the independent review determines that the development is not complying with the air quality and/or noise impact assessment criteria listed in schedule 4 at the dwelling, but that more than one mine are responsible for this non-compliance, then the Applicant shall, with the agreement of the landowner and other mine(s) prepare and implement a Cumulative Air Quality and/or Noise Impact Management Plan for the land to the satisfaction of the Director-General. This plan must provide the joint approach to be adopted by the Applicant and other mine(s) to manage cumulative air quality and/or noise impacts at the landowner's dwelling, and the acquisition of any land.

   If the Applicant is unable to finalise an agreement with the landowner and/or other mine(s), and/or prepare a Cumulative Air Quality and Noise Impact Management Plan, then the Applicant or landowner may refer the matter to the Director-General for resolution.

   If the matter cannot be resolved within 21 days, the Director-General shall refer the matter to an Independent Dispute Resolution Process.

   If, following the Independent Dispute Resolution Process, the Director-General decides that the Applicant shall acquire all or part of the landowner's land, then the Applicant shall acquire this land in accordance with the procedures in conditions 9-11 below.

8. If the landowner disputes the results of the independent review (referred to in condition 4), either the Applicant or the landowner may refer the matter to the Director-General for resolution.

   If the matter cannot be resolved within 21 days, the Director-General shall refer the matter to an Independent Dispute Resolution Process.

Land Acquisition

9. Within 6 months of receiving a written request from the landowner, the Applicant shall pay the landowner:
   (a) the current market value of the landowner's interest in the land at the date of this written request having regard to:
      - in the case of any property listed in Table 1 of condition 1 of schedule 4, the assessment of current market value as if the land was unaffected by coal mining and related activities at Hunter Valley Operations (both north and south of the Hunter River);
      - in the case of any other property, the assessment of current market value as if the land was unaffected by the development the subject of this consent;
      - existing and permissible use of the land, in accordance with the applicable planning instruments at the date of the written request; and
      - presence of improvements on the land and/or any approved building or structure which has been physically commenced at the date of the landowner's written request, and is due to be completed subsequent to that date;
   (b) the reasonable costs associated with:
      - relocating within the Singleton or Muswellbrook local government areas, or to any other local government area determined by the Director-General;
      - obtaining legal advice and expert advice for determining the acquisition price of the land, and the terms upon which it is required; and
   (c) reasonable compensation for any disturbance caused by the land acquisition process.

   However, if at the end of this period, the Applicant and landowner cannot agree on the acquisition price of the land, and/or the terms upon which the land is to be acquired, then either party may refer the matter to the Director-General for resolution.

   Upon receiving such a request, the Director-General shall request the President of the NSW Division of the Australian Property Institute to appoint a qualified independent valuer or Fellow of the Institute, to consider submissions from both parties, and determine a fair and reasonable acquisition price for the land, and/or terms upon which the land is to be acquired.

   Within 14 days of receiving the independent valuer's determination, the Applicant shall make a written offer to purchase the land at a price not less than the independent valuer's determination.

   If the landowner refuses to accept this offer within 6 months of the date of the Applicant's offer, the Applicant's obligations to acquire the land shall cease, unless otherwise agreed by the Director-General.

10. The Applicant shall bear the costs of any valuation or survey assessment requested by the independent valuer, panel, or the Director-General and the costs of determination referred to in Condition 9.

11. If the Applicant and landowner agree that only part of the land should be acquired, then the Applicant shall pay all reasonable costs associated with obtaining Council approval for any plan of subdivision, and registration of the plan at the Office of the Registrar-General.

SCHEDULE 6
ENVIRONMENTAL MANAGEMENT, MONITORING, AUDITING & REPORTING

ENVIRONMENTAL MANAGEMENT STRATEGY

1. Within 6 months of the date of this consent, the Applicant shall prepare and implement an Environmental Management Strategy for the development to the satisfaction of the Director-General. This strategy must:
   (a) provide the strategic context for environmental management of the development;
   (b) identify the statutory requirements that apply to the development;
   (c) describe in general how the environmental performance of the development would be monitored and managed during the development;
   (d) describe the procedures that would be implemented to:
      - keep the local community and relevant agencies informed about the operation and environmental performance of the development;
      - receive, handle, respond to, and record complaints;
      - resolve any disputes that may arise during the course of the development;
      - respond to any non-compliance;
      - manage cumulative impacts; and
      - respond to emergencies; and
   (e) describe the role, responsibility, authority, and accountability of all the key personnel involved in environmental management of the development.

2. Within 14 days of the Director-General's approval, the Applicant shall:
   (a) send copies of the approved strategy to the relevant agencies, Council, and the CCC; and
   (b) ensure the approved strategy is publicly available during the development.

2A. Within 6 months of the completion of the Independent Environmental Audit, the Applicant shall review, and if necessary revise, the Environmental Management Strategy to the satisfaction of the Director-General.

ENVIRONMENTAL MONITORING PROGRAM

3. Within 6 months of the date of this consent, the Applicant shall prepare an Environmental Monitoring Program for the development in consultation with the relevant agencies, and to the satisfaction of the Director-General. This program must consolidate the various monitoring requirements in schedule 4 of this consent into a single document.

3A. Within 6 months of the completion of the Independent Environmental Audit, the Applicant shall review, and if necessary revise, the Environmental Monitoring Program to the satisfaction of the Director-General.

UPDATING ENVIRONMENTAL MANAGEMENT REQUIREMENTS

4. The Applicant shall ensure that the Environmental Management Strategy, the Environmental Monitoring Program and all other environmental management plans and strategies required under this consent are reviewed and if necessary updated to reflect any changes to the development (or modifications to the development consent), to the satisfaction of the Director-General.

ANNUAL REPORTING

5. The Applicant shall submit an AEMR to the Director-General and the relevant agencies. This report must:
   (a) identify the standards and performance measures that apply to the development;
   (b) include a summary of the complaints received during the past year, and compare this to the complaints received in the previous 5 years;
   (c) include a summary of the monitoring results on the development during the past year;
   (d) include an analysis of these monitoring results against the relevant:
      - impact assessment criteria;
      - monitoring results from previous years; and
      - predictions in the EIS;
   (e) identify any trends in the monitoring over the life of the development;
   (f) identify the location of actual mining operations in relation to the locations predicted in the EIS (see schedule 4, condition 7);
   (g) identify any non-compliance during the previous year; and
   (h) describe what actions were, or are being, taken to ensure compliance.

INDEPENDENT ENVIRONMENTAL AUDIT

6. Within 3 years of the date of this consent, and every 3 years thereafter, unless the Director-General directs otherwise, the Applicant shall commission and pay the full cost of an Independent Environmental Audit of the development. This audit must:
   (a) be conducted by suitably qualified, experienced, and independent expert/s whose appointment has been endorsed by the Director-General;
   (b) assess the various aspects of the environmental performance of the development, and its effects on the surrounding environment;
   (c) assess whether the development is complying with the relevant standards, performance measures, and statutory requirements;
   (d) review the adequacy of any strategy/plan/program required under this consent; and, if necessary,
   (e) recommend measures or actions to improve the environmental performance of the development, and/or any strategy/plan/program required under this consent.

7. Within 3 months of completion of this audit, the Applicant shall submit a copy of the audit report to the Director-General, with a response to any of the recommendations contained in the audit report.

COMMUNITY CONSULTATIVE COMMITTEE

8. The Applicant shall continue the operation of the Hunter Valley Operations Community Consultative Committee to oversee the environmental performance of the development. This committee shall, unless otherwise agreed by the Director-General:
   (a) be comprised of:
      - 1 representative from the Applicant, (plus technical support staff, as required);
      - 1 representative from Council;
      - 1 representative from MSC; and
      - 7 representatives from the local community whose appointment has been approved by the Director-General in consultation with the Council;
   (b) be chaired by the representative from Council
   (c) be able to invite representatives of government agencies to attend meetings;
   (d) meet at least three times a year; and
   (e) review and provide advice on the environmental performance of the development, including any construction or environmental management plans, monitoring results, audit reports, or complaints.

9. The Applicant shall, at its own expense:
   (a) ensure that its representatives attend the Committee's meetings;
   (b) provide the Committee with regular information on the environmental performance and management of the development;
   (c) provide meeting facilities for the Committee;
   (d) arrange site inspections for the Committee, if necessary;
   (e) provide financial and in-kind support to enable Council to take the minutes of the Committee's meetings and make these minutes available to the public for inspection within 14 days of the Committee meeting, or as agreed to by the Committee;
   (f) respond to any advice or recommendations the Committee may have in relation to the environmental management or performance of the development;
   (g) forward a copy of the minutes of each Committee meeting, and any responses to the Committee's recommendations to the Director-General within a month of the Committee meeting.

ACCESS TO INFORMATION

10. From 30 June 2007, and during the life of the development thereafter, the Applicant shall place a copy of the following documents and information (and any subsequent revisions) required under this consent on its website:
   (a) all current environmental management plans, strategies and programs;
   (b) all Independent Environmental Audits;
   (c) all AEMRs; and
   (d) a summary of all environmental monitoring results (to be updated at least every 6 months),

   to the satisfaction of the Director-General.

APPENDIX 1
SCHEDULE OF LAND

Hunter Valley Operations, West Pit Extension and Minor Modifications						
Development Application Area - Lot and DP Schedule						
DP	Lot	Portion	Part	Volume	Folio	Property Owner
752468	128					Coal & Allied Operations Pty Limited
1018576	1					Coal & Allied Operations Pty Limited
1017998	100					Novacoal Australia Pty Limited
705454	161					Novacoal Australia Pty Limited and Mitsubishi Development Pty Ltd
727718	165					Coal & Allied Operations Pty Limited
191982	1					Coal & Allied Operations Pty Limited
752481			20	3269	568	Coal & Allied Operations Pty Limited
752481		170				Coal & Allied Operations Pty Limited
808301	2					Coal & Allied Operations Pty Limited
90727	1			7716	156	Coal & Allied Operations Pty Limited
752481						Coal & Allied Operations Pty Limited
544091	201					Coal & Allied Operations Pty Limited
752481	98					Coal & Allied Operations Pty Limited
752481	21					J. & A. Brown and Abermain Seaham Collieries Limited
752481	18					Coal & Allied Operations Pty Limited
752481	17					Coal & Allied Operations Pty Limited
752481	22					J. & A. Brown and Abermain Seaham Collieries Limited
752481	124					Coal & Allied Operations Pty Limited
752481	125					Coal & Allied Operations Pty Limited
752481	126					Coal & Allied Operations Pty Limited
752481	127					Coal & Allied Operations Pty Limited
752481	123					Coal & Allied Operations Pty Limited
752481	122					Coal & Allied Operations Pty Limited
752481	121					Coal & Allied Operations Pty Limited
752481	120					Coal & Allied Operations Pty Limited
752481	119					Coal & Allied Operations Pty Limited
752481	118					Coal & Allied Operations Pty Limited
752481	117					Coal & Allied Operations Pty Limited
7542481		89				J. & A. Brown and Abermain Seaham Collieries Limited
740183	10					Coal & Allied Operations Pty Limited
752481	171			6353	145	J. & A. Brown and Abermain Seaham Collieries Limited
110662	1			13933	249	J. & A. Brown and Abermain Seaham Collieries Limited
737796	1					Coal & Allied Operations Pty Limited
110656	1			11057	141	J. & A. Brown and Abermain Seaham Collieries Limited
752468	126					Novacoal Australia Pty Limited
779625	1					Novacoal Australia Pty Limited
779626	1					Novacoal Australia Pty Limited
625507	1					Novacoal Australia Pty Limited and Mitsubishi Development Pty Ltd
48165						Lemington Road
786904	22					Coal & Allied Operations Pty Limited
786904	21					Novacoal Australia Pty Limited

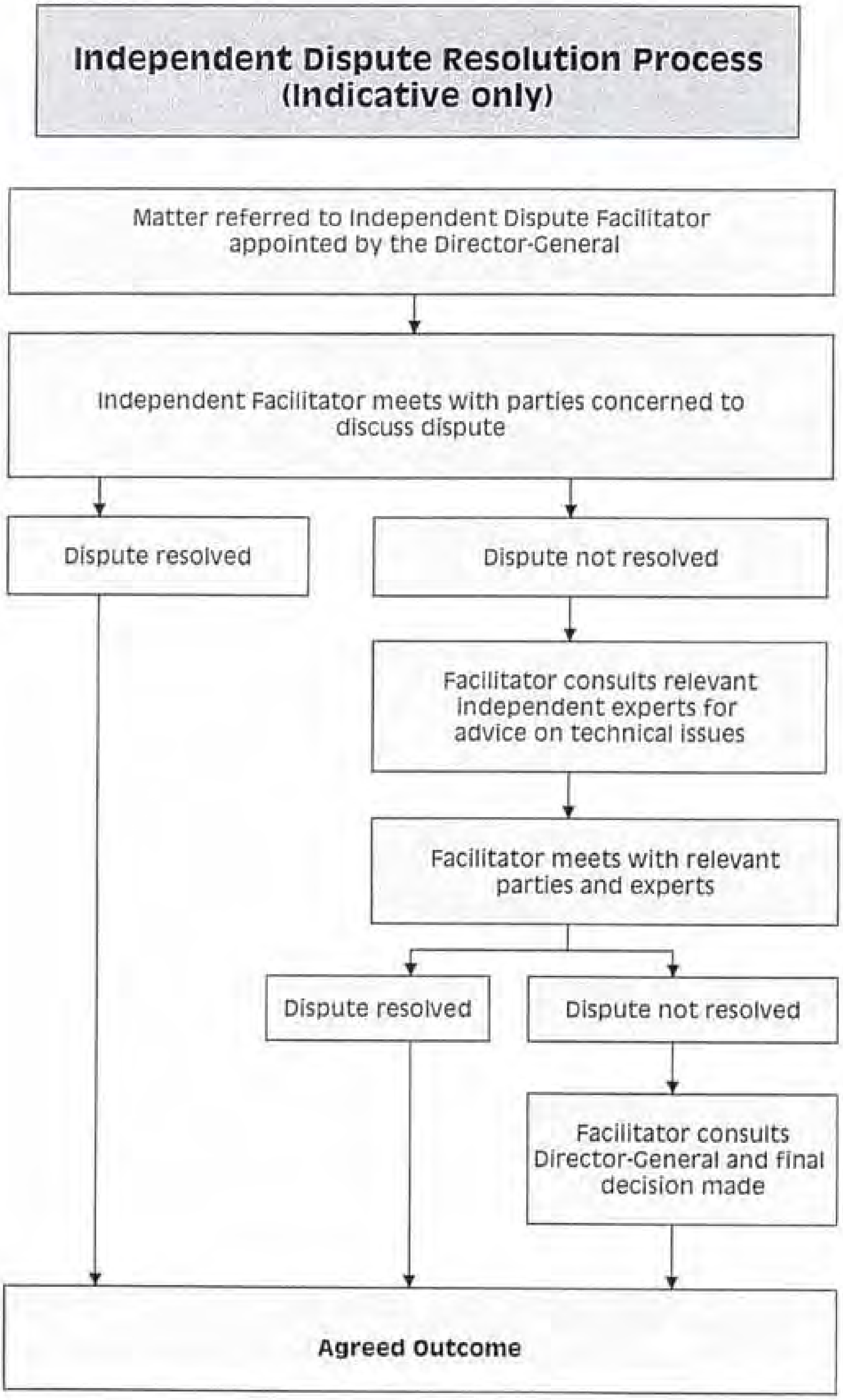
48555	4			Novacoal Australia Pty Limited
1037665	101			Coal & Allied Operations Pty Limited
752468	80	1782	37	Novacoal Australia Pty Limited
752468	81			Novacoal Australia Pty Limited
752468	53	7834	45	Novacoal Australia Pty Limited
752468	83	7834	45	Novacoal Australia Pty Limited
752468	157			Novacoal Australia Pty Limited
752481	83	6408	207	Novacoal Australia Pty Limited
752481	82	6408	207	Novacoal Australia Pty Limited
596670	3	13659	69	J. & A. Brown and Abermain Seaham Collieries Limited
868175	305			Novacoal Australia Pty Limited
752481	200	6408	207	Novacoal Australia Pty Limited
752468	158	6408	206	Novacoal Australia Pty Limited
752468	84	6408	206	Novacoal Australia Pty Limited
752468	54	6408	206	Novacoal Australia Pty Limited
752468	65			Novacoal Australia Pty Limited
752468	70	1782	37	Novacoal Australia Pty Limited
752468	71			Novacoal Australia Pty Limited
752468	68	1782	37	Novacoal Australia Pty Limited
752468	66	6408	206	Novacoal Australia Pty Limited
752468	159	6408	206	Novacoal Australia Pty Limited
252530	8	8625	137	Novacoal Australia Pty Limited
752468	94	6408	206	Novacoal Australia Pty Limited
752468	156	6408	206	Novacoal Australia Pty Limited
752468	102	6408	206	Novacoal Australia Pty Limited
700554	12	8625	137	Novacoal Australia Pty Limited
130831	1	10547	67	Novacoal Australia Pty Limited
252530	2	8625	137	Novacoal Australia Pty Limited
252530	4	8625	137	Novacoal Australia Pty Limited
48555	7			Novacoal Australia Pty Limited
252530	5	8625	137	Novacoal Australia Pty Limited
130831	2			Novacoal Australia Pty Limited
252530	3	8625	137	Novacoal Australia Pty Limited
393657	1			Novacoal Australia Pty Limited
780177	1	8625	137	Novacoal Australia Pty Limited
868175	304			Novacoal Australia Pty Limited
860535	319			Coal & Allied Operations Pty Limited
48555	3			Novacoal Australia Pty Limited
48555	2			Novacoal Australia Pty Limited
48555	5			Novacoal Australia Pty Limited
752481	58	8625	137	Novacoal Australia Pty Limited
256503	2			J. & A. Brown and Abermain Seaham Collieries Limited
130831	4	10547	67	Novacoal Australia Pty Limited
130831	3	10547	67	Novacoal Australia Pty Limited
752468	82	1782	37	Novacoal Australia Pty Limited
752481	38	8625	137	Novacoal Australia Pty Limited
48537	1			Novacoal Australia Pty Limited
727260	1			Novacoal Australia Pty Limited and Mitsubishi Development Pty Ltd
574166	1			Macquarie Generation
211043	1			Cumnock No 1 Colliery Pty Limited

574166	2			Novacoal Australia Pty Ltd and Mitsubishi Development Pty Ltd
700429	100			The Shortland County Council
979456				J. & A. Brown & Abermain Seaham Collieries Ltd
869839	380			Novacoal Australia Pty Limited and Mitsubishi Development Pty Ltd
808431	2			Novacoal Australia Pty Limited
1019325	601			Macquarie Generation
808431	1			Coal & Allied Operations Pty Limited
201214	1			Novacoal Australia Pty Limited
869399	22			Coal Operations Australia Limited, Cumnock No.1 Colliery Pty Limited, Muswellbrook Coal Company Limited, BCA No. 11 Pty Limited
858172	11			Coal & Allied Operations Pty Limited
752470				Coal & Allied Operations Pty Limited
659810	1			J. & A. Brown and Abermain Seaham Collieries Limited
114966	2	12915	20	J & A Brown & Abermain Seaham Collieries Limited
700429	101			Coal & Allied Operations Pty Limited
729048	1			Coal & Allied Operations Pty Limited
752470	148			Crown Land Reserve 144
93617				Crown land Reserve 68816

Hunter River
Crown land fronting Portion 170, DP 752481

Roads
Mitchell Line of Road – Parish of Ravensworth
Pikes Gully Road – Parish of Ravensworth

APPENDIX 2
INDEPENDENT DISPUTE RESOLUTION PROCESS



Appendix C

Groundwater Study

www.coalandallied.com.au

COAL & ALLIED
CARRINGTON WEST WING MODIFICATION
GROUNDWATER ASSESSMENT
MARCH 2010

prepared by ..

Mackie Environmental Research

193 Plateau Rd., Bilgola 2107

Phone (02) 89190182

for ..

Environmental Management Group Australia

330 Wattle St, Ultimo 2007

on behalf of ..

Coal & Allied

Lemington Rd., Ravensworth 2330

SUMMARY OF FINDINGS

Coal & Allied is seeking consent to extend mining operations within its Carrington Pit. The proposed West Wing extension is situated immediately south of the existing West Wing rehabilitated void and is proposed to extend southward to within 250 m of the Hunter River at its nearest point. Mining would extract coal over a period of about six years from seams including the Vaux, Broonie(s), and Bayswater, to pit floor depths ranging from less than 40 m in the north, to about 75 m in the south-eastern corner of the pit.

Operations in the northern part of the pit would be close to or below the prevailing water table which has already been affected by prior mining in the West Wing and Carrington areas. Southward extension of the pit would lead to a progressive dewatering and pre-stripping of the alluvium before mining the underlying coal measures. Interburden waste rock (spoils) would be emplaced in the pit and in two out of pit areas to the north of the proposed pit extension area. Re-saturation of the spoils emplaced within the mine pit following closure and rehabilitation, would ultimately lead to the generation of a leachate within the pit shell and within a final open void. A relatively impermeable barrier wall is proposed to be constructed to the south of the extended area in order to isolate the potential impacts of mining from the Hunter River and its associated alluvium. A barrier wall is presently being constructed across the eastern channel.

Detailed groundwater management studies have been conducted for the proposed mining operations in order to characterise the magnitude and extent of strata depressurisation, potential impacts on the Hunter River, and the long term void water quality. Findings are as follows.

The paleochannel alluvium in the western channel is similar to alluvium encountered in the eastern channel which is now largely removed. Shallow soil, and sandy-silty sediments overlie a clay layer of 2 to 6 m thickness which in turn overlies a mixed clayey, silty, gravel sequence of similar thickness. The clay layer is absent in a number of piezometers drilled in the western part of the project area. A typical thickness of the unconsolidated succession is 11 to 15 m.

Measured groundwater levels in the alluvium support a northwards flow system at the present time with about 2.5 to 3 m saturation (in the deep clayey gravel sequence) along the southern perimeter of the project area and zero saturation along the now buried crest of the Carrington West Wing pit in the north. Groundwater salinity ranges from 1300 to 8500 mg/l (2000 to 5500 uS/cm). Permeabilities of saturated gravels vary from 1 m/day to more than 100 m/day and suggest the presence of localised cleaner gravel braids that conduit groundwater flows in a manner similar to conditions observed in the course of mining in Carrington Pit. Pre-mining (saline) baseflow contributions to the Hunter River are calculated to have been 0.17 ML/day and 0.22 ML/day for the eastern and western arms of the paleochannel respectively.

The hardrock coal measures strata provide very limited groundwater storage and transmission capacity. Jointing and fracturing are sparse and groundwater flow is more generally governed by matrix permeabilities except in coal seams where cleating and micro fracturing enhance transmission and storage characteristics – the coal seams are commonly regarded as the more permeable strata. Interburden and overburden lithologies comprising sandstones, siltstones and shales are noted from core testing to possess low intergranular hydraulic conductivities. Water quality in the coal seams is generally saline with dissolved salts concentrations ranging from 1000 to more than 4000 mg/L (1500 to 6000 uS/cm).

A computer based aquifer model of the region has been consolidated from previous groundwater models. The updated model has been used to simulate the existing groundwater flow regime and to predict the changes that may occur during mining of the West Wing extension. The model has been re-calibrated to historical and recent piezometric monitoring data for both the eastern and western arms of the paleochannel. This process has resulted in a modified permeability distribution for the project area when compared to the prior model(s).

Within the limitations and constraints imposed by numerical modelling, the simulation results demonstrate that proposed mining would enhance the hydraulic sink associated with existing mining operations, attracting groundwater flows from surrounding hardrock strata for distances of 2 km or more beyond the pit crest. The depressurisation envelope would in turn sustain leakage

from the overlying alluvial lands associated with the paleochannel and the Hunter River. Current and future leakage losses (as baseflow losses) from the Hunter River have been estimated at 0.05 ML/day for each reach of the river adjacent to the eastern and western arms of the paleochannel. These losses will have negligible impact on Hunter River flow and will decline post mining when groundwater levels in the West Wing-Carrington pit shell recover.

During stripping of the alluvium within the proposed pit area, dry weather groundwater drainage from the alluvium (as mine water) is predicted to rise from an initial rate of less than 0.01 ML/day in year 1 to about 0.04 ML/day in year 4. Similarly, hardrock drainage is predicted to increase from an initial rate of less than 0.01 ML/day to a final rate of about 0.07 ML/day over the proposed six years mining period. The relatively low seepage/drainage rates are attributed to the depressurisation envelope already evident around Carrington Pit. It is noted that the hardrock drainage rates represent complete drainage of the strata based on porous media flow. In reality, blast fragmentation and handling-dumping of the waste rock which has very low effective porosity, will result in a large component of evaporative loss. Actual contributions to the mine water system from hardrock dewatering are therefore likely to be lower than predicted. Rainfall recharge through spoils emplaced during mining, may contribute an additional 0.25 ML/day to pit seepage. During the period of mining, losses from baseflow in the Hunter River are predicted to be about 0.048 ML/day (via the coal measures) and to remain relatively constant. The constancy indicates there would be little change if mining did not proceed.

At the cessation of mining water levels within the emplaced spoils in the West Wing–Carrington pit shell will recover as a result of sustained rainfall infiltration through spoils, and direct rainfall and runoff to the final void. The void is located in the eastern part of Carrington Pit and has been designed to operate as an evaporative sink with a maximum surface area of about 100 ha. The proposed long term steady state free standing water elevation for the void is 40 mAHD consistent with previous design criteria. This elevation is approximately 25 m below the elevation of the crests of the barrier walls and 20 m below the median water level of the Hunter River. Numerical model simulations have confirmed that the nominated free standing water level would ensure that groundwater within the mine spoils would remain isolated from the Hunter River alluvial lands south of the barrier walls.

An estimate of the final void water quality has been calculated from simple reaction path modelling of the dissolution of typical waste rock sandstones, siltstones and shales. The mineralogy of these rocks has been assessed by X-ray diffraction and found to comprise quartz, feldspar, mixed layer clays (illite-smectite), and carbonate minerals (siderite/ankerite and minor dolomite). Modelled long term water quality is characterised by Na,Ca>>Mg depending on exchange capacity, and SO_4,Cl>>HCO_3. pH would range from 8.0 to 9.0 while TDS would rise above 1300 mg/l depending upon mineral availability and type. These results have been compared with previous leachate trials conducted for the Carrington Pit, West Pit and for coarse rejects from the washery. Consideration of all results suggests a long term void water quality exhibiting a pH range from 7.5 to 9.5, a TDS range from 1000 mg/L increasing to about 3000-4000 mg/L in the long term with a ion speciated signature Na>Mg>Ca and HCO_3>Cl >SO_4.

There are no privately owned boreholes (excluding those associated with mining operations) that are likely to be yield affected within the predicted envelope of groundwater depressurisation that will surround the mine pit. Nearest boreholes are located about 2.5 km to the south and are situated in Hunter River alluvium.

Regulatory approvals would be required to strip the alluvial materials within the proposed mining area since these materials are identified as water storage aquifers and mining activity would most likely be regarded as an interference activity with respect to the Water Management Act 2000, and the Hunter Unregulated and Alluvial Water Sources 2009. Licensing would also be required under the Water Act (1912) for groundwater seepage entering the mine pit. These impacts may be offset by relinquishment of existing water/groundwater licences with appropriate approvals.

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1. INTRODUCTION

Coal & Allied is seeking consent to extend mining operations within its existing mining leases at Carrington located in the Upper Hunter region. The proposed extension is known as Carrington West Wing and would provide for the extraction of up to 17 Million tonnes of coal over a period of about six years. Mining would be completed within the existing development consent period, which is currently approved to 2025.

Mining is planned to progress from the western side of the project area, eastward to join the existing Carrington Pit. The West Wing pit is also proposed to extend southward to within 250 m of the Hunter River at its nearest point.

Mining would extract coal from numerous seams including the Vaux, Broonie(s), and Bayswater, to pit floor depths ranging from less than 40 m in the north, to about 75 m in the south-eastern corner of the pit. Stripping of unconsolidated paleochannel alluvium would be required over most of the proposed pit area. Operations in the northern part of the pit would be close to, or below the prevailing water table which has already been affected by prior mining in the West Wing area of Carrington Pit.

Interburden waste rock (spoils) would be emplaced in the pit and in two out of pit emplacement areas to the north of the proposed pit extension area. A barrier wall is proposed to be constructed to the south of the southern pit crest in order to isolate the pit from the Hunter River and its associated alluvium, in a similar manner to the existing approved Carrington Pit.

Mine pit development below the water table will result in continued depressurisation of the exposed coal seams and interburdens. Such depressurisation will induce further change to groundwater flow directions within the coal measures and the overlying undisturbed alluvium. Recovery of the water table within the pit after mining has ceased, will generate a water table that will be different to the pre-mining water table. Long term groundwater quality in mined areas will also change due to the dissolution of minerals contained within the emplaced spoils materials.

Mackie Environmental Research Pty Ltd (MER) was commissioned by Coal & Allied in mid 2009, to undertake groundwater impact assessments addressing the identified issues and to provide advice in respect of future measurement and monitoring of groundwater conditions. The assessments were also designed to comply with the Department of Planning (DoP) Director-General’s Requirements for the project in relation to groundwater, being broadly summarised as:

- a description of the existing environment;
- an assessment of the potential impacts of all stages of the project including the quantity and quality of groundwater taking into consideration any relevant policies, guidelines, plans and statutory provisions;
- a description of the measures that would be implemented to avoid, minimise, mitigate and/or offset the potential impacts, including detailed contingency plans for managing any significant risk to the environment.

This report provides results of impact assessments and includes historical groundwater data for the region and computer based simulations of aquifer systems in order to assess the likely impacts of the proposed pit extension.

2. BACKGROUND

2.1 Existing Carrington Pit

In May 1999, Coal & Allied prepared an Environmental Impact Statement addressing the development of Carrington Pit. The mine plan provided for coal extraction down to and including the Bayswater seam with mining progressing in a southward direction for a distance of about 1.8 kilometres from the sub cropping Bayswater seam in the northern part of the area. MER undertook field investigations and prepared a report examining the impacts on the groundwater and surface water regimes (MER, 1999). Findings supported the presence of essentially two of different types of aquifer systems comprising (1) a moderately permeable alluvium system contained within an ancient paleochannel of the Hunter River, and (2) an underlying relatively impermeable coal measures system. These two systems were found to be hydraulically connected in so far as the deeper coal measures generated upwards seepage of saline groundwater to the alluvium. The alluvium in turn acted as a flow pathway for the saline groundwater to migrate southwards to the Hunter River where a slight increase in river water salinity (at low flows), could be observed downstream of the paleochannel. Rainfall recharge to the paleochannel alluvium was calculated to be negligible due to the widespread occurrence of a thick clay layer.

Mining over an area of about 290 ha required dewatering and pre-stripping of the channel alluvium in such a manner as to induce slow gravity drainage from the unconsolidated silts, sands and clayey gravels. This required construction of several initial dewatering slots in the alluvium which then acted as seepage attractors before stripping commenced. Groundwater seepage from both the alluvium and the coal measures was predicted to occur at an increasing rate during early years of mining, peaking at a little over 2 ML/day by mid 2001 and declining thereafter.

In September 2005, MER conducted a further groundwater assessment for a southerly and north-easterly extension to the mine pit of approximately 145 ha. A review of groundwater drawdowns and pit water seepage rates generated in the course of mining (to 2005), supported the predictions made in 1999 that groundwater levels in the paleochannel alluvium would continue to decline. The prevailing hydraulic gradients within the alluvium to the south of the pit, were observed at that time to be southward in both the eastern and western arms of the paleochannel with saline groundwater contained within the alluvium, continuing to migrate towards and into the Hunter River. A reversal of this gradient as a result of mining, was predicted for the eastern channel by about 2007 after which time, leakage would be induced from the Hunter River into the alluvium and ultimately into the mine pit. Change to the hydraulic grade in the western and less disturbed channel was expected to be slower.

MER also reported that leakage from the river to the mine pit via the alluvium, could be mitigated by installation of impermeable barrier walls across the paleochannel. Such walls would also inhibit long term leakage of leachate from the emplaced waste rocks within the mine void, southward into the undisturbed alluvium and the Hunter River. Computer model simulations of barrier walls in the east and west channels indicated a need to key into the underlying consolidated and relatively impermeable coal measures strata and to construct the walls to an elevation of 65 m above Australian Height Datum (mAHD). Groundwater levels to the south of the walls between the mine pit and the Hunter River would then rise in response to rainfall recharge over time, and a weak southward hydraulic gradient would be re-established towards the river. Coal & Allied are currently constructing a barrier wall in the eastern channel.

Proposed closure design for Carrington Pit incorporated a final void evaporative sink. The sink has been designed to facilitate evaporative losses at a rate which is greater than the accumulation of groundwater within the pit shell, and rainfall runoff and infiltration through the rehabilitated final landform. As a result, groundwater levels within the shell are predicted to remain below the barrier wall(s) thereby inhibiting leakage of contained groundwaters, back to the Hunter River in the long term.

2.2 Proposed West Wing extension mine plan

The proposed West Wing extension pit outline is identified on Figures 1 and 2. The area is flat lying with land surface elevations ranging from about 100 mAHD on the western end wall, to about 70 mAHD over most of the floodplain area. The Hunter River is about 250m south of the proposed pit crest at its nearest point and for a distance of about 500m along the pit crest. The river water level in this same area is between 60 and 59 mAHD.

Mining in the West Wing extension would commence at the western extremity and progress eastwards to join the existing Carrington Pit. This will add approximately 135 ha to the Carrington Pit shell resulting in a combined pit shell area of about 570 ha.

The same fundamental design criteria have been adopted for the proposed West Wing extension as have been employed for the Carrington project. That is, the pit will need to be isolated from the Hunter River alluvium by construction of a barrier wall across the western arm of the paleochannel, and the proposed evaporative sink will need to be expanded to accommodate a changed long term water budget. The 2005 MER study previously identified and assessed a barrier across the western arm of the channel.

2.3 Geology

Regional geology is summarised on the published 1:100,000 Hunter Coalfield Regional Geology Map 1993 (Dept. Mineral Resources) and described by Beckett (1988). Fundamentally the geology in the West Wing extension comprises Permian coal measures that host the ancient paleochannel.

The target seams for the project are the same as those found in Carrington Pit and include from top down, the Vaux, Broonie(s) and Bayswater seams. Figure 3 provides a general summary of the coal seams illustrating their stratigraphic location. The Bayswater seam is well developed regionally and is mostly dull. The remaining seams (and splits) are classed as dull and bright. Cleating is often variable in all seams but more common in the bright coals; face and butt cleats are generally evident in core samples. Between the seams, the interburden comprises well cemented sandstones and siltstones, often laminated, with relatively low to negligible intergranular permeability and relatively uniform mineralogy.

The strata dip at a shallow angle of 2^o to 5^o to the south-east. Structure contours for the floor of the Bayswater seam are shown on Figure 4 to illustrate the general trend of bedding.

Figure 5 provides a south-north generalised section through the existing Carrington Pit area near the eastern boundary of the West Wing project area (see Figure 2 for section location) to illustrate the dip of the strata.

2.3.1 Paleochannel alluvium

The paleochannel geometry has been progressively defined from exploration drilling and piezometer installations during the period of mining at Carrington. Recent drilling in the western channel and installation of 12 piezometers identified as 4032P to 4040P and 4052P to 4053P (see Figure B1 for locations), has facilitated an improved understanding of the depth and extent of the paleochannel in the West Wing extension. Figure 6 provides an updated structure contour map for the base of alluvium which includes areas now mined out (areas beneath the Hunter River have been interpolated).

The depositional environment for the unconsolidated paleochannel alluvium was characterised by frequent flooding and as a result, gravels were emplaced contiguously with silts and clays. This process generated a variable but commonly silt bound alluvial matrix which is commonly observed in deeper sediments within the paleochannel.

Hill slope runoff and sheet wash from surrounding hard rock areas also contributed colluvial deposits in the form of localised fans and braids.

The alluvium thickness typically varies from 11 m to a maximum of about 18 m, pinching out around the channel perimeter. The deepest 3 to 6 m comprise fine to coarse gravels and cobbles often contained within a silty-clayey matrix. This zone is overlain by a thick clay bed 2 to 8 m in thickness, which is in turn overlain by relatively thin surficial sands, silts, clays and loams. Occasional clean and clay free sand and gravel braids are noted within the deep clayey gravel matrix but these are rare. Although connectivity cannot be easily mapped, these cleaner zones provide groundwater flow pathways which have in the past provided a conduit for gravity drainage from the adjacent less permeable materials.

Figure 7 provides photos of a typical alluvium profile observed in the existing Carrington Pit. The thick section of clay is clearly evident over much of the section. Uniformity and stiffness are indicated by the presence of shovel tooth marks.

2.3.2 Structural features

There are a number of faults and dykes that have been identified in the area, the most prominent of which include:

- a north-east trending fault zone immediately east of Carrington Pit (Figure 4);
- a southerly trending fault zone located at the western extremity of the proposed West Wing extension;
- a north-east trending dyke through Carrington Pit (now mined out).

Through observations in Carrington Pit and experiences in surrounding mine pits, these features can exhibit modest permeability in some areas and impermeability in other areas. This can sometimes lead to minor compartmentalisation of groundwater movement. When moderately permeable, they may influence pore pressures to some extent.

Jointing has been mapped in a number of areas in adjacent pits, the dominant directions being north-east and north-west which are common throughout the Upper Hunter region. They are more readily mapped on highwall faces and benches where loss of confinement (de-stressing) also leads to more freely draining conditions when compared to unexposed areas further behind the highwall and at depth.

2.4 Registered bores and wells

The NSW Office of Water (NOW) retains a database of registered bores and wells in NSW. This database includes exploration/test wells which may not have been completed as permanent structures, observation/monitoring bores, and privately owned bores and wells currently in use or abandoned.

A database search indicates there are no privately owned bores (other than Coal & Allied boreholes) in the project area or within a few kilometres of the area. Nearest privately owned bores or wells that are not mining related, are located 2.5 and 3 km to the south of the project area. These are apparently constructed within the Hunter River alluvium to depths of 9 to 13 m.

2.5 Rainfall and evaporation

The prevailing climate for the area is temperate and is influenced to some extent by coastal weather patterns. Rainfall averages about 640 mm per annum as measured at Jerrys Plains which is the nearest continuous long term rain gauging station located some 4 km to the west of the project area. Calculated rainfall statistics for Jerrys Plains are provided in Appendix A.

A number of periods during the last decade have witnessed below average annual rainfalls with moderately dry years occurring from 1994 to 1997 and exceptionally dry conditions occurring from 2002 to mid 2007. The pattern of rainfall during these years was not conducive to groundwater recharge and resulted in regional water table declines. However since June 2007, rainfall frequency has increased and as a result many mine pits in the region now have surplus water.

The nearest long term evaporation gauging station is located at Scone where an average of about 1600 mm per annum (Pan loss) has been recorded. A review of the historical record indicates evaporation exceeds rainfall for all months of the year, the smallest difference occurring in June where average rainfall is almost equal to the average evaporation. Hence there is increased potential for recharge during winter months. However this generally depends on the pattern of rainfall events.

2.6 Surface drainage and groundwater recharge

The West Wing extension is characterised mostly by the alluvial floodplain environment at surface. Present drainage is via an unnamed minor creek channel that transgresses the proposed project area and discharges to the Hunter River.

Rainfall infiltration and recharge to the shallow alluvium has historically been very limited over much of the defined paleochannel area due to the widespread occurrence of a thick and impermeable clay layer. Limited recharge is believed to have contributed to the very shallow hydraulic gradients and poor groundwater qualities (high salinities) observed prior to mining in the Carrington area. However, alluvial deposits nearer the river appear to support higher rates of rainfall recharge suggesting an increase in permeability of the shallower unconsolidated materials.

Beyond the paleochannel, rainfall recharge to the regolith and underlying coal measures is calculated to be very low based upon the observed water table and the measured permeabilities of the rock strata regionally. Low recharge rates are also evident from inspections of open cut highwalls prior to and following rainfall events where minor seepage is generally evident in the shallower strata and commonly associated with fractures, joints and bedding planes that are de-stressed at the highwall face.

3. GROUNDWATER HYDROLOGY

3.1 Aquifer systems

The Upper Hunter Region hosts three recognised types of aquifer-aquitard systems – the coal measures, the shallow weathered rock zone including the regolith, and the alluvial deposits adjacent to major drainages (Mackie 2009). These systems tend to act in an integrated way in some areas while in other areas they may act in isolation.

The main systems that have been previously identified around the project area include:

- ***the alluvial lands primarily associated with the Hunter River*** where porosity and permeability are sometimes sufficiently developed to warrant exploitation for stock and domestic water supplies from bores and wells. The paleochannel system while comprised of alluvium, differs from the Hunter River alluvium encountered in the alluvial areas immediately to the south and east of Carrington in so far as they are either stiff clays, or silty-clayey sand and gravel zones exhibiting variable and often low permeability. Water quality in the paleochannel has historically been saline with localised freshening towards the river;

- ***the coal measures*** with groundwater storage primarily in coal cleats, or in matrix porosity in non coal strata. The seams tend to be the main seepage zones in exposed highwalls. These aquifers are generally constrained above and below by interburden aquitards or aquicludes (sandstones, siltstones and claystones). Occasional secondary storage may also be developed within interburden fractures. Groundwater quality is generally brackish to saline;
- ***parts of the weathered shallow coal measures*** as intergranular storage or shallow de-stressed joints and fractures that are generally less evident in deeper unweathered coal measures. The weathered areas can sometimes support springs following periods of high rainfall but these features are depleted during extended dry and drought periods. Water quality in this system, while not measured directly, is typically variable from fresh to saline.

The weathered shallower bedrock systems are not present within the project area but are noted in surrounding areas beyond the floodplain environment.

Water tables and groundwater pressures in the coal measures are sustained by rainfall percolation to sub cropping strata at a generally low rate with estimates of rainfall recharge varying from almost zero to no more than 1 per cent of annual rainfall based upon previous studies in the Upper Hunter region. Water tables in the regolith and shallow weathered rock zone while not monitored, are infrequent and mainly observed only after lengthy wet periods.

The target coal seams subcrop in or close to the project area but all are progressively confined in areas to the south where they dip below the Hunter River. This increasing ‘wedge’ of rock undoubtedly provides a measure of isolation between depressurised strata at depth, and the Hunter River. Groundwater encountered within a particular seam during drilling in these areas, rises above the seam thereby indicating sub-artesian pressures and confinement. Confinement is also indicated by monitoring at a number of piezometers located in the different seams. In addition, an exploration borehole exhibited surface artesian flow prior to mining in the Carrington area - the borehole has since been mined through.

3.2 Piezometric surface within the alluvium – pre-mining and current

Since 1998, there have been numerous piezometer installation campaigns. In all, some 77 monitoring locations have been constructed throughout the paleochannel but many piezometers have now been removed with the southward advancement of mining in Carrington Pit. Monitoring of water levels and basic water quality parameters (pH and EC) has been maintained to the present time. Appendix B provides piezometer locations, hydrographs and water quality data for both the existing and destroyed locations.

Pre-mining groundwater hydraulic gradients measured within the paleochannel in 1999 were noted to support a weak flow from north to south towards the Hunter River (MER, 1999) with a change in height of approximately 3 m over 3 km. The approximate geometry of that pre mining flow regime is represented by the potentiometric surface plotted on Figure 8.

The water table as at December 2009 is represented by the contours shown on Figure 9. These contours indicate northwards hydraulic gradients from the river to the mine pit within the undisturbed areas of alluvium in both the eastern and western channels. The observed trends are generally consistent with predicted aquifer modelling in 2007 (MER, 2007). However the measured groundwater levels in the eastern channel near the river are higher than model predicted levels by between 0.5 to 1.5 m (see Appendix B plots CGW52A, CGW53A, CGW54A, CGW55A). This may be due to significant rainfall recharge in June 2007 and subsequent events which have slowed the river leakage rate, or it may be due to alluvium permeabilities being lower than originally thought.

3.3 Paleochannel alluvium saturation

The saturated thickness of the undisturbed alluvium in the paleochannel has been estimated by subtracting the channel floor (Figure 6) from the current piezometric surface (Figure 9). Results are provided on Figure 10 which indicates the possibility of desaturation in the western channel near the highwall of the rehabilitated West Wing pit about 1.1 km north of the river. Saturation is calculated to be between 2.5 and 3.0 m along the southern limit of the proposed pit extension area.

The eastern channel is expected to be desaturated along the line of the southern pit crest but increased saturation (rising groundwater levels) will occur following completion of the eastern channel barrier wall.

3.4 Hydraulic properties distribution within the alluvium

The permeability (hydraulic conductivity) distribution within the paleochannel alluvium has been assessed over a period of 10 years by undertaking hydraulic testing at piezometer locations, and subsequently using computer based numerical modelling to develop candidate areas of higher or lower conductivity in accordance with observed impacts of mining on the drainage of the alluvium. Most recently, falling head tests have been conducted at 9 recently installed piezometer locations in the proposed West Wing pit extension area (see Appendix C).

A probable pre-mining permeability distribution is provided in Appendix D (Figure D2) and is the result of five significant model re-calibrations undertaken in 2002, 2004, 2005, 2007 and 2010 using field measurements as a guide. The distribution continues to support the presence before mining, of preferred drainage pathways within the paleochannel. The estimated permeability range is from 2 to 100 m/day with the western channel. Drainable porosity of this system is moderate and reconciled at about 5 per cent from current numerical model calibration.

3.5 Hydraulic properties of the coal measures

Hydraulic properties of different coal measures strata have been assessed from an extensive regional database held by MER and more recently from core testing undertaken at ‘type’ hole 4036C located near the southern boundary of the proposed pit extension area. (see Figure B1 for borehole location). Core testing provides estimates of matrix conductivity and facilitates the derivation of consolidated conductivity distributions for all geologically logged non coal strata. All core tests within and beyond the project area have indicated low permeability values consistent with reported values elsewhere throughout the Upper Hunter region (Mackie, 2009). Appendix C provides a detailed summary of test results while Table 1 provides an indicative range of hydraulic properties for hardrock strata within and beyond the project area.

Table 1: Indicative range in matrix hydraulic properties

Lithology	Kxy range (m/day)	Bulk porosity %	Effective porosity %
Permian sandstones	5.0E-06 – 5.0E-04	1 - 18	.01 - 5
Permian siltstones	5.0E-07 – 1.0E-04	1 - 15	.01 – 1
Permian claystones and shales	5.0E-08 – 1.3E-06	1 - 15	.01 - .1
coal seams – dull	1.0E-04 – 1.0E-01	0.1 - 2	0.1 - 2
coal seams – dull and bright	1.0E-03 – 1.0E-01	0.1 - 3	0.1 - 3

Kxy = horizontal hydraulic conductivity

3.6 Regional water quality

Regional groundwater quality is routinely monitored in the vicinity of the project area for basic parameters pH and EC. Historically, the salinity of the paleochannel alluvium has been elevated (typically >8000 uS/cm) with some freshening evident in areas close to the river where the effects of rainfall recharge are more pronounced. Appendix B provides a summary of historical monitoring while Figure B4 illustrates the generally saline nature of groundwaters contained within the channel alluvium – even in areas quite close to the Hunter River. Figure B5 provides a current (2009-2010) summary of conductivities measured at remaining piezometer locations and at recently installed locations in the proposed pit extension area. Groundwater in the western channel alluvium is moderately saline with a measured electrical conductivity (EC) range from 2000 to more than 8500 uS/cm (median 3650 uS/cm). Eastern channel salinity ranges from 2000 to 12000 uS/cm (median 6550 uS/cm). Parameter pH typically ranges from about 6.8 to 8.5 pH units.

A summary of speciated water quality data is also provided in Appendix B for the annual sampling period 2008-2009. This data is represented on a Piper tri-linear speciation plot in Figure 11 (upper plot). The plot comprises two triangular fields representing cations and anions, and a central diamond field. Individual samples are represented as percentage milli-equivalents within the lower triangular fields where each apex represents 100 per cent of the nominated ion. Plotted positions within the triangular fields have been projected into the central diamond field thereby facilitating a generalised classing of groundwaters and examination of possible mixing trends. Also represented on Figure 11 are historical data for Carrington Pit to illustrate the common characterisation.

Plotted data for the alluvium support a water quality which is dominated by primary salinity as is typical of the region generally. Paleochannel groundwaters are characterised by Na>Mg>>Ca and $Cl>HCO_3>SO_4$.

4. MINING INDUCED CHANGES TO GROUNDWATER SYSTEMS

4.1 Groundwater flow modelling

Proposed mining will require stripping/removal of alluvium within the proposed pit extension area prior to mining of the Permian coal measures. Coal & Allied propose to isolate this alluvium from the alluvial lands beyond the project area, by construction of a barrier wall across the western arm of the channel. Mining will then be undertaken to the floor of the Bayswater seam north of the barrier wall.

The mining process will induce further depressurisation of rock strata in the area. The extent to which such depressurisation will become more regionalised, depends upon a number of factors including aquifer hydraulic properties, variation in stratigraphy, structural features including dykes and faults, recharge sources and the pore pressure reductions that have already been induced by surrounding operations. The spatial distribution and interaction of these various components cannot be evaluated using simple mathematical (analytical) expressions. Rather, computer based numerical modelling is commonly employed which permits the introduction of spatial and temporal variability.

Historically, two models have been utilised for impact assessments and re-evaluations for the existing Carrington Pit:

1. a single layer model representing the paleochannel and Hunter River alluvium – used to assess pit seepage rates and leakage from the river, and
2. a three layer model representing the coal measures and the alluvium.

Both models have been consolidated into a new seven layer model as part of the current study. Total modelled area is 110 sq. km with individual cell areas varying from 0.0625 ha (25 m x 25 m) to 0.25 ha (50 m x 50 m). Cells have been designed to give increased detail to the existing and proposed pits, drainage lines and the alluvial aquifers associated with the Hunter River.

Hunter Valley Operations at North Pit (see Figures 1 &2) have been included and are assumed to be generally dewatered in order to generate a likely 'worst' case for regional strata depressurisation. Hunter Valley West Pit operations located 3 km north of the proposed West Wing extension, are considered to have generated limited depressurisation of coal measures strata in the project area and have not been included in the models. Appendix D provides an expanded description of the groundwater models including calibration.

4.2 West Wing groundwater flow predictions

Following installation of a barrier wall, mining in the West Wing extension is proposed to commence in the western part of the project area and to progress eastwards to the existing Carrington Pit over a period of approximately six years. This process has been simulated in the groundwater model by removal of the alluvium about 12 months in advance of hardrock mining using appropriate model boundary conditions.

Figure 12 illustrates the water table at the completion of mining where abrupt changes in elevations are evident along the barrier wall constructed across the western and eastern channels. Seep gradients are also evident in the hardrock zone between the two barriers and along the eastern perimeter of Carrington Pit where the deeper mining of the Bayswater seam abuts shallower and older operations (down to the Vaux seam) in the adjacent Hunter Valley Operations North Pit. South of the barrier, the water table is unaffected and is equilibrated to river levels. Appendix D, Figures D5 to D8 illustrate the progressive impacts of mining at 2 yearly intervals.

Figure 13 shows the piezometric elevations in the Bayswater seam at the completion of mining where a minimum elevation of about –20 mAHD is evident in the south eastern corner of Carrington. Depressurisation impacts extend southwards beneath the Hunter River inducing flows from the coal seam and overlying strata, ultimately as leakage from the alluvium, towards the pit.

Estimates of dry weather pit seepage (mine water sourced entirely from groundwater seepage for the assumed long term climatic conditions) have been made by examining cell flow budgets throughout the model and developing a volumetric balance. Model results indicate a steady increase in mine water as a result of dewatering and stripping of the alluvium north of the barrier wall, from an initial rate of less than 0.01 ML/day in year 1 to about 0.04 ML/day in year 4 (Table 2). Hardrock seepage into the mine pit is predicted to increase from an initial rate of about <0.01 ML/day to a final rate of 0.073 ML/day.

Table 2: Model predicted total dry weather seepage rates to the mine pit

Approx year	Alluvium (ML/day)	Hardrock (ML/day)	Total seepage (ML/day)
1	<0.010	<0.010	<0.01
2	0.030	0.052	0.082
3	0.039	0.077	0.116
4	0.005	0.085	0.090
5	0.001	0.083	0.084
6	0.000	0.073	0.073

The relatively low seepage rates are attributed to the strata depressurisation already evident around Carrington Pit ie. mining progresses from west to east towards the already dewatered strata in that pit. It is noted that the hardrock seepage rates represent complete drainage of the mined strata based on porous media flow. In reality, blast fragmentation and handling-dumping of the waste rock which has very low effective porosity, will result in a large component of evaporative loss. Actual contributions to the mine water system are therefore likely to be lower than predicted. However, rainfall recharge through emplaced spoils may contribute an additional 0.25 ML/day to pit seepage.

4.3 Leakage budgets and baseflow changes to the Hunter River

Pre-mining dry weather (saline) baseflow contributions from the paleochannel alluvium to the Hunter River are calculated to have been 0.17 ML/day and 0.22 ML/day for the eastern and western arms of the paleochannel respectively. Currently (January 2010), the prevailing piezometric surfaces within the paleochannel alluvium support northwards flows in both the eastern and western channels towards the existing mine pits (see Figure 9). Flow rates in the alluvium are estimated to be of the order of 0.1 ML/day in the eastern channel and 0.2 ML/day in the western channel at the present time (no barriers). These flows occur predominantly within the alluvium, and are supported by supplementary rainfall recharge, and a small component from the Hunter River as leakage losses via the bed and bank.

Installation of the barrier walls will arrest all northwards leakage through the alluvium. However sustained leakage will occur via the coal measures where deep regional depressurisation induces downwards flow from the alluvial lands over a wide area (see Figure 13 for seam depressurisation). The contributions to pit seepage via this pathway are estimated to be about 0.05 ML/day for each arm of the paleochannel.

Impact on the Hunter River has been assessed in terms of baseflow (leakage) losses which are calculated to be approximately 0.05 ML/day for the river reaches adjacent to each arm. Figure 14 provides flow duration relationships for Hunter River gauging stations located at Liddell (upstream of Carrington), and Bayswater at the confluence with Bayswater Creek (downstream of Carrington). These plots indicate a 90 percent exceedance flow is about 90 ML/day while a 99 percent exceedance flow is in the range 15 to 20 ML/day. A future base flow loss of 0.05 ML/day for the West Wing extension is calculated to represent about 0.3 percent of the 99 percentile low river flow. This loss will reduce as water table recovery occcurs within the final void.

Substantial wet periods like the June 2007 event (high rainfall and localised flooding), can be expected to mitigate leakage losses for extended periods of time.

4.4 Mine pit seepage quality

The quality of groundwater entering the mine pit is expected to reflect an average of water quality for the alluvium and coal measures generally. Based on current monitoring, the quality is expected to be in the range 2000 to 8000 μS/cm with a likely average value of about 4000 μS/cm (2600 mg/L) determined from coal measures water samples. Ionic speciation is expected to be variable with primary salinity (as NaCl) dominating, and some increase in bicarbonates due to spoils interaction along preferential flow pathways in and at the base of spoils.

All seeped water would remain within the mine water management system.

4.5 Final void water levels

Spoils emplaced within the pit shell will exhibit significantly different hydraulic properties to the intact coal measures. They are more permeable and porous due to their fragmentation. While the spoils materials are normally reshaped and rehabilitated, they permit rainfall to infiltrate and percolate downwards to the floor of the pit shell. Post mining this water will steadily rise within the final pit shell and unless controlled, would eventually be expected to fill and spill from the pit shell. In order to inhibit spillage, a final void was incorporated in the Carrington pit closure preliminary design (MER, 2005). This void area has been expanded to between 85 and 100 ha (depending on long term water table elevation) to accommodate the West Wing extension pit shell.

The size of the void has been tested using steady state numerical modelling. For this model, a permeability of 1 m/day has been adopted (1 to 20 m/day expected range) together with a drainable porosity of 20 per cent for the emplaced spoils in the final pit shell. In addition, rainfall recharge contributions via infiltration into the spoil and percolation have been applied at rate of 32 mm/year (approximately 5 per cent of annual rainfall) based on soil moisture modelling of 110 years of daily rainfall records for Jerrys Plains (Mackie 2009).

After more than 50 years of recovery, the long term open void water level is designed to stabilise at about 40 mAHD with groundwater flow through the spoil to the open void. This elevation is about 25 m below a system 'spill' elevation at the top of the barrier walls of 65 mAHD. It is also about 20 m below the median water level in the Hunter River. At this stabilised level the average net contributions to the pit from rainfall, runoff and infiltration, are adequately balanced by evaporative losses from the open water void. Figure 15 illustrates the predicted steady state water table within spoils and the flow paths that are likely to prevail towards the evaporative sink.

4.6 Final void groundwater quality

The hydrochemistry of recovering groundwater within the voids will reflect contributions from coal measures seepage, contributions from spoils seepage and contributions from rainfall runoff entering the voids. Estimates of the overall total dissolved solids and ionic speciation characteristics of void water resulting from dissolution of minerals contained within the fragmented interburden rocks, have been made using hydrochemical reaction path modelling. Mineralogical (XRD) analyses of interburden core have been obtained from exploration hole 4036C located in the project area.

Appendix E provides a summary of the mineralogies. The rock samples are typically dominated by quartz and the clay minerals including kaolinite, mixed layer illite-smectite and illite with variable carbonate minerals. Two basic mineralogies are evident with the main difference being the presence (or absence) of certain carbonate minerals including siderite, ankerite, dolomite and calcite. Reaction pathways have therefore been modelled for the presence of varying carbonate minerals. Ion exchange has also been included in a generalised way since this process could lead to the generation of $NaHCO_3$ groundwaters frequently observed throughout the region. While not identified in XRD analyses, small amounts of halite and gypsum have both been added to the modelling process to provide sources of Cl and S which are commonly reported in groundwater samples. It is also possible that pyrite may provide S. The resultant modelled water quality is characterised by Na,Ca>>Mg depending on exchange capacity, and SO_4,Cl>>HCO_3. The pH was found to fall to a longer term range of 8.0 to 9.0 while TDS rises above 1300 mg/l depending upon mineral availability and type.

Model results have been compared with reported leachate trials conducted for Carrington Pit (MER, 1999), West Pit (MER, 2003) and for coarse rejects from the washery. Leachate trial results differ from reaction path model outcomes with an increased Mg presence. A part of the reason for this may be attributed to the geochemical database underpinning the modelling.

The long term void water quality is considered most likely to exhibit a pH range from 7.5 to 9.5, a TDS range from 1000 mg/L increasing to about 3000-4000 mg/L in the long term with a speciated signature Na>Mg>Ca and HCO_3>Cl >SO_4 if rejects are not emplaced. If they are then SO_4 may become more dominant. This characterisation is similar to the regional groundwater quality observed in the coal measures. It differs from the pre-mining paleochannel groundwater quality in so far as bicarbonate is more dominant than chloride – the void water is less saline.

5. POTENTIAL ENVIRONMENTAL IMPACTS

Proposed mining of the West Wing extended pit has the potential to change the local groundwater systems. The proposed development has the following identified or potential impacts:

- aquifer stripping, strata depressurisation and impacts on the Hunter River;
- loss of yield from water supply bores and wells;
- groundwater dependent ecosystems
- change in groundwater quality in coal measures;
- salinisation in the final void following cessation of mining.

5.1 Aquifer stripping, strata depressurisation and impacts on the Hunter River

The proposed mining will require the removal of alluvium between the current West Wing pit and the southern boundary of the West Wing extended pit. Saturation within the alluvium currently varies from zero at the northern boundary of the project area to about 3.0 m along the southern boundary where a barrier wall is proposed. The groundwater salinity varies from 2000 to 8500 uS/cm (median 3650 uS/cm) and is considered to have little beneficial use. Installation of a barrier wall across the paleochannel would isolate these groundwaters from the Hunter River system thereby inhibiting future flows of saline groundwaters from reaching the river.

Mining would induce further reductions in piezometric heads throughout the coal measures. These reductions will extend southwards beneath the Hunter River and will be enhanced by surrounding mining operations – particularly Carrington. Reduced piezometric heads (in the coal measures) will induce leakage from overlying alluvium at a rate governed by the vertical permeability of the coal measures. Since the vertical permeability is low, the leakage rate is predicted to be low. The calculated impact on the baseflow of the Hunter River is a (leakage) loss of 0.05 ML/day for the relevant reach of the Hunter River adjacent to the western arm of the paleochannel, mostly via hardrock strata. The loss is calculated at about 0.3 percent of the very low river flow condition defined as occurring less than 1 percent of the time.

The leakage loss from the Hunter River would prevail after cessation of mining but would reduce steadily as groundwater levels recover within the West Wing-Carrington Pit shell. Recovery and equilibration to the evaporative sink, is expected to take more than 50 years assuming average rainfall conditions.

5.2 Loss of yield from water supply bores and wells

There are no identified private boreholes within 2.5 km of the pit crest that would be impacted in a measurable way. Nearest boreholes are located more than 2.5 km to the south and are constructed in shallow river alluvium. The alluvium would not be impacted by the proposed mining operations.

5.3 Groundwater dependent ecosystems

The only identified groundwater dependent ecosystem in proximity to the proposed pit, is the river red gum and billabong area immediately south of Carrington Pit. There would be no impact on the groundwater water levels within the alluvium hosting this ecosystem.

5.4 Change in groundwater quality

Groundwater within the coal measures and the overlying alluvium is dominated by primary salinity as is typical of the region where salinity levels are observed to exhibit an average TDS of about 4000 mg/L in the coal measures and historically about 5500 mg/L in the alluvium. Waters are characterised by Na>Mg>Ca and Cl>SO_4>HCO_3.

Proposed mining is not expected to contribute to changes in groundwater quality although periods of high rainfall may lead to a reduction in mine water salinity through shallow flushing.

5.5 Salinisation in the final voids

An open pit (free standing water) void is proposed on completion of mining. The current closure plan incorporates a void located in the eastern part of the West Wing – Carrington Pit shell. This void will eventually create an evaporative sink which will induce flows from within the overall pit shell, to the void and thereby inhibiting a sustained rise in groundwater elevations which would otherwise lead to subsurface over topping of the barrier wall and leakage back to the river. The void water is predicted to exhibit a salinity in the very long term (+50 years) of the order of 3000 to 4000mg/l.

Since the pit shell and evaporative sink will be isolated from the Hunter River and the adjacent alluvium, it is improbable that water qualities beyond the final pit shell will be measurably affected.

6. WATER SHARING PLANS

Water Sharing Plans (WSP) are an integral part of the *Water Management Act 2000*, the objective of which is the sustainable and integrated management of NSW water resources. The WSP's support the long-term health of rivers and aquifers by making water available specifically for the environment. This is achieved through the establishment of rules for sharing water between the environment and water users. Two WSP's are relevant to the project area:

The Hunter Regulated River Water Source 2003 which took effect from 1st July 2004. Waters which apply to this water source include the surface waters between the banks of the Hunter River (and Glennies Ck) and the alluvial aquifer materials immediately underlying these surface waters.

The Hunter Unregulated and Alluvial Water Sources 2009 which took effect from 1st August 2009. Relevant waters which apply to this water source include the alluvial aquifer materials extending from those prescribed above, to the boundary of these materials (basically any and all hydraulically connected alluvium).

Groundwater issues arising from the proposed mining operations affect the operation of the water sharing plans in so far as any interference/removal of aquifer materials would need appropriate Government approvals.

7. LICENSING REQUIREMENTS

Licensing in respect of groundwater seepage into mining operations will be required under Part 5 of the Water Act (1912). An estimate of dry weather seepage from the alluvium (to be stripped) and the coal measures has been made through the use of computer based numerical modelling. Estimates are an average 0.04ML/day (15ML per annum) from the alluvium during stripping, and 0.07 ML/day (26 ML per) from the coal measures giving a total of 0.11 ML/day (41 ML/annum).

Post mining seepage via the regional coal measures and largely via leakage from alluvial lands to the south (deep beneath the barrier wall) is about 0.05 ML/day.

8. IMPACT ASSESSMENT CRITERIA

The establishment of impact assessment criteria is an important element of future monitoring of both the groundwater and surface water regimes. The criteria should establish a series of benchmarks against which the impacts can be measured, alert protocols developed and mitigative actions initiated. While these criteria (and impacts) can be relatively easily established for surface waters, they can be more difficult for groundwater as the rate of change in groundwater may occur over distance and time.

8.1 Groundwater assessment criteria and recommended monitoring

Potential impacts in respect of groundwater relate to two key areas:

- physical depressurisation and removal of the alluvium and coal measures and potential indirect impacts on the Hunter River and the alluvial systems, and
- changes to groundwater hydrochemistry induced by regional depressurisation.

Depressurisation can be calculated by regular measurement of prevailing groundwater levels in the rock strata and comparing these levels with those measured prior to mining impacts. Coal & Allied currently monitors groundwater levels at a number of borehole locations in the alluvial lands and has recently installed pore pressure monitoring in the West Wing extension area. Additional piezometers are proposed in the future.

Further pressure losses will become evident with the onset of mining activities at many of the existing piezometers. Groundwater impact assessment should therefore be based on the measured change in aquifer pore pressures, flows and hydrochemistry.

Recommended future monitoring of piezometric levels should include:

- two-monthly monitoring of water levels in any new standpipe piezometers in proximity to the West Wing extension (quarterly monitoring elsewhere unless water level changes dictate a more frequent monitoring);
- daily or more frequent monitoring of pore pressures by installed auto recorders at existing locations in order to discriminate between oscillatory pore pressure changes attributed to rainfall recharge, and longer term pressure losses related to mining;
- construction of additional piezometers where deemed necessary as information is generated from within the existing network. Permeability testing should be completed on new standpipe piezometers in order to facilitate estimation of strata leakage and subsurface flows, and
- construction of piezometers in rehabilitated spoils following pit closure. The purpose of these piezometers would be the monitoring of void/spoils water level recovery and water quality post mining in areas more distant from the open void. Number and locations can be finalised when the pit closure plan is formalised.

Continued groundwater quality monitoring should include:

- two-monthly or quarterly monitoring (depending upon location) of basic water quality parameters pH and EC in existing and any new piezometers;
- six monthly measurement of total dissolved solids (TDS) and speciation of water samples in piezometers. Speciation should include major ions Ca, Mg, Na, K, CO_3, HCO_3, Cl, SO_4 (or S) and elements/metals including Al, As, B, Ba, Fe (soluble), Li, Mn, P, Pb, Se, Si, Sr, Zn.

Future impact analyses should include:

- an assessment of departures from identified monitoring or predicted data trends. If consecutive data over a period of six months (minimum of three consecutive readings) exhibit an increasing divergence in a negative impact sense from the previous data or from the established or predicted trend then such departures should initiate further action. This could include a need to conduct more intensive monitoring (including installation of additional piezometers) or to invoke impacts re-assessment and/or remedial actions if causality is attributed to mining operations and is assessed to be detrimental to the environment beyond predicted impacts;
- formal review of depressurisation of coal measures and comparison of responses with aquifer model predictions biennially. Expert review would be undertaken by a suitably qualified hydrogeologist; and
- annual reporting (including all water level and water quality data) to NOW in an agreed format.

In addition to the above and as part of overall Coal & Allied environmental monitoring and management systems, the monitoring programme should be subject to review.

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IMPORTANT INFORMATION ABOUT YOUR HYDROLOGICAL REPORT

Mackie Environmental Research (MER) has applied skills and standards appropriate for a Chartered Professional (AusIMM) in the preparation of this report, the content of which is governed by the scope of the study and the database utilised in generating outcomes.

In respect of the database, historical data is often obtained from different sources including clients of MER, Government data repositories, public domain reports and various scientific and engineering journals. While these sources are generally acknowledged within the report, the overall accuracy of such data can vary. MER conducts certain checks and balances and employs advanced data processing techniques to establish broad data integrity where uncertainty is suspected. However the application of these techniques does not negate the possibility that errors contained in data sourced external to MER, may be carried through the analytical process. MER does not accept responsibility for such errors.

It is also important to note that in the earth sciences more so than most other sciences, conclusions are drawn from analyses that are based upon limited sampling and testing which can include drilling of exploration and test boreholes, flow monitoring, water quality sampling or many other types of data gathering. While conditions may be established at discrete locations, there is no guarantee that these conditions prevail over a wider area. Indeed it is not uncommon for some measured geo-hydrological properties to vary by orders of magnitude over relatively short distances. In order to utilize discrete data and render an opinion about the overall surface or subsurface conditions, it is necessary to apply certain statistical measures and other analytical tools that support scientific inference. Since these methods often require some simplification of the systems being studied, results should be viewed accordingly. Importantly, predictions made may exhibit increasing uncertainty with longer prediction intervals. Verification therefore becomes an important post analytical procedure and is strongly recommended by MER.

This report, including the data, graphs and drawings generated by MER, and the findings and conclusions contained herein remain the intellectual property of MER. A license to use the report is granted to Coal & Allied and Environmental Management Group Australia. The report should not be used for any other purpose than that which it was intended and should not be reproduced, except in full. MER also grants Coal & Allied a licence to access, use and modify the data files supporting the groundwater model described in this report. Coal & Allied must not permit any third party to use or modify these data files without obtaining the prior written consent of MER.

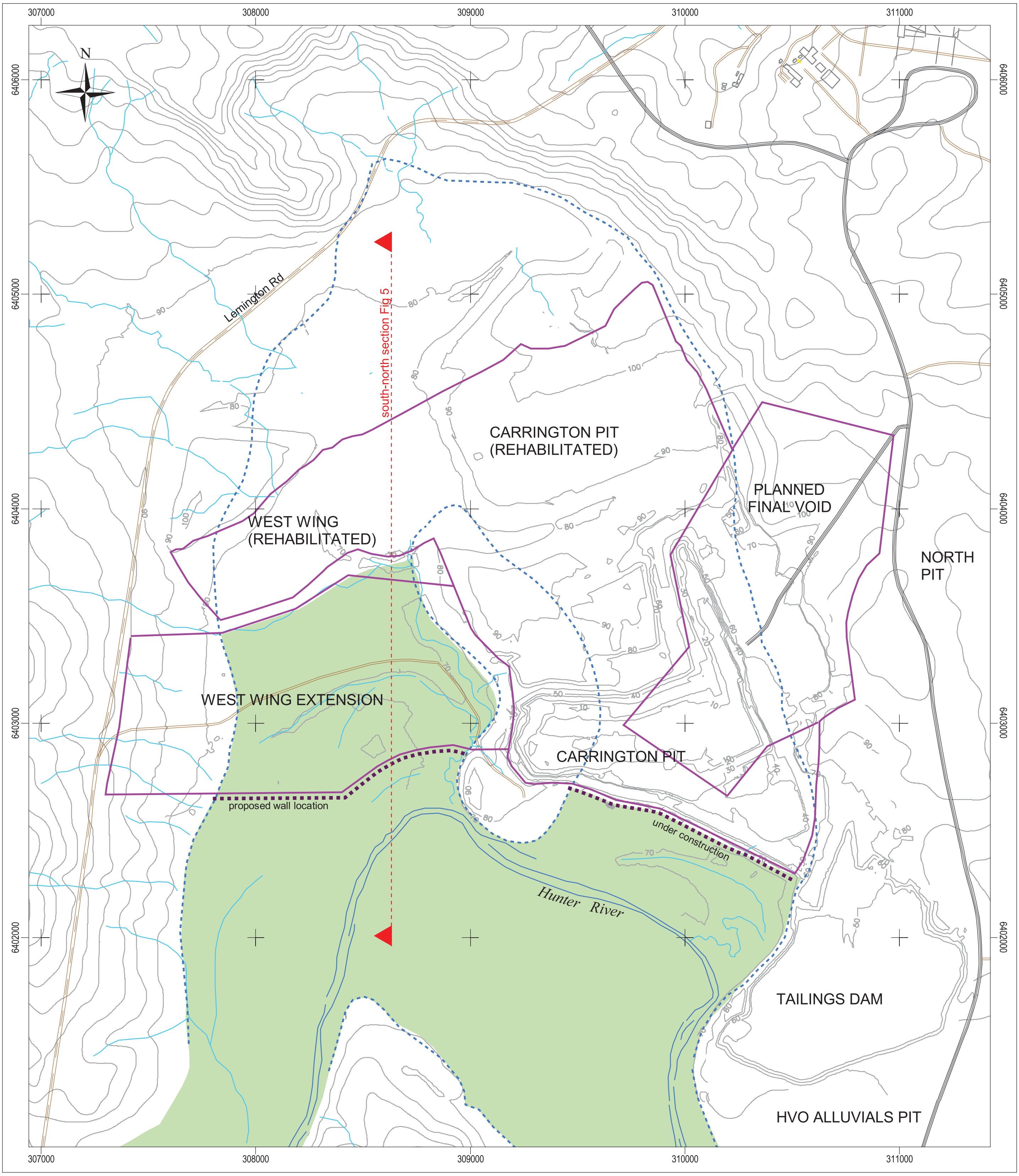
Dr. C. Mackie
CP. (Env)

CARRINGTON WEST WING EXTENSION GROUNDWATER STUDY

Carrington mine and paleochannel extents

Mackie Environmental Research

Figure 1



0 0.5 1 1.5 Kilometres

- alluvium
- current and proposed pit crests
- haul roads
- approximate paleochannel extents
- pre-mining topography (10m contour interval)
- proposed barrier wall
- ephemeral drainage
- site road
- main road

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CARRINGTON WEST WING EXTENSION GROUNDWATER STUDY

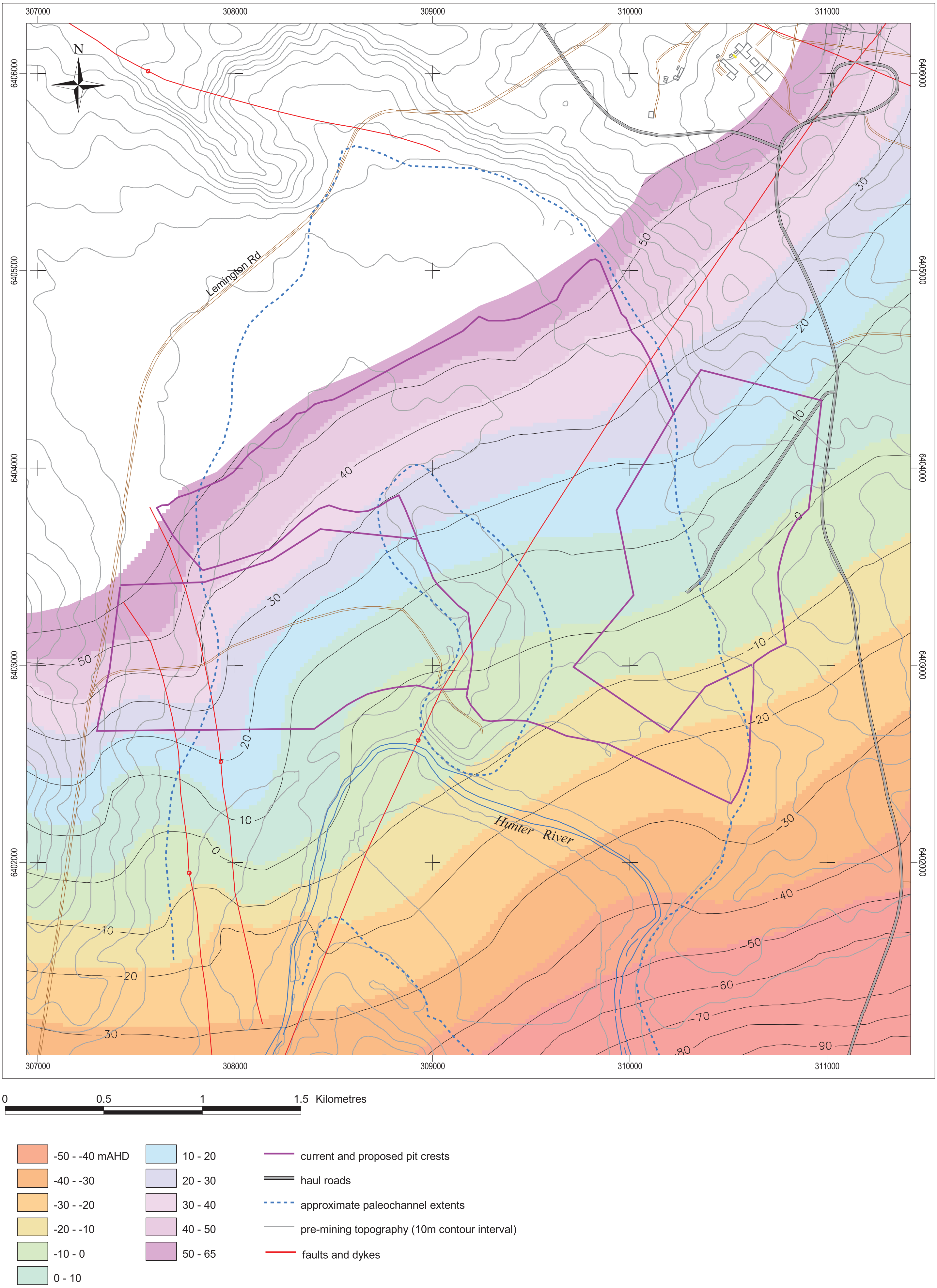
Topography and drainage

Figure 2

STRATIGRAPHY OF THE UPPER HUNTER COAL MEASURES

SINGLETON SUPER GROUP	NEWCASTLE (WOLLOMBI) COAL MEASURES		MOON ISLAND BEACH FORMATION	*VALES POINT SEAM*	UD	limited knowledge
				WALLARAH SEAM	UD	low sulphur, DDB
				GREAT NORTHERN SEAM	UD	low sulphur, DDD
			AWABA TUFF (NALLEEN TUFF)		UD	tuffaceous sandstone
			BOOLAROO FORMATION	*FASSIFERN SEAM*	UD	low sulphur, DDB
				UPPER PILOT SEAM	UD	low sulphur, DB
				MT HUTTON TUFF	UD	tuffaceous sandstone
				LOWER PILOT SEAM	UD	limited knowledge
				HARTLEY HILL SEAM	UD	limited knowledge
			WARNERS BAY TUFF		UD	tuffaceous sandstone
			ADAMSTOWN FORMATION	*AUSTRALASIAN SEAM*	UD	limited knowledge
				STOCKRINGTON TUFF	UD	limited knowledge
				MONTROSE SEAM	UD	limited knowledge
				WAVE HILL SEAM	UD	limited knowledge
				EDGEWORTH TUFF	UD	tuffaceous sandstone
				FERN VALLEY SEAM	UD	limited knowledge
				VICTORIA TUNNEL SEAM	UD	limited knowledge
			NOBBYS TUFF (MONKEY PLACE CREEK TUFF)		UD	tuffaceous sandstone
			LAMBTON FORMATION	NOBBYS SEAM	UD	limited knowledge
				DUDLEY SEAM	UD	limited knowledge
				YARD SEAM	LD.UD	limited knowledge
				BOREHOLE SEAM	LD	limited knowledge
			WARATAH SANDSTONE (WATTS SANDSTONE)		LD	sandstone, minor congl. marker
	WITTINGHAM COAL MEASURES		DENMAN FORMATION		SM	sandstone, siltstone, laminite
		JERRYS PLAINS SUBGROUP	MT LEONARD FORMATION	*WHYBROW SEAM*	LD	moderate to low sulphur, DB
			ALTHORP FORMATION		LD	claystone
			MALABAR FORMATION	*REDBANK CREEK SEAM*	LD	moderate sulphur, DDB
				WAMBO SEAM	LD	low sulphur, DBB
				WHYNOT SEAM	LD	low sulphur, DDB
				BLAKEFIELD SEAM	LD	moderate to low sulphur, DB
			SAXONVALE MBR		LD	siltstone claystone
			MOUNT OGILVIE FORMATION	*GLEN MUNRO SEAM*	UD.LD	moderate sulphur, DB
				WOODLANDS HILL SEAM	UD	low sulphur, DB
			MILBRODALE FORMATION		UD	claystone
			MOUNT THORLEY FORMATION	*ARROWFIELD SEAM*	UD	low sulphur, DB
				BOWFIELD SEAM	UD	low sulphur, DB
				WARKWORTH SEAM	UD	low sulphur, DB
			FAIRFORD FORMATION		UD	claystone marker
			BURNAMWOOD FORMATION	*MT. ARTHUR SEAM*	UD	low sulphur, DB
				PIERCEFIELD SEAM	UD	low sulphur, DBB
				VAUX SEAM	LD.UD	low sulphur, DBB
				BROONIE SEAM	LD	moderate to high sulphur, DBB
				BAYSWATER SEAM inc. RAVENSWORTH	LD	marker seam – low sulphur, DDD
			ARCHERFIELD SANDSTONE		MR	lithic sandstone – marker bed
		VANE SUBGROUP	BULGA FORMATION		MT	sandstone, siltstone, laminite
			FOYBROOK FORMATION	*LEMINGTON - WYNN SEAM*	ULD	moderate to high sulphur, DB
				PIKES GULLY - BENGALLA SEAM	UD	moderate to low sulphur, DB
				ARTIES - EDENGLASSIE SEAM	UD	moderate to low sulphur, DB
				LIDDELL - RAMROD CK. SEAM	LUD	moderate to low sulphur, DBB
				BARRETT SEAM	LD	moderate sulphur, DBB
				HEBDEN SEAM	LD	moderate to high sulphur, DBB
			SALTWATER CK FORMATION		MR	sandstone, siltstone, laminite
MAITLAND GROUP			MULBRING SILTSTONE		MT	siltstone claystone
			MUREE SANDSTONE		MR	sandstone, siltstone, congl.
			BRANXTON FORMATION		MT	sandstone, siltstone, congl.
	GRETA COAL MEASURES		ROWAN FORMATION	*HILLTOP SEAM*	UD.LD	high sulphur, DDD
				BROUGHAM SEAM	UD	low sulphur, DDD
				PUXTREES SEAM	UD	low sulphur, DDD
				AYRDALE SANDSTONE	UD	sandstone
				BALMORAL SEAM	LD	moderate sulphur, DDD
			SKELETAR FORMATION			rhyolite, chert, claystone

MT=marine transgression MR=marine regression LD=lower deltaic UD=upper deltaic ULD=upper to lower delts LUD=lower to upper delta SM=sub marine
BBB=bright DBB=more bright than dull, DB=bright and dull, DDB=more dull than bright DDD=dull

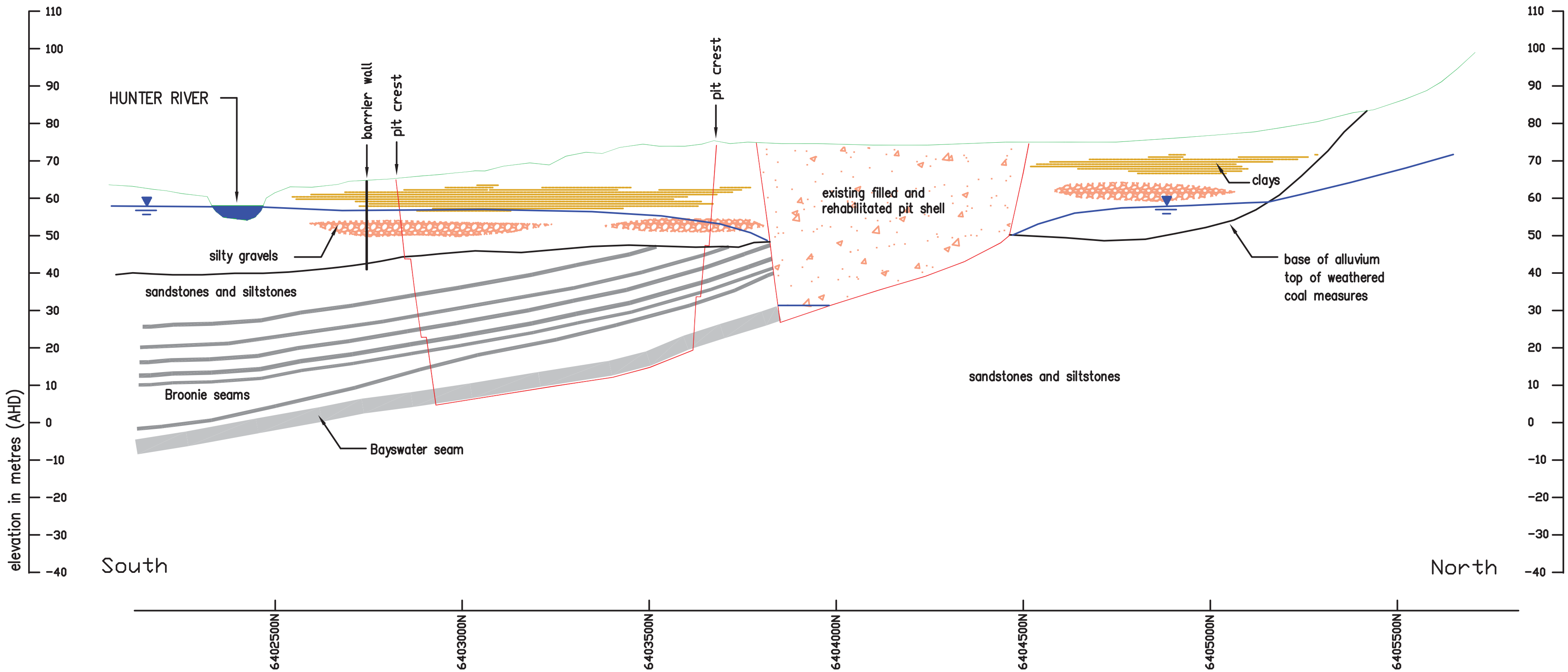


CARRINGTON WEST WING EXTENSION GROUNDWATER STUDY

Bayswater seam floor contours and regional structure

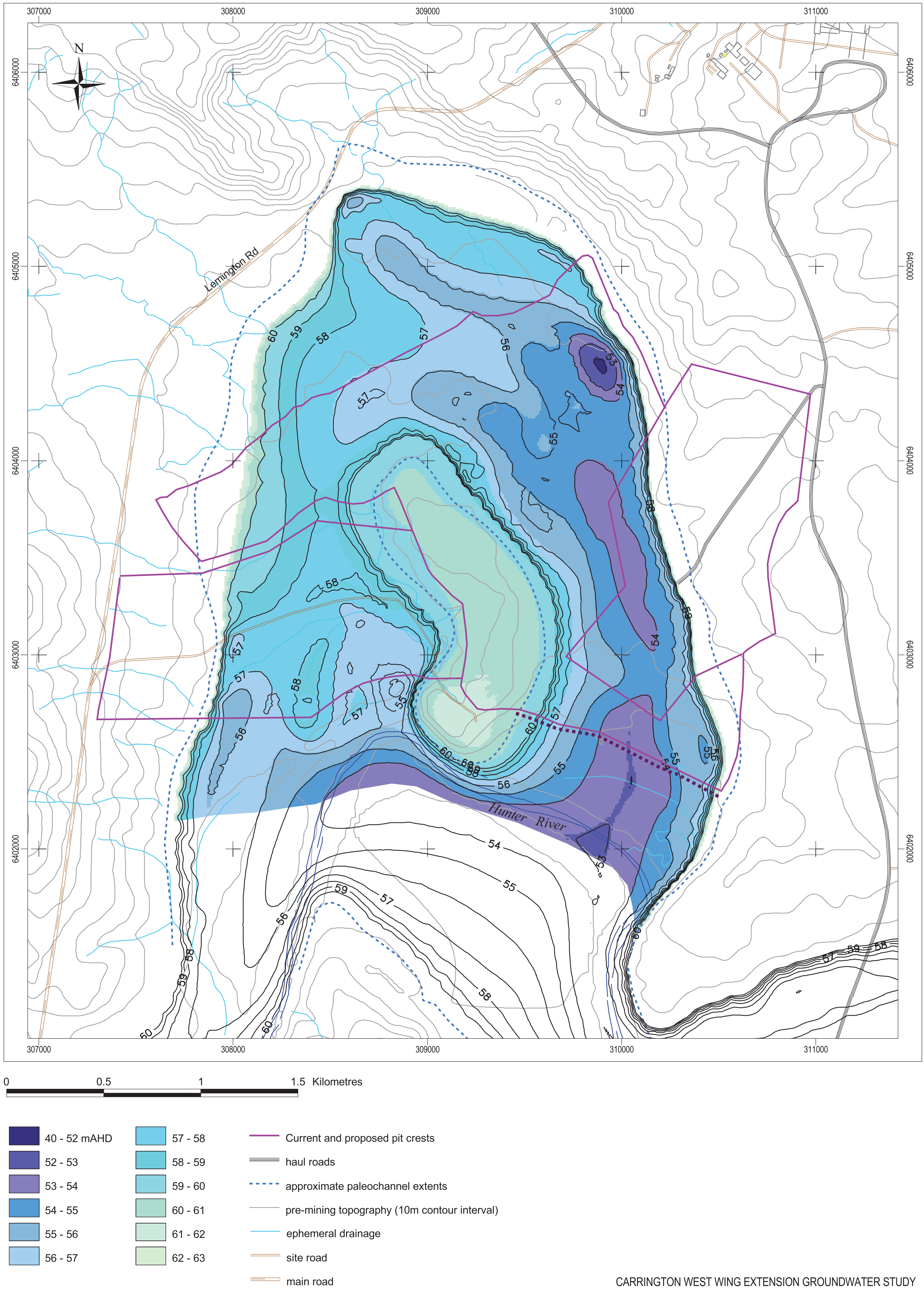
Mackie Environmental Research

Figure 4



Vertical exaggeration 10x
See Figure 2 for section location
Schematic only - not to scale

SOUTH-NORTH SECTION



CARRINGTON WEST WING EXTENSION GROUNDWATER STUDY

Pre-mining base of paleochannel alluvium

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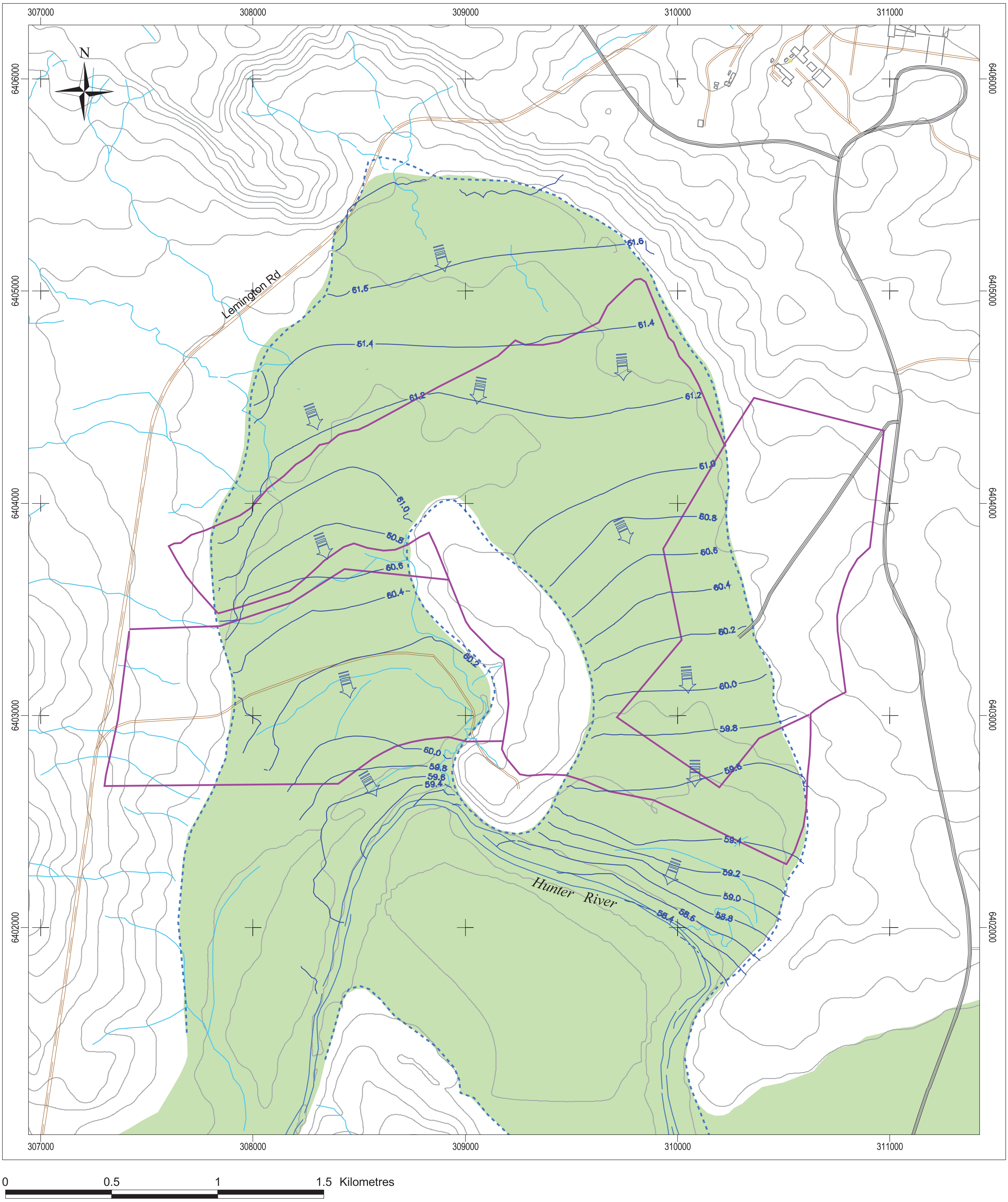
Figure 6

Plate 1: Typical alluvium highwall looking to the south-east. Stiff clay exposed in highwall.

Plate 2: Typical alluvium highwall looking to the south-west. Clayey gravels exposed in highwall.



CARRINGTON WEST WING EXTENSION GROUNDWATER STUDY

Pre-mining (2000) water table contours in paleochannel alluvium

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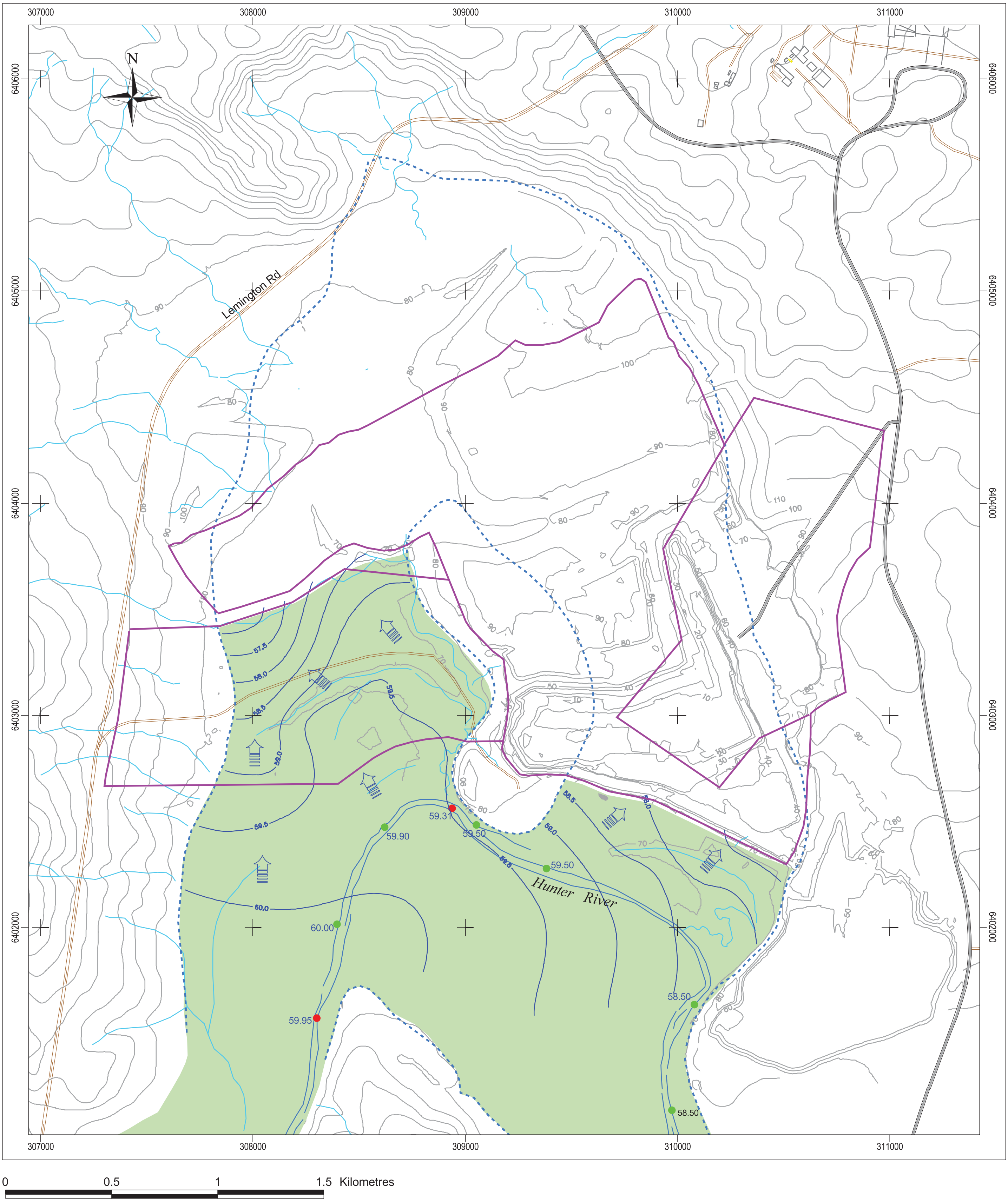
Figure 8



alluvium

current and proposed pit crests

haul roads

approximate paleochannel extents

pre-mining topography (10m contour interval)

water table equipotential (mAHD)

approx. flow direction

river bed survey (2007)

river bed survey (2005)

CARRINGTON WEST WING EXTENSION GROUNDWATER STUDY

December 2009 water table contours in paleochannel alluvium

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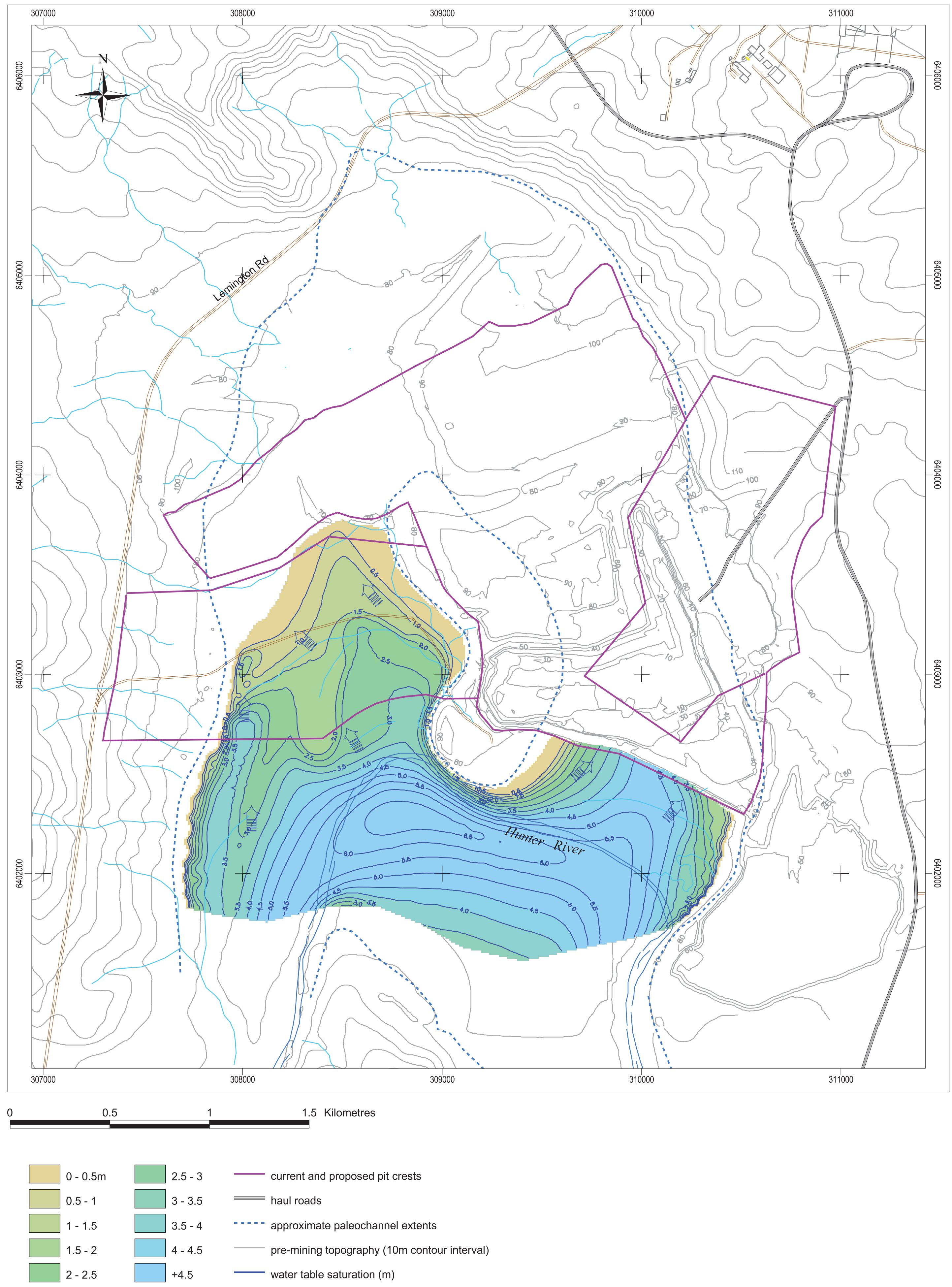
Figure 9



CARRINGTON WEST WING EXTENSION GROUNDWATER STUDY

December 2009 saturated alluvium

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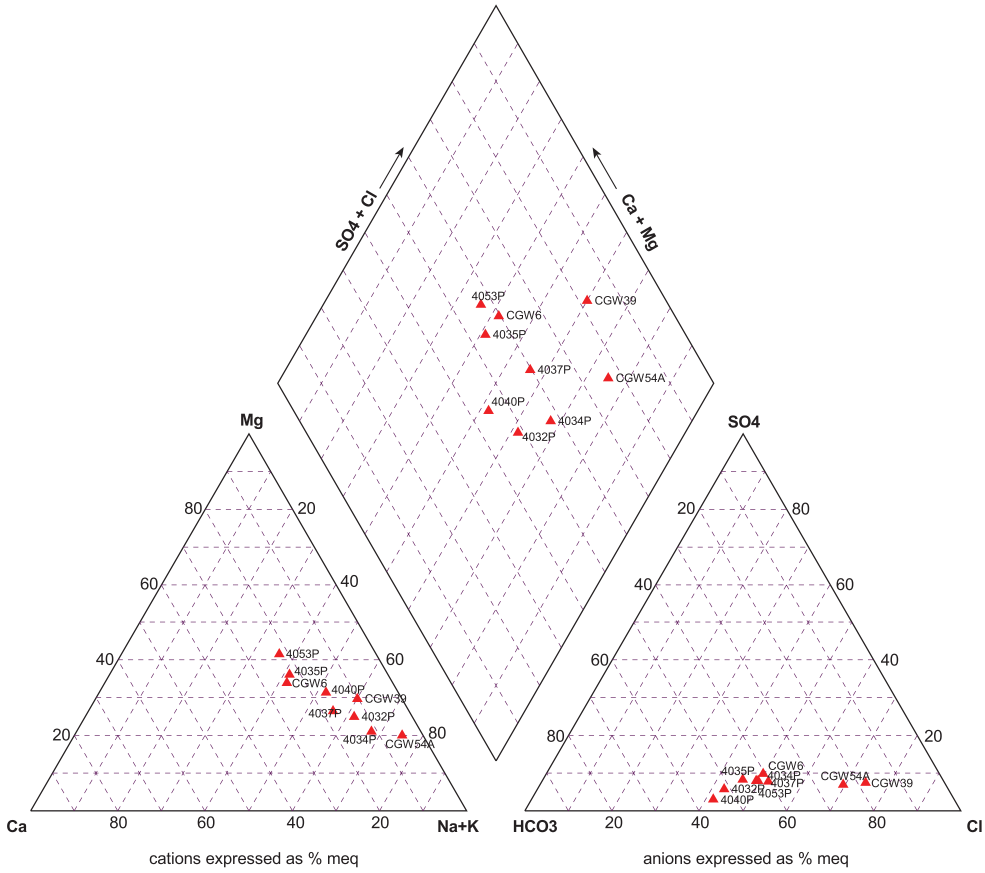
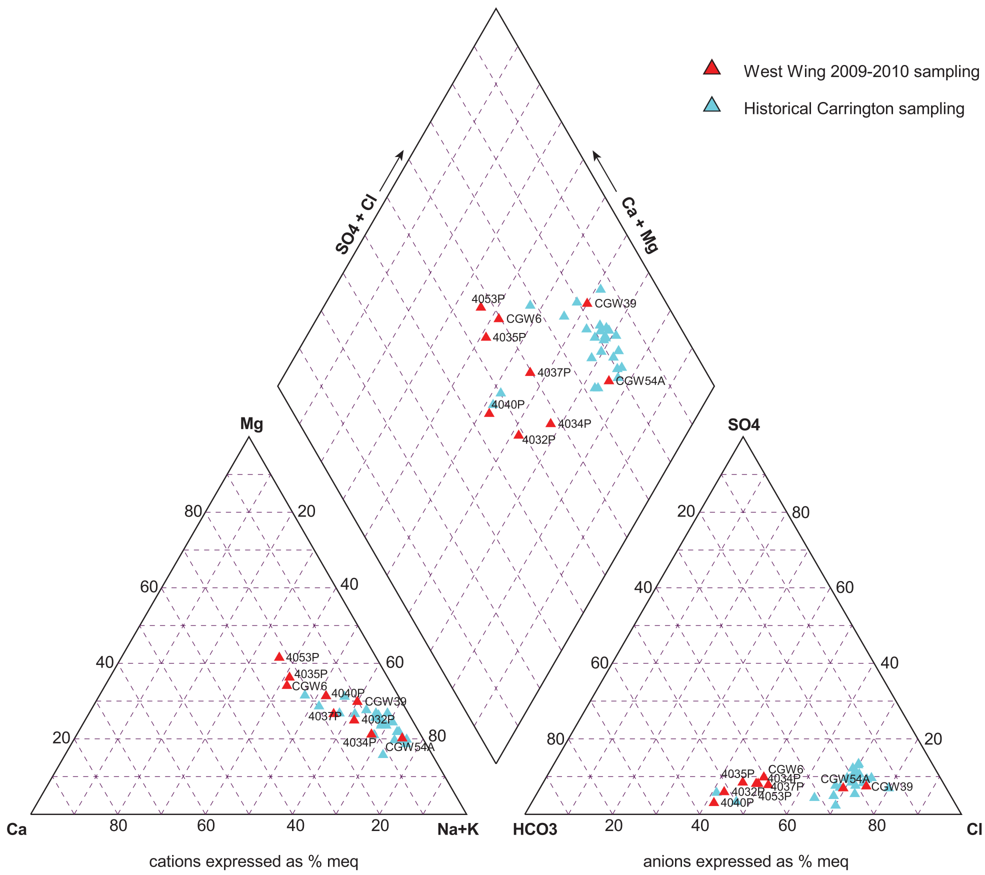
Figure 10





CARRINGTON EXTENDED - WATER MANAGEMENT STUDIES

Speciation of major ions for groundwaters

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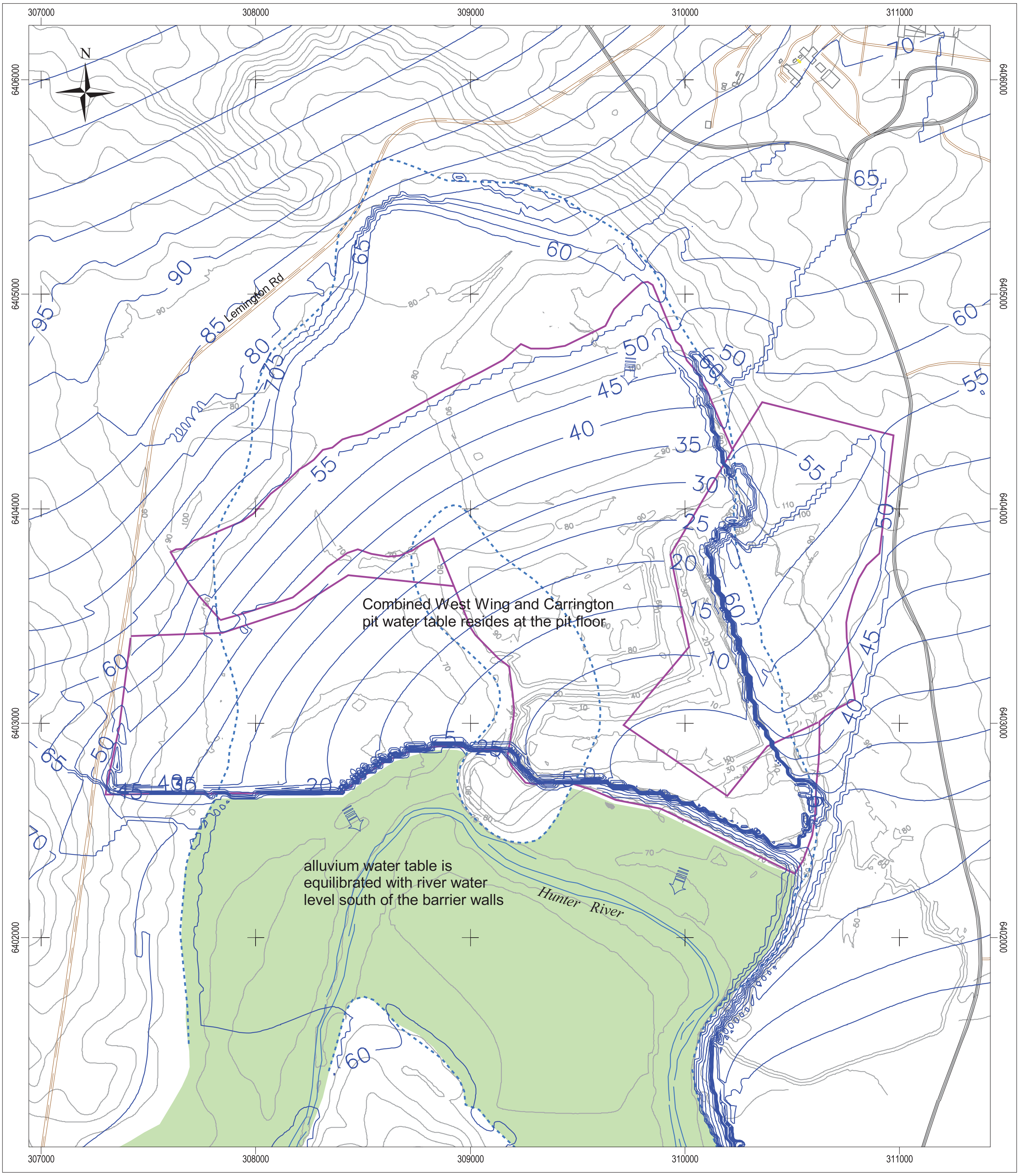
Figure 11



0 0.5 1 1.5 Kilometres

- alluvium
- current and proposed pit crests
- haul roads
- approximate paleochannel extents
- pre-mining topography (10m contour interval)
- water table equipotential (mAHD)
- approx. flow direction
- site road

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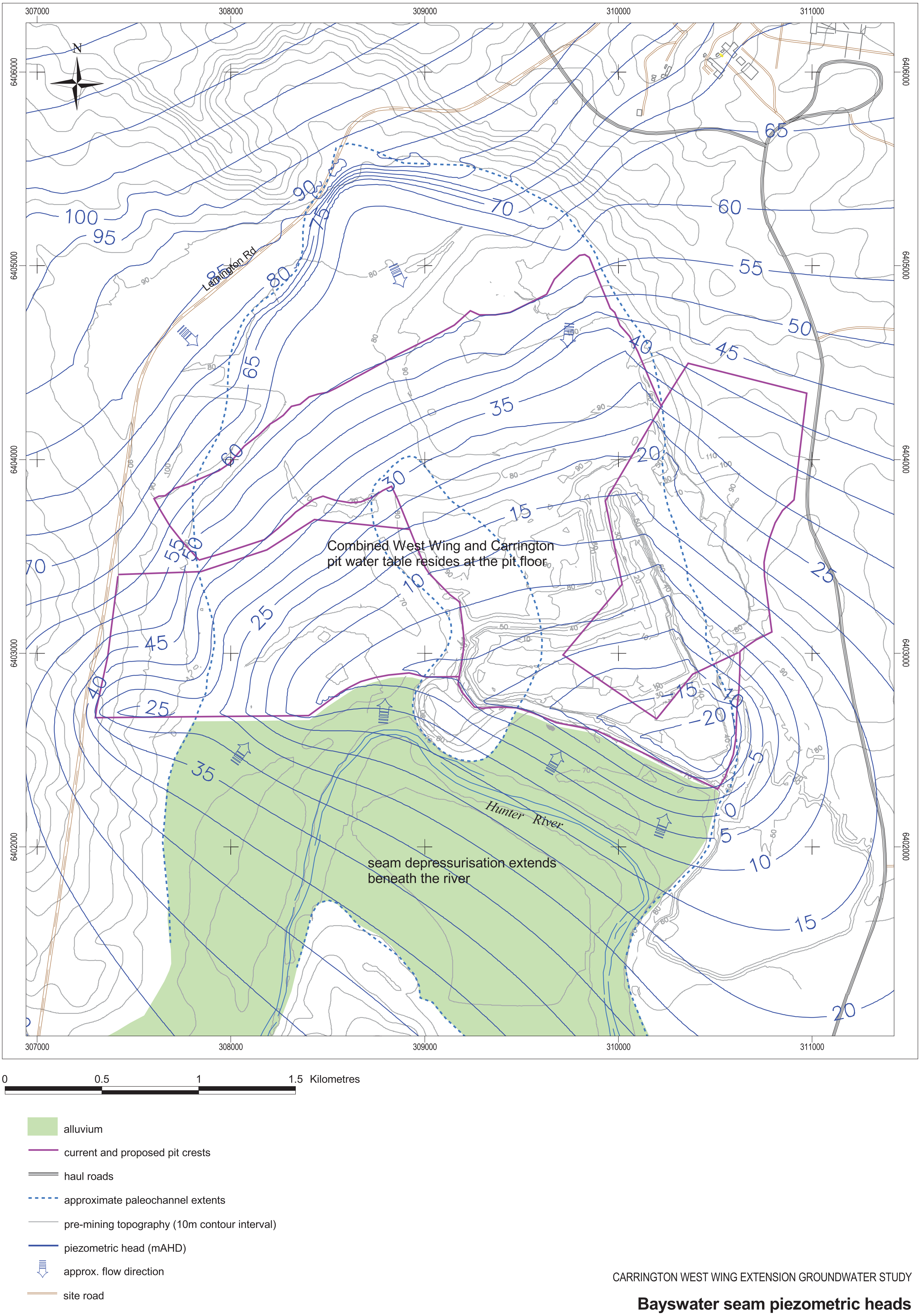
CARRINGTON WEST WING EXTENSION GROUNDWATER STUDY

Water table contours in paleochannel alluvium at the end of mining

Figure 12



CARRINGTON WEST WING EXTENSION GROUNDWATER STUDY

Bayswater seam piezometric heads at the end of mining

Figure 13

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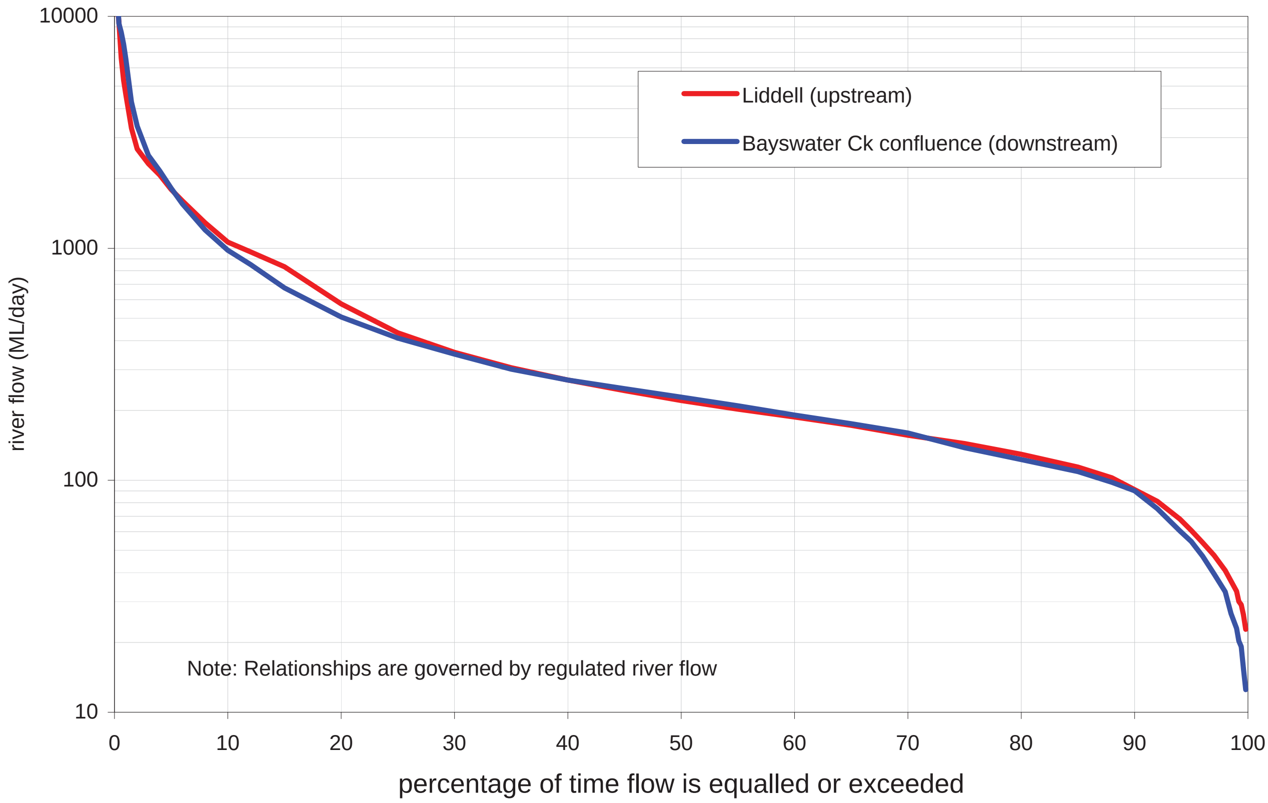
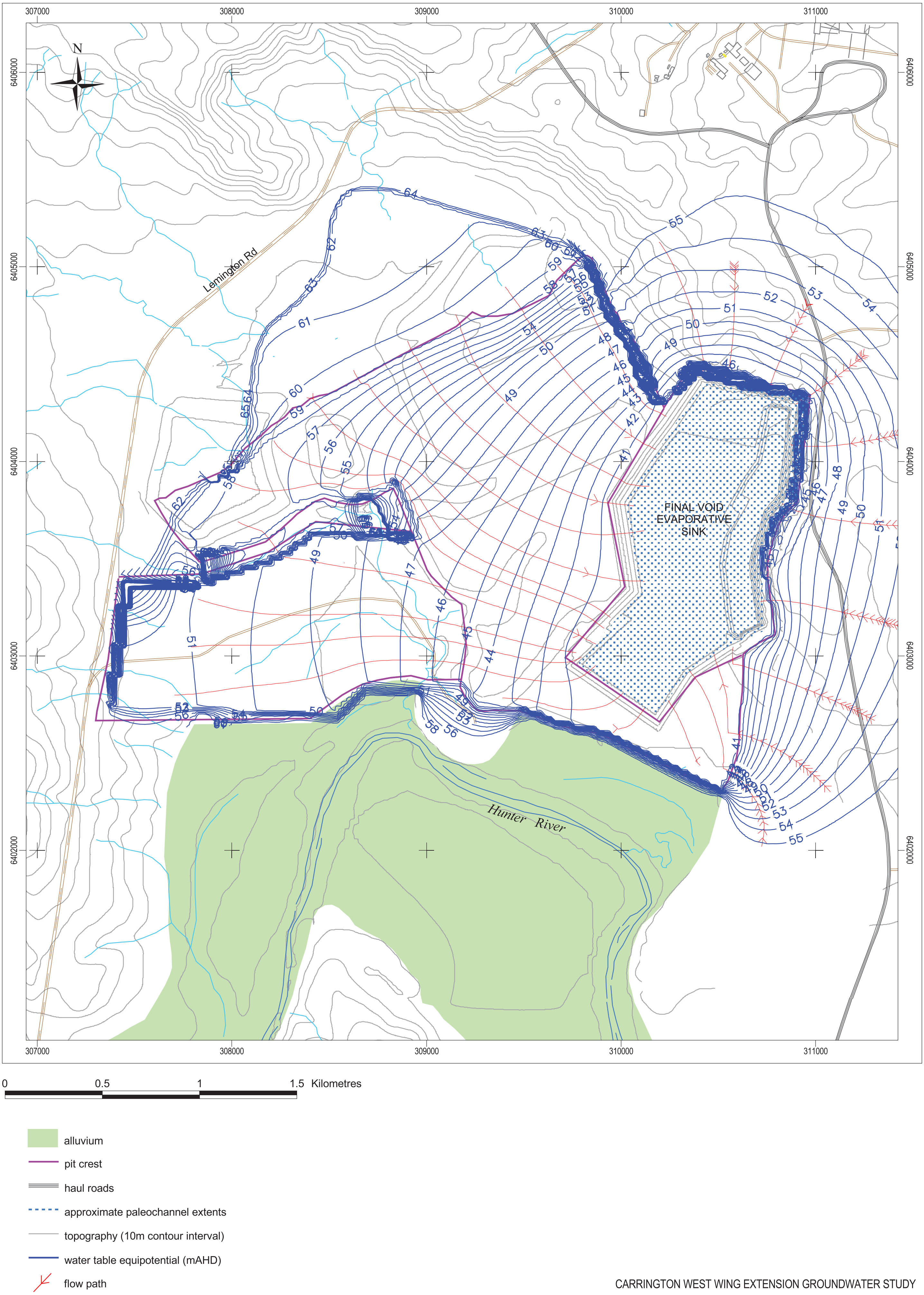


Hunter River flow-duration relationship for Carrington reach

Figure 14



CARRINGTON WEST WING EXTENSION GROUNDWATER STUDY

Final void groundwater levels and flow paths

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Figure 15

APPENDIX A: CLIMATE DATA

Climate data has been sourced from the Bureau of Meteorology for use in groundwater system modelling.

Long term data for Jerrys Plains has been used in void water management simulations where testing has been conducted against the historical record. In addition, data has been processed to generate recurrence intervals and average exceedance probabilities for specified rainfall durations up to 20 days. The following Table A1 provides a summary.

Evaporation data has been sourced from the Scone Research Centre and is summarised in table A2.

Table A1: Longer term intensity, frequency, duration statistics for 118 years of data.

ARI	AEP %	1 day	2 day	3 day	4 day	5 day	6 day	8 day	10 day	15 day	20 day
once in 1 years	63.2	50	65	72	77	81	85	91	98	114	126
once in 2 years	39.3	63	84	93	100	104	109	117	124	143	158
once in 5 years	18.1	80	110	122	131	137	141	151	159	182	199
once in 10 years	9.5	93	130	144	155	161	166	178	186	211	230
once in 20 years	4.9	106	150	167	179	186	191	204	213	240	261
once in 50 years	2.0	123	177	198	212	220	225	240	249	279	302
once in 100 years	1.0	137	198	222	238	247	251	268	277	309	333

Durations are based on screening of daily Jerrys Plains data within each year of available records from 1890 to 2007 - a log normal distribution is assumed. The long term annual average is 642mm.

ARI (Average Recurrence Interval) means – the average or expected value of the periods between exceedances of a given rainfall total accumulated over a given duration. For example, a continuous rainfall event total of 98 mm over 10 days has an average recurrence interval of 1 year.

AEP (Average Exceedance Probability) means – the probability that a given rainfall total accumulated over a given duration will be exceeded in any one year. For example, a continuous rainfall event total of 98 mm over 10 days has a 63.2 per cent probability of being equaled or exceeded in any one year.

Table A2: Average potential evaporation (Pan A) in Scone and Jerrys Plains rainfall in mm.

	Jan	Feb	Mar	Apl	May	Jun	Jly	Aug	Sep	Oct	Nov	Dec
Daily evaporation	7.1	6.2	5.0	3.5	2.2	1.6	1.8	2.8	3.9	5.1	6.1	7.3
Monthly evaporation	220.1	173.6	155.0	105.0	68.2	48.0	55.8	86.8	117.0	158.1	183.0	226.3
Monthly rainfall	76.9	72.5	59.1	44.1	40.4	47.6	43.5	36.7	41.7	52.2	59.9	67.6

APPENDIX B: PIEZOMETRIC MONITORING DATA

A network of monitoring bores exists within the project area and in surrounding areas near the Hunter River. The current network includes both standpipe and pore pressures piezometers constructed in the paleochannel alluvium and the underlying coal measures. The network includes:

- 36 locations equipped with standpipes installed in the alluvium and coal measures that facilitate dipping of the piezometric level(s) and water sampling;
- 1 recently installed location equipped with a vertical array of vibrating wire transducers that monitor formation pore pressures in the coal measures (Broonie, Bayswater seams).

Figure B1 shows monitoring locations. In addition to these locations Coal & Allied maintains an extended network around other mining operations (eg. South Pit, North Pit, West Pit).

B1.1 Piezometric elevations

Historical piezometric monitoring data is summarised on the following Figure B2. Piezometers that have been mined through (Carrington Pit), have been included for completeness.

B1.2 Groundwater quality

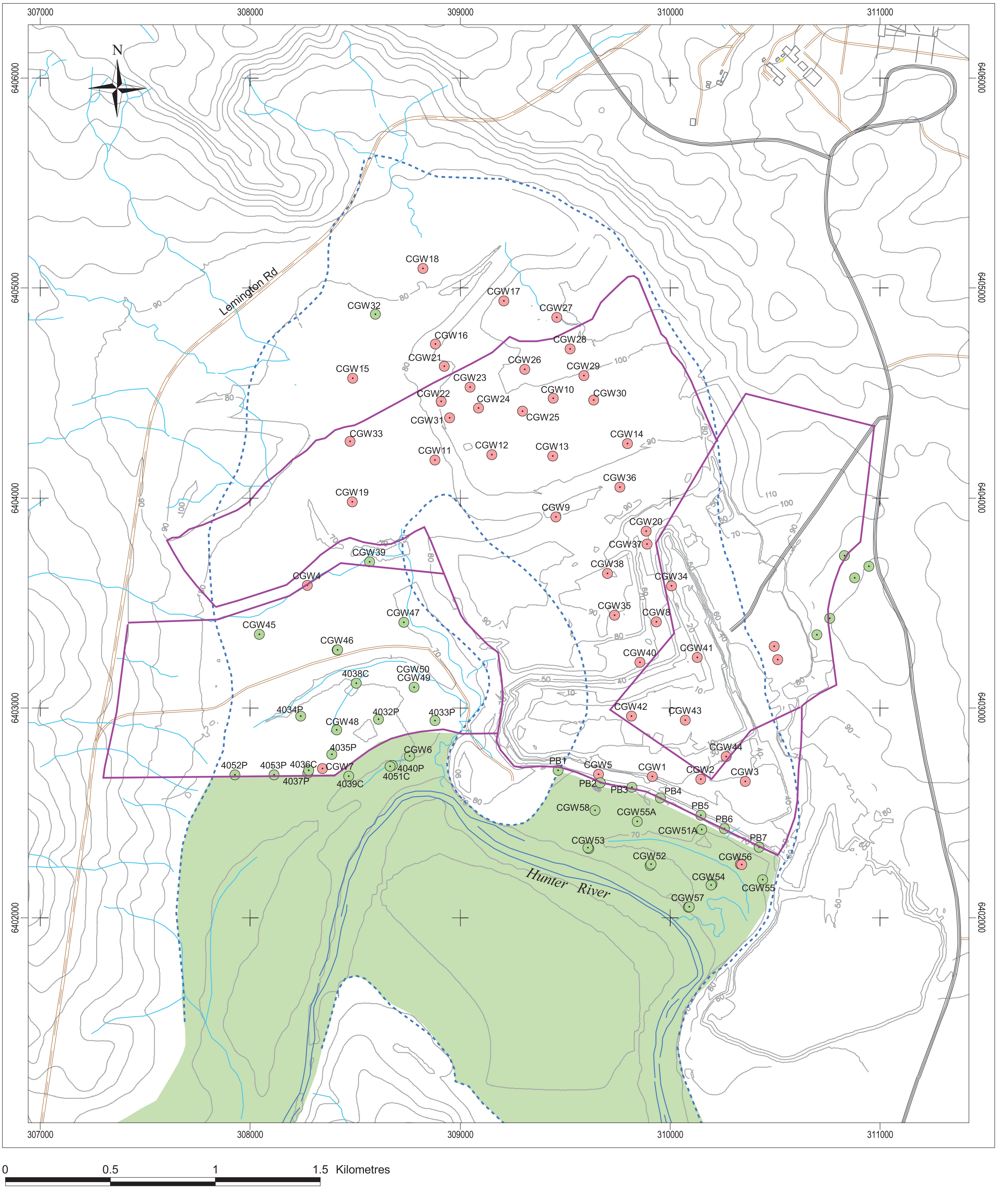
Groundwater quality parameters pH and electrical conductivity (EC) have been routinely monitored since mining commenced at Carrington. Figure B3 provides summary scatter plots illustrating the general trends. Freshening of groundwaters is evident at piezometers located within the eastern channel immediately south of current mining operations at Carrington (CGW52A to CGW55A).

A pre-mining salinity distribution is provided on Figure B4 for completeness. Data are based on sampling over the period from 2000 to 2004 before the alluvium was stripped and exhibit a range from 4000 uS/cm to 12500 uS/cm. A current salinity distribution is provided on Figure B5. Data are based on recent 2009 to 2010 sampling and exhibit a range from 2000 uS/cm to 12000 uS/cm.

Table B1 provides a summary of historical speciation data for piezometers that have been mined through, and the most recent speciated data relevant to new piezometers installed in the project area. Figure B6 provides a Piper tri-linear speciation plot of the data which supports a general water type dominated by primary salinity Na>Mg>>Ca and $Cl>HCO_3>SO_4$.

Table B1: Summary of major ions

Bore	Date	TDS mg/l	pH	EC uS/cm	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	HCO3 mg/l	SO4 mg/l	Cl mg/l
CGW1	Aug-04	6860	7.0	12000	93	290	2080	30	1415	625	3050
CGW3	Aug-04	7940	7.1	12500	120	410	1950	40	1610	700	3370
CGW39	Aug-04	4410	7.1	6900	126	229	980	8.8	976	195	1880
CGW43	Aug-04	5830	7.0	9900	91	265	1650	24	1098	650	2550
CGW47A	Aug-04	1760	7.2	3200	74	63	540	11.5	561	40	814
CGW48	Aug-04	1930	7.1	3500	120	139	430	3.2	1159	65	619
CGW6	Aug-04	2690	6.9	3700	160	144	400	7.6	744	85	867
CGW1	Sep-97	5710	7.23	9080	91	235	1680	16	1180	469	2380
CGW2	Sep-97	6360	7.34	8710	154	330	1810	25	1476	531	2740
CGW3	Sep-97	6100	7.19	8910	111	339	1830	31	1126	540	3030
CGW4	Sep-97	4980	7.39	8960	226	296	1270	15	739	304	2550
CGW6	Sep-97	3670	7.17	4190	205	210	843	7	797	238	1610
CGW7	Sep-97	1220	7.45	2200	92	82	275	5	754	65	332
CGW8	Sep-97	5340	7.16	8540	88	217	1670	21	1209	426	2310
CGW9	Sep-97	4600	6.95	7233	201	307	1040	11	1232	297	1890
CGW10	Sep-97	4070	6.99	7200	101	179	1250	18	1220	178	1780
CGW11	Nov-99	6460	7.28	9820	175	380	1750	10	1230	570	2780
CGW12	Nov-99	5720	7.29	8720	160	295	1600	7	1000	630	2380
CGW13	Nov-99	4800	7.26	7320	145	280	1350	10	1070	342	2060
CGW14	Nov-99	6020	7.11	9160	110	290	1800	29	1220	495	2560
CGW15	Nov-99	4980	7.29	8030	135	265	1400	13	970	348	2210
CGW16	Nov-99	5480	7.08	8785	140	290	1550	16	1070	525	2320
CGW17	Nov-99	5840	7.12	9225	150	340	1600	27	1140	585	2400
CGW18	Nov-99	5460	7.18	8670	140	300	1500	22	970	420	2410
CGW19	Nov-99	3840	7.11	6690	155	185	1120	9	990	228	1600
4053P	Feb-10	1308.18	7.7	2000	87	99	160	2.7	529	80	350
4037P	Feb-10	1619.1	8.2	2300	78	73	280	16	616	96	460
4035P	Feb-10	1421.74	7.9	2000	92	90	190	4.4	606	89	350
4034P	Feb-10	1428.78	8.2	2200	47	54	320	6	548	84	370
4032P	Feb-10	1519.84	8.1	2100	55	63	290	2.9	704	65	340
4040P	Feb-10	1413.98	7.1	3500	120	139	430	3.2	1414	65	619
CGW39	Sep-09	5600	8.00	7630	168	302	1135	10	909	303	2180
CGW54A	Sep-09	3800	7.50	6550	63	164	1140	14	976	235	1680
CGW6	Sep-09	1100	8.60	1940	91	78	178	3.1	442	91	333



CARRINGTON WEST WING EXTENSION GROUNDWATER STUDY

Current and historical groundwater monitoring network

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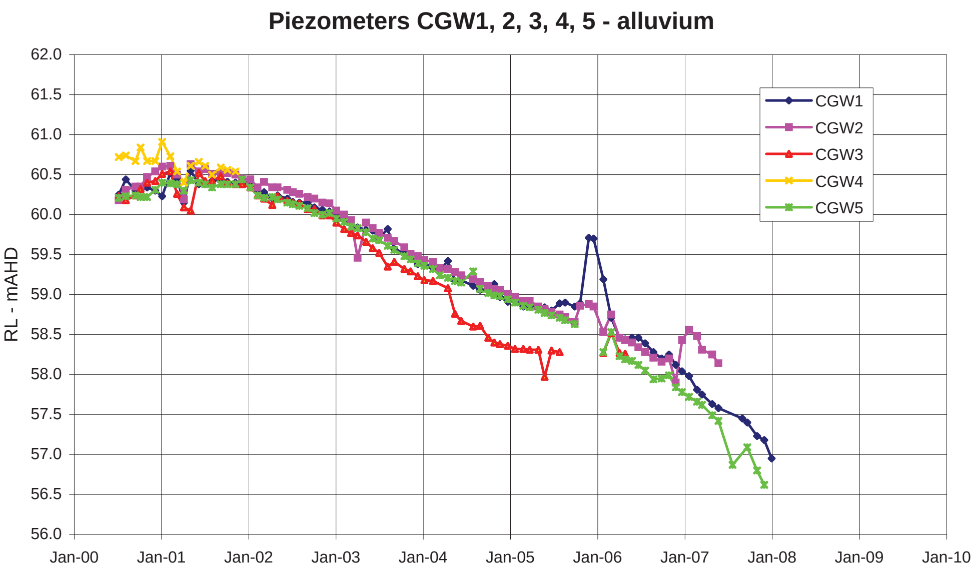
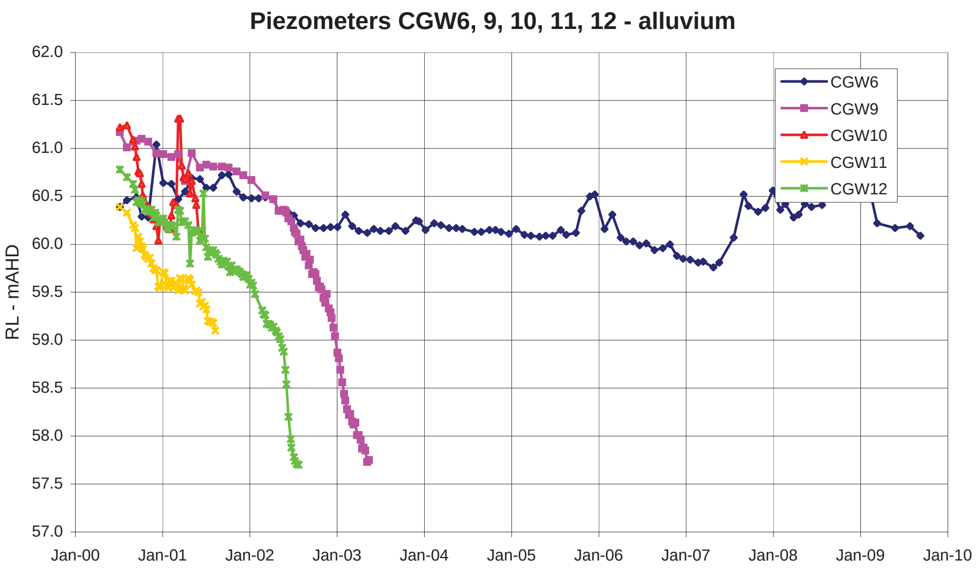
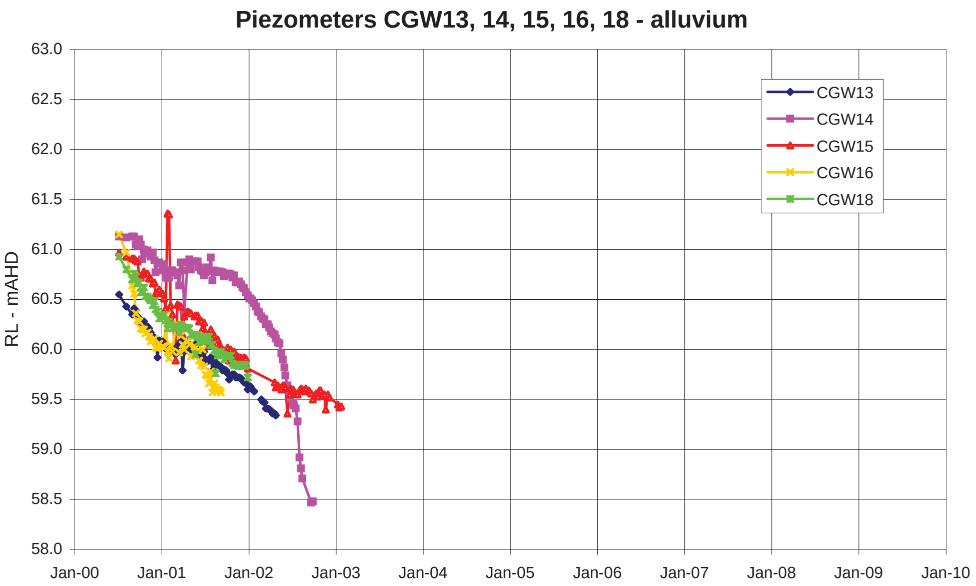
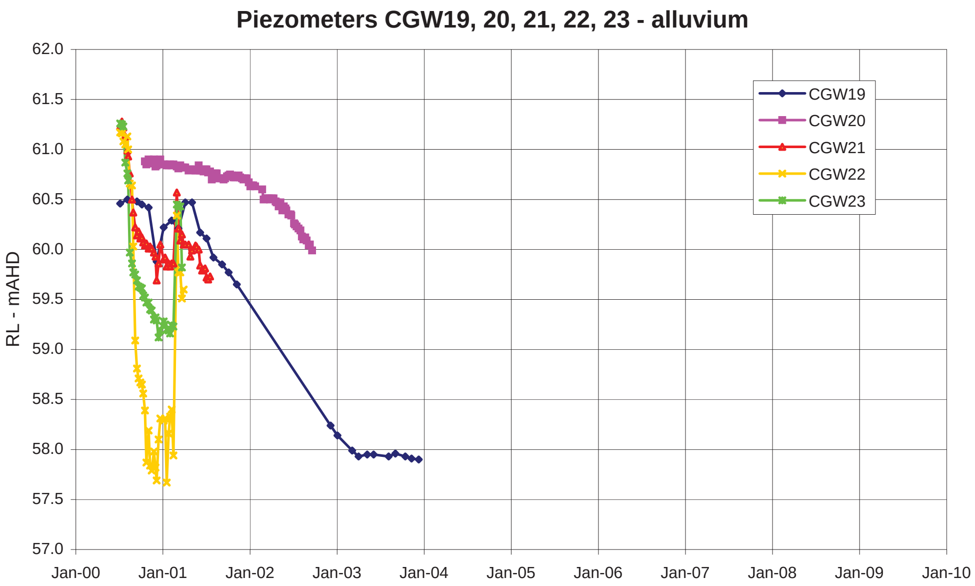
Figure B1



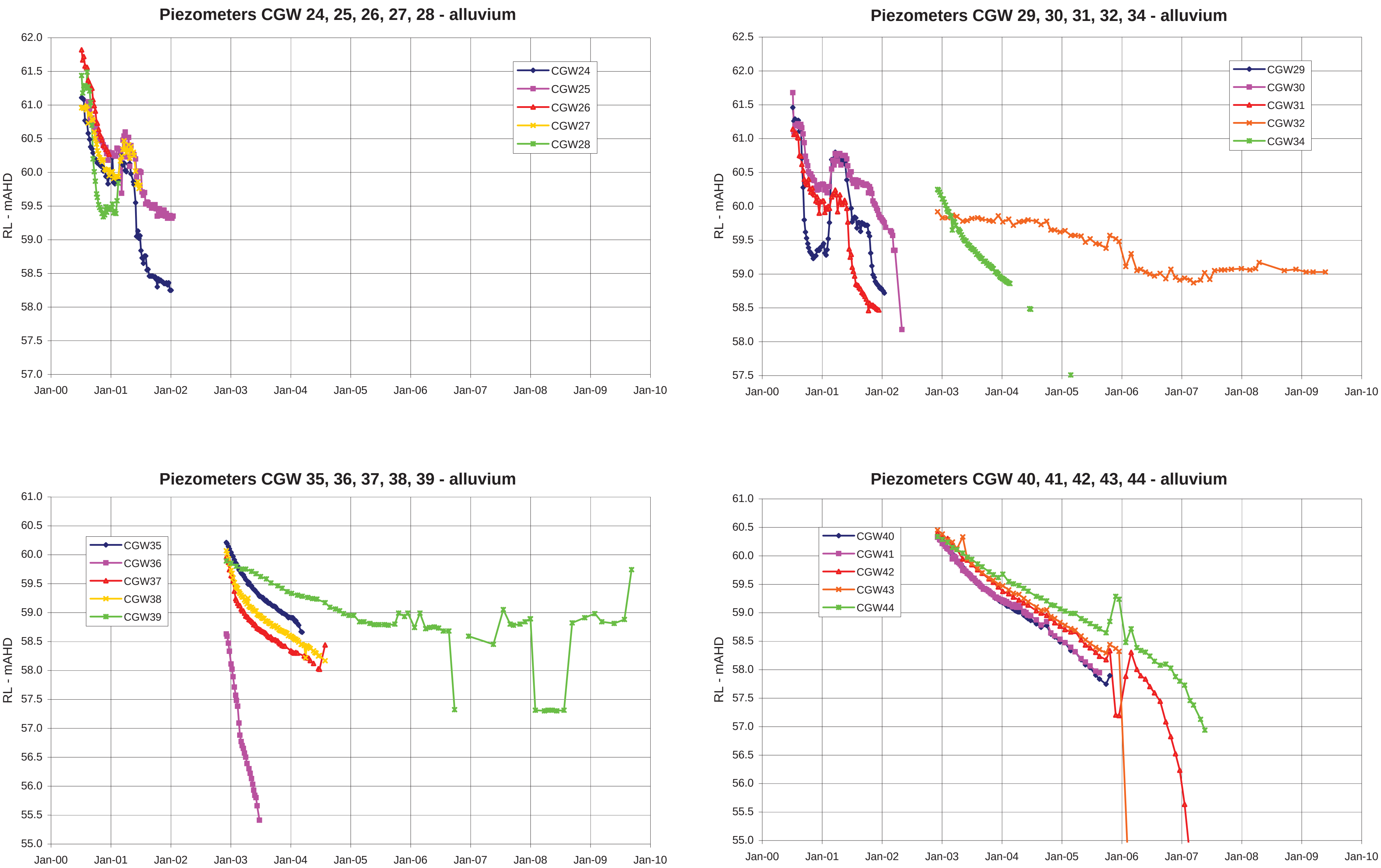






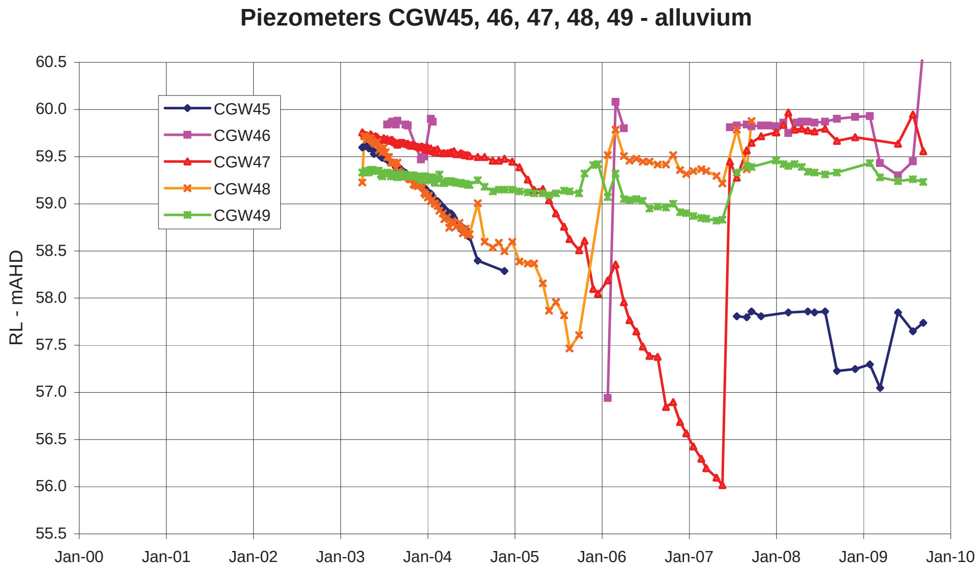
Piezometric elevations

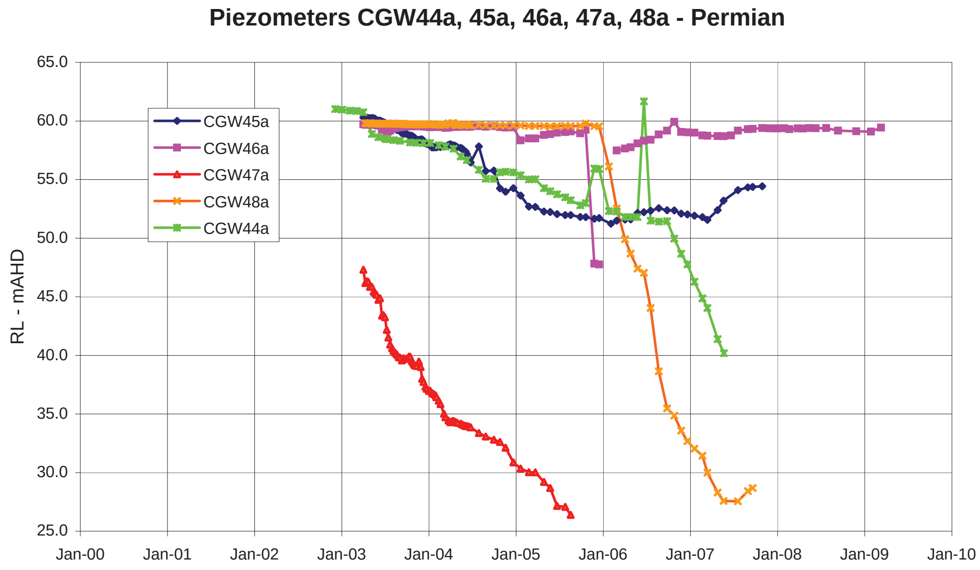
Figure B2

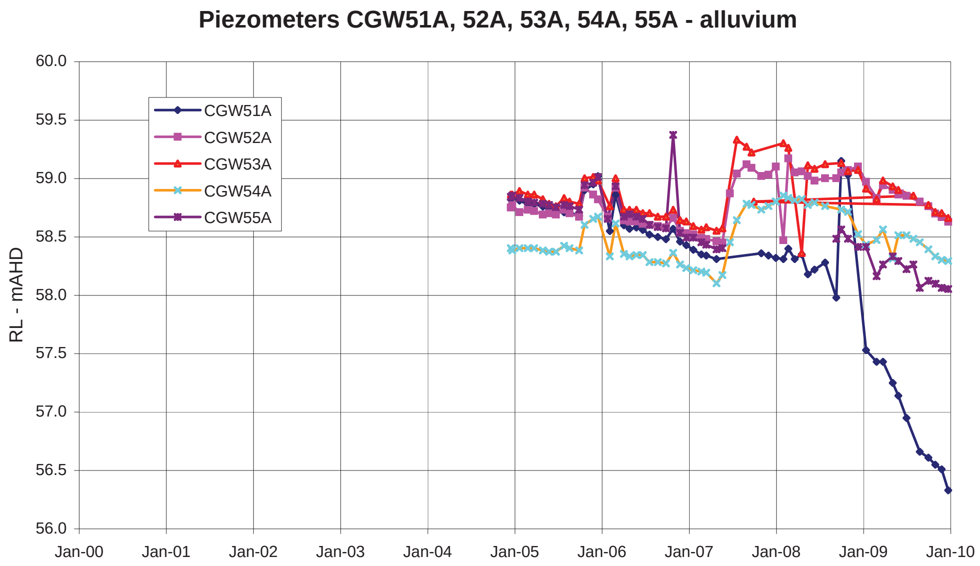


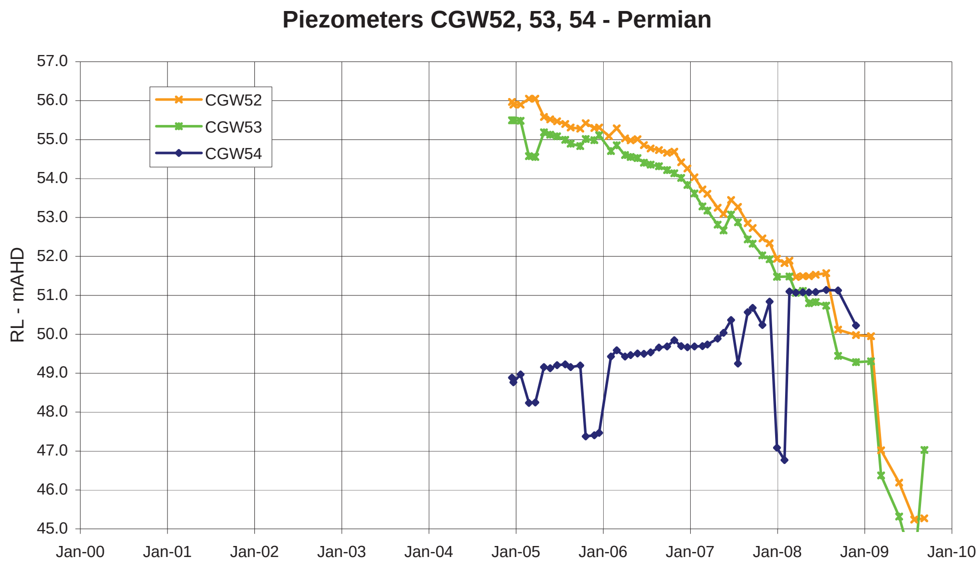
Piezometric elevations

Figure B2





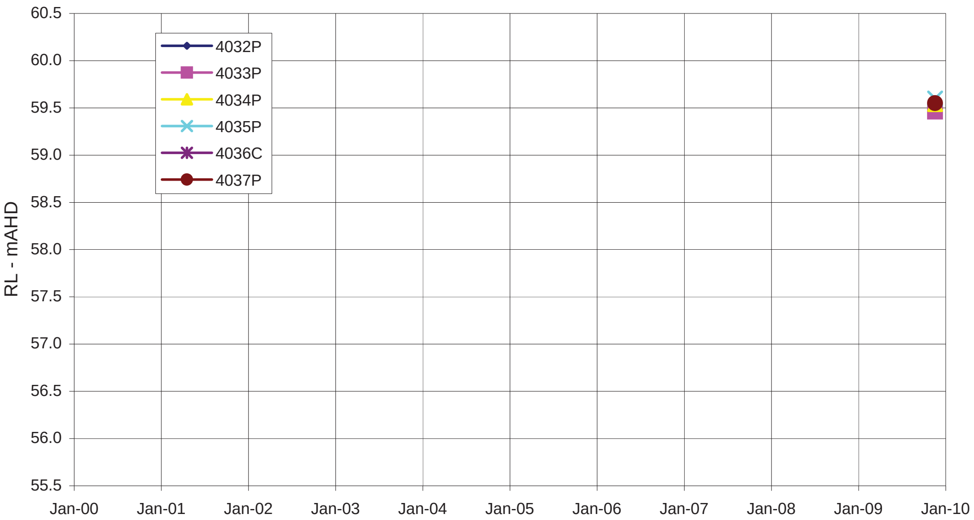




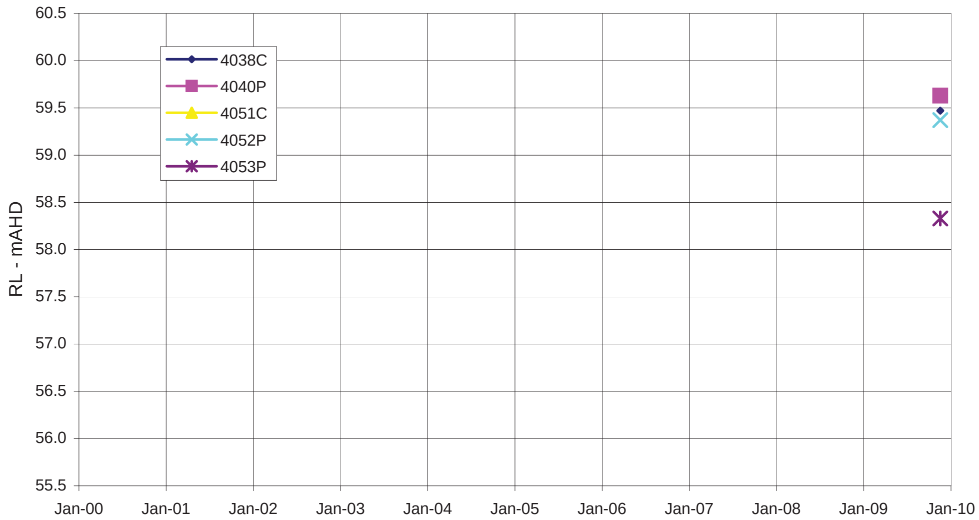
Piezometric elevations

Figure B2

Piezometers 4032P, 4033P, 4034P, 4035P, 4036C, 4037P - alluvium

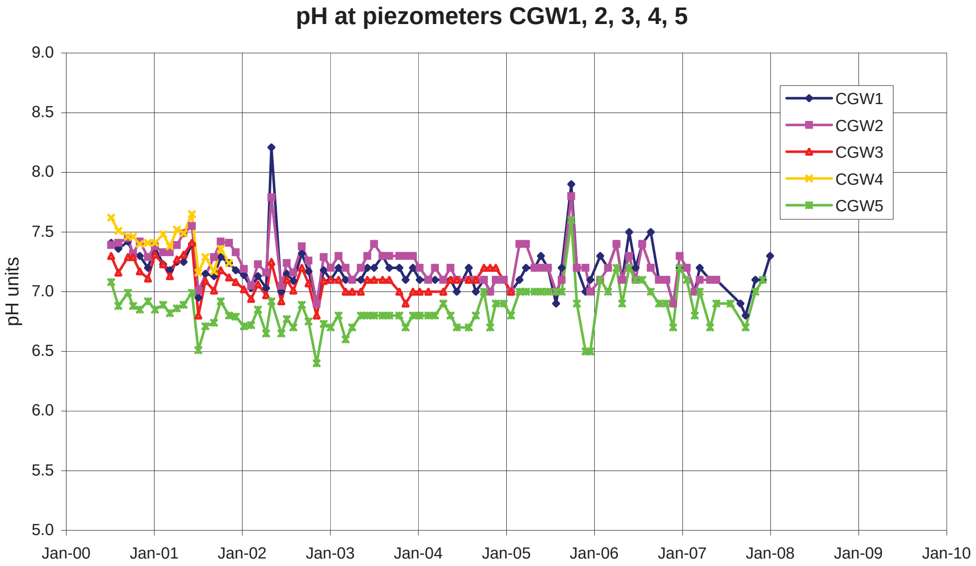


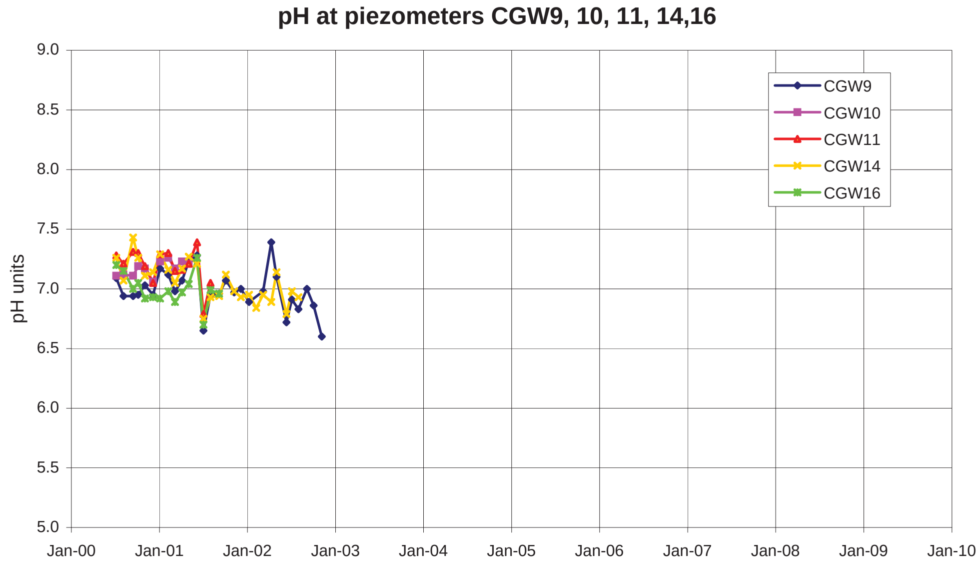
Piezometers 4038C, 4040P, 4051C, 4052P, 4053C - alluvium

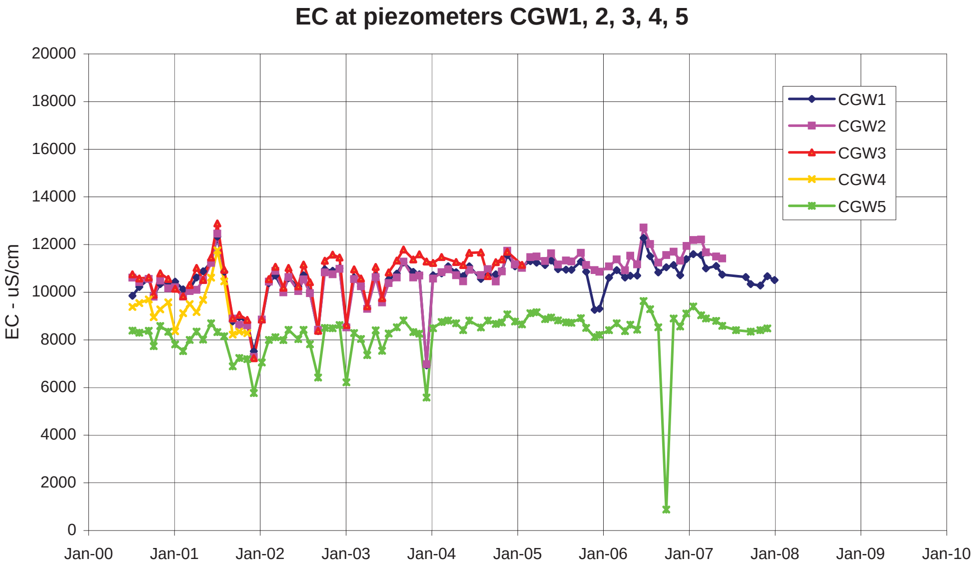


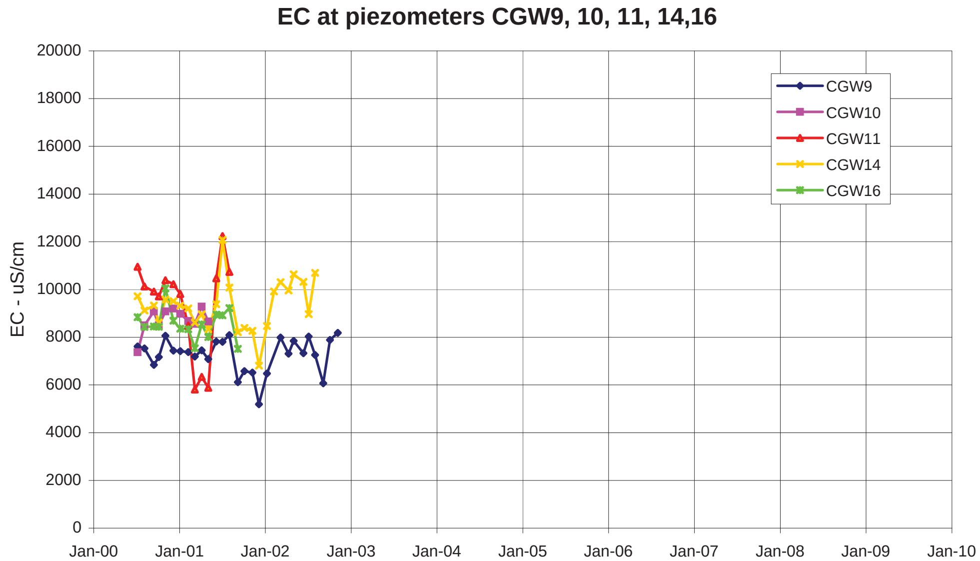
Piezometric elevations

Figure B2

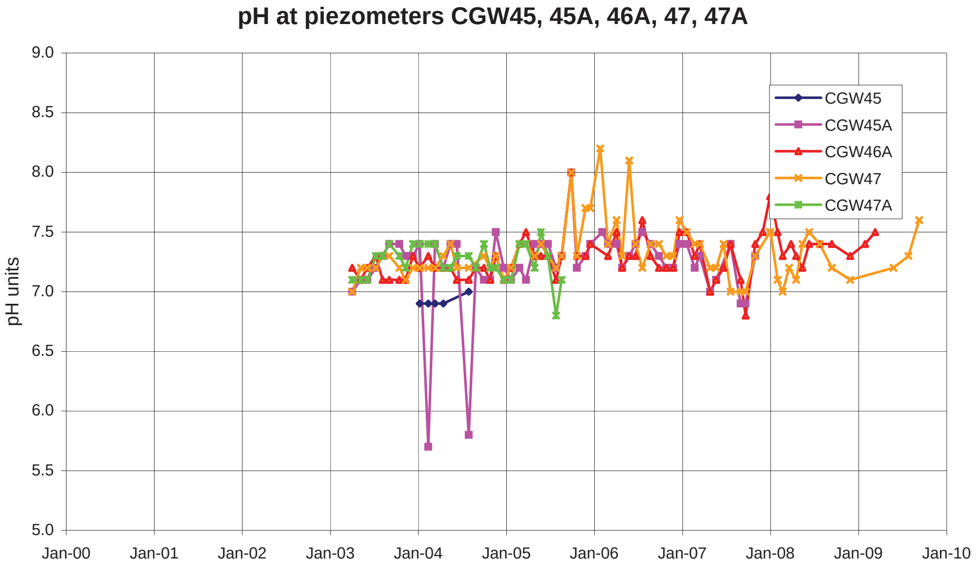


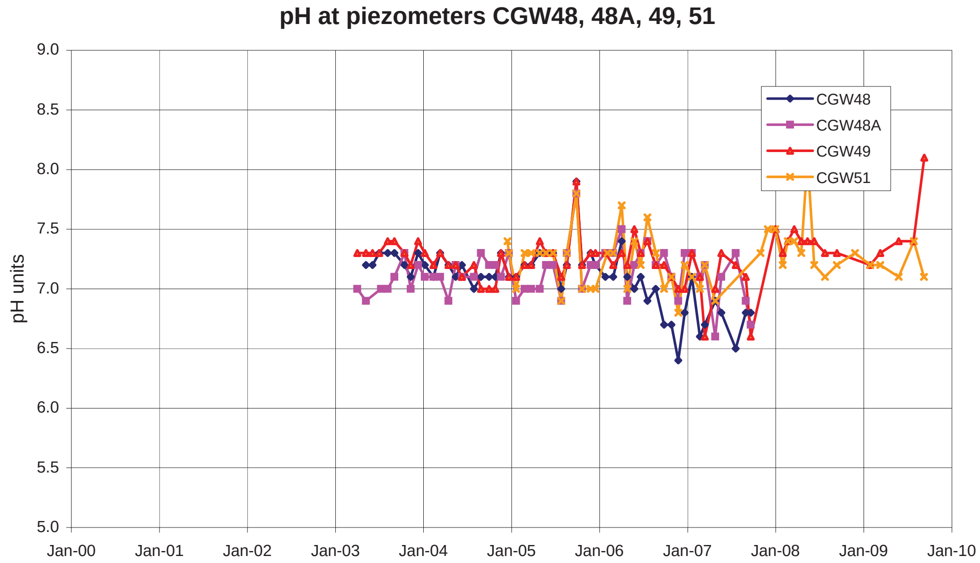


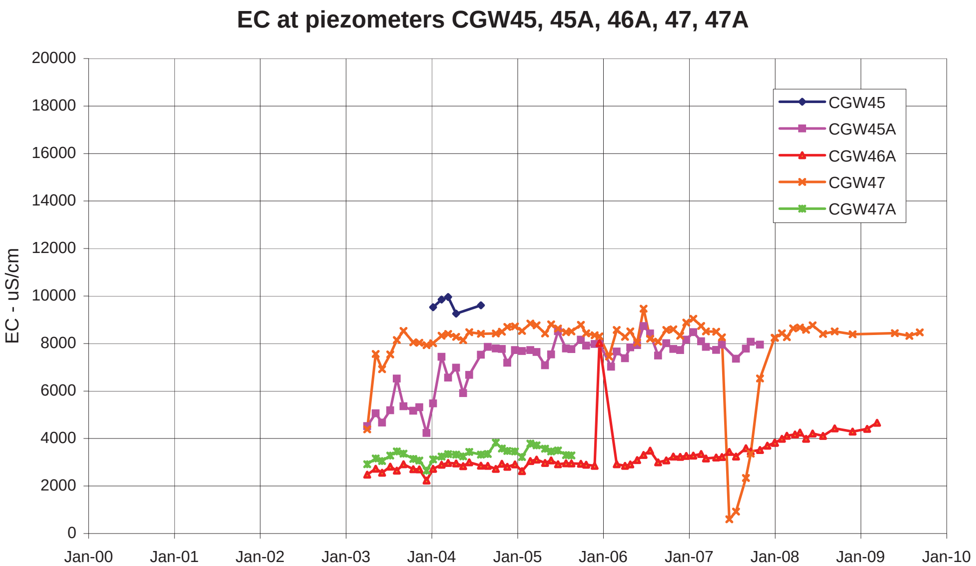


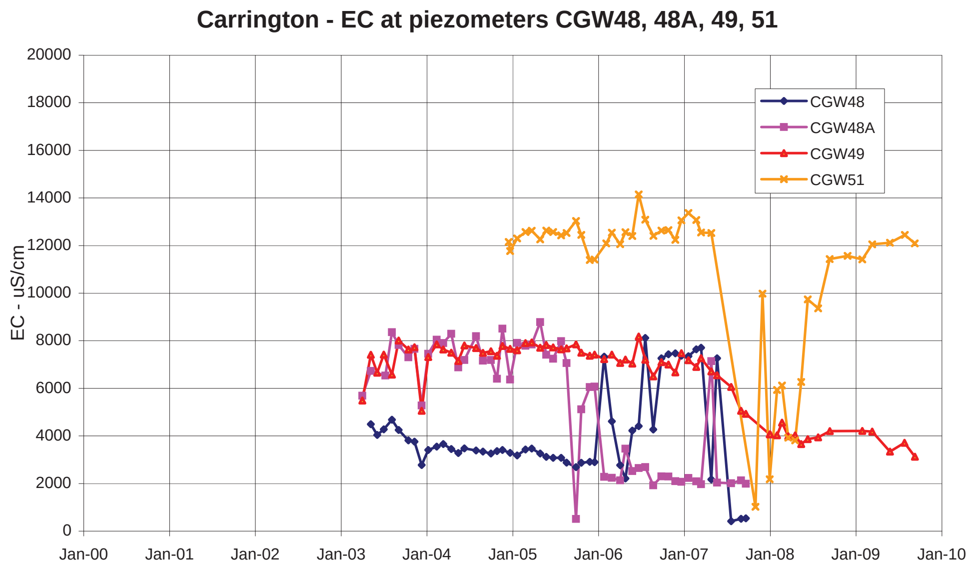


pH and EC data
Figure B3

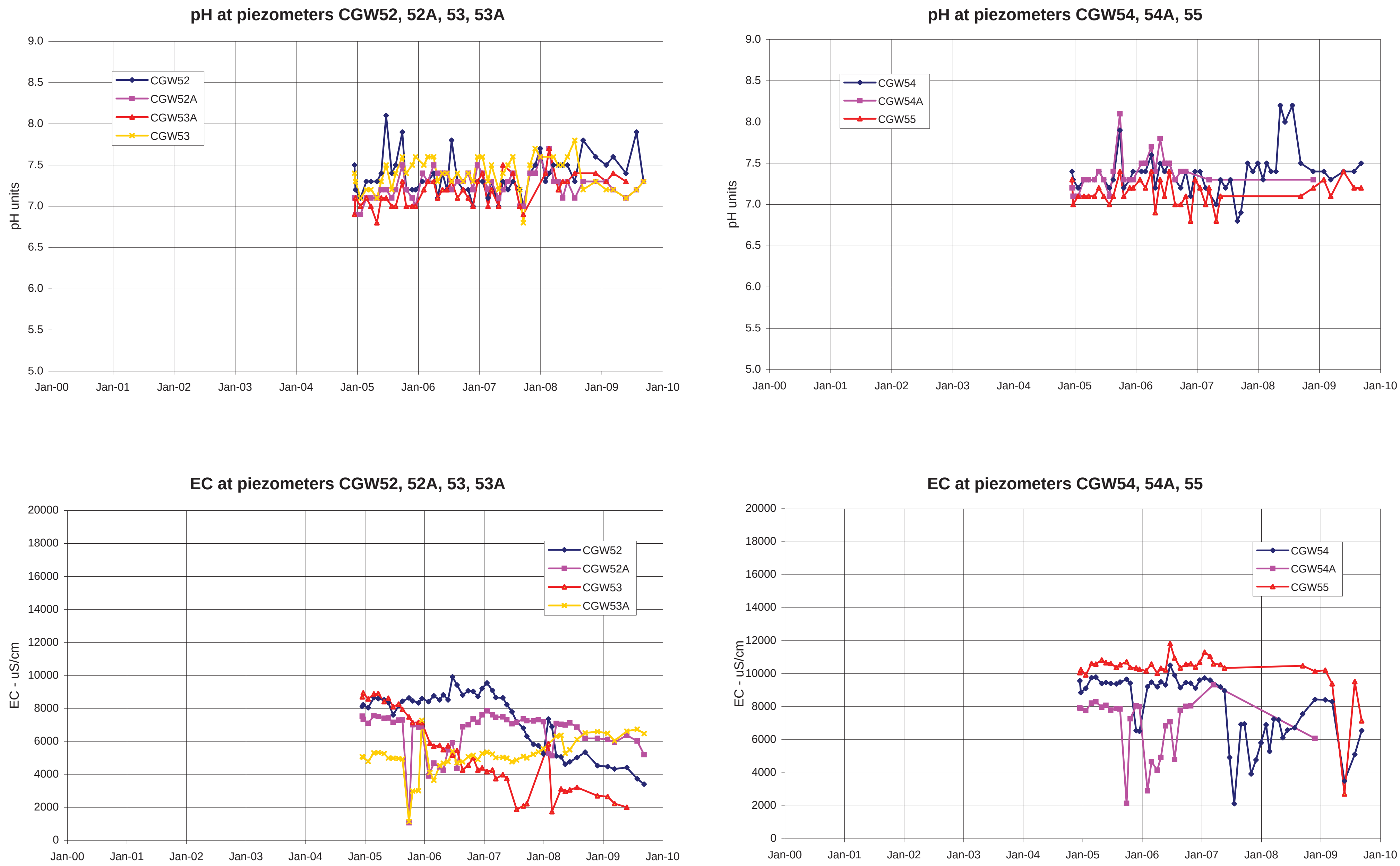






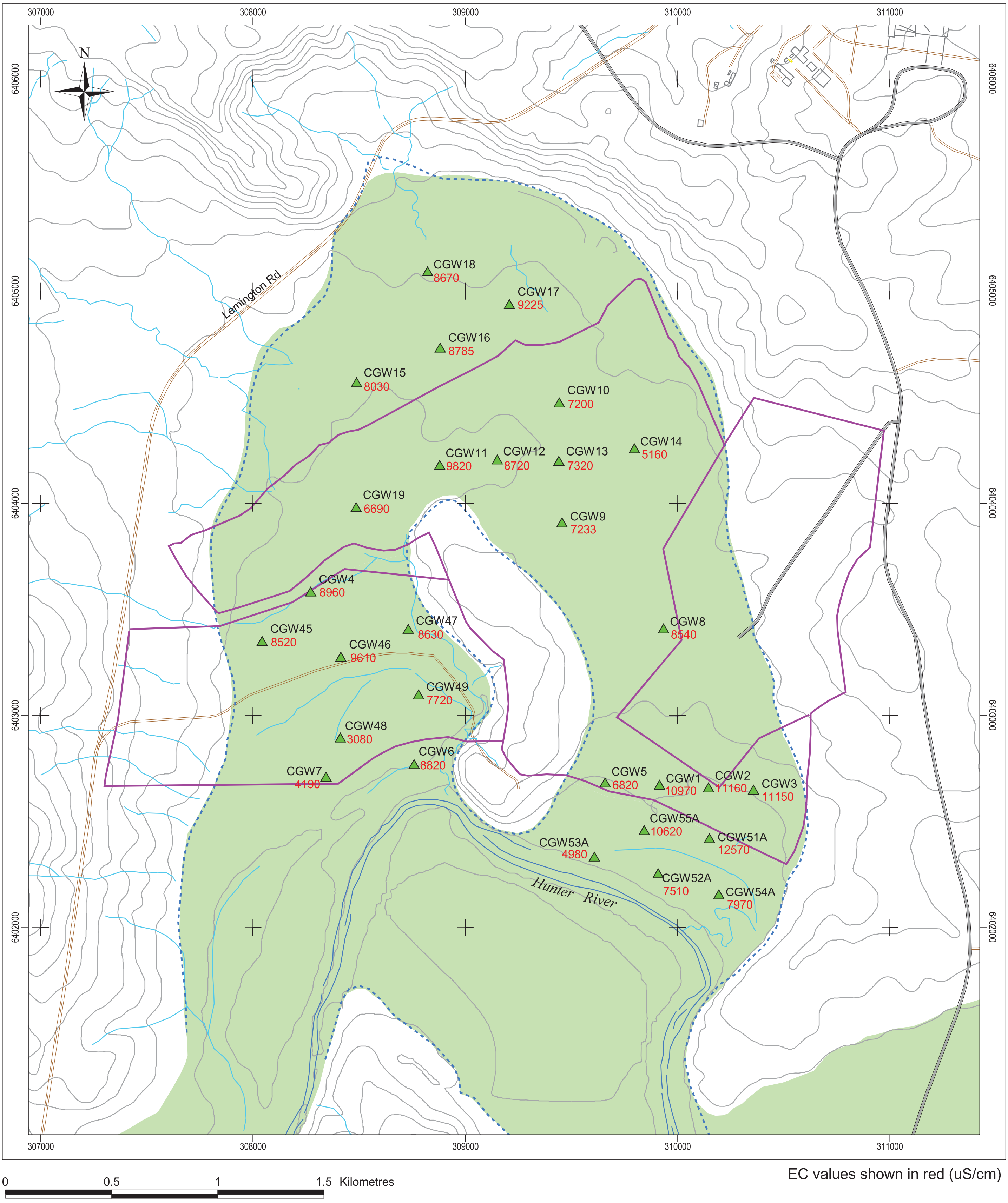


pH and EC data
Figure B3



pH and EC data

Figure B3



EC values shown in red (uS/cm)

- alluvium
- Current and proposed pit crests
- haul roads
- approximate paleochannel extents
- pre-mining topography (10m contour interval)
- ephemeral drainage
- site road
- main road

CARRINGTON WEST WING EXTENSION GROUNDWATER STUDY

Measured pre-mining EC based on 2000-2004 historical monitoring

Figure B4

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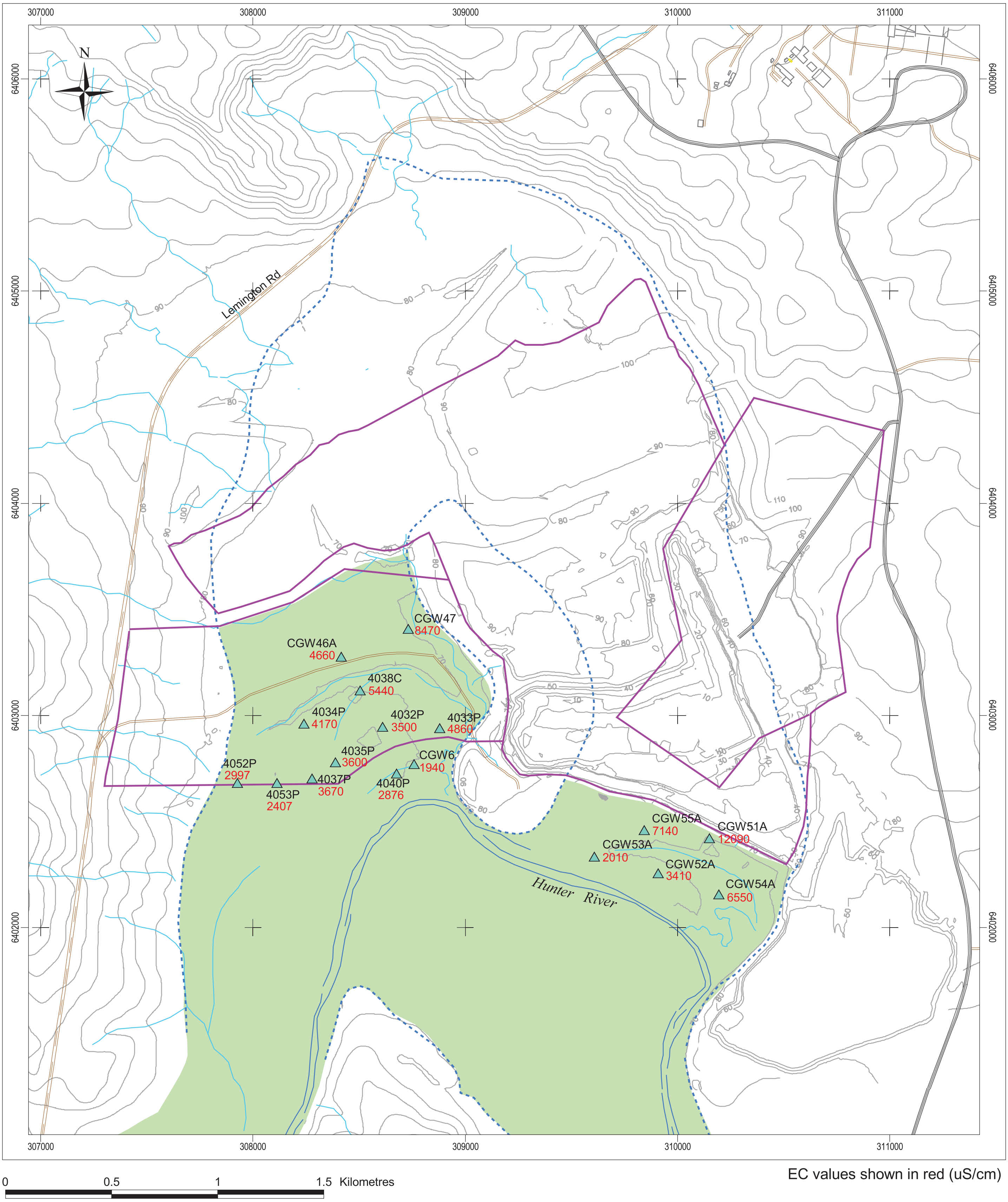

EC values shown in red (uS/cm)

- alluvium
- Current and proposed pit crests
- haul roads
- approximate paleochannel extents
- pre-mining topography (10m contour interval)
- ephemeral drainage
- site road
- main road

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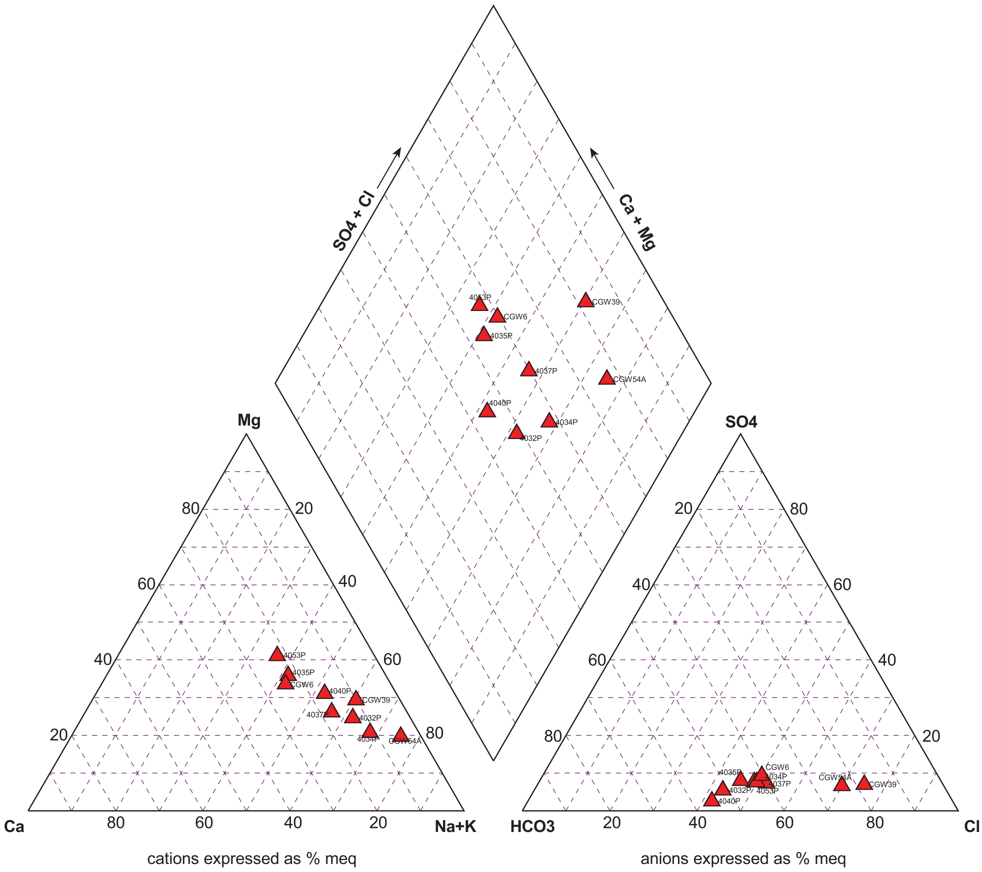
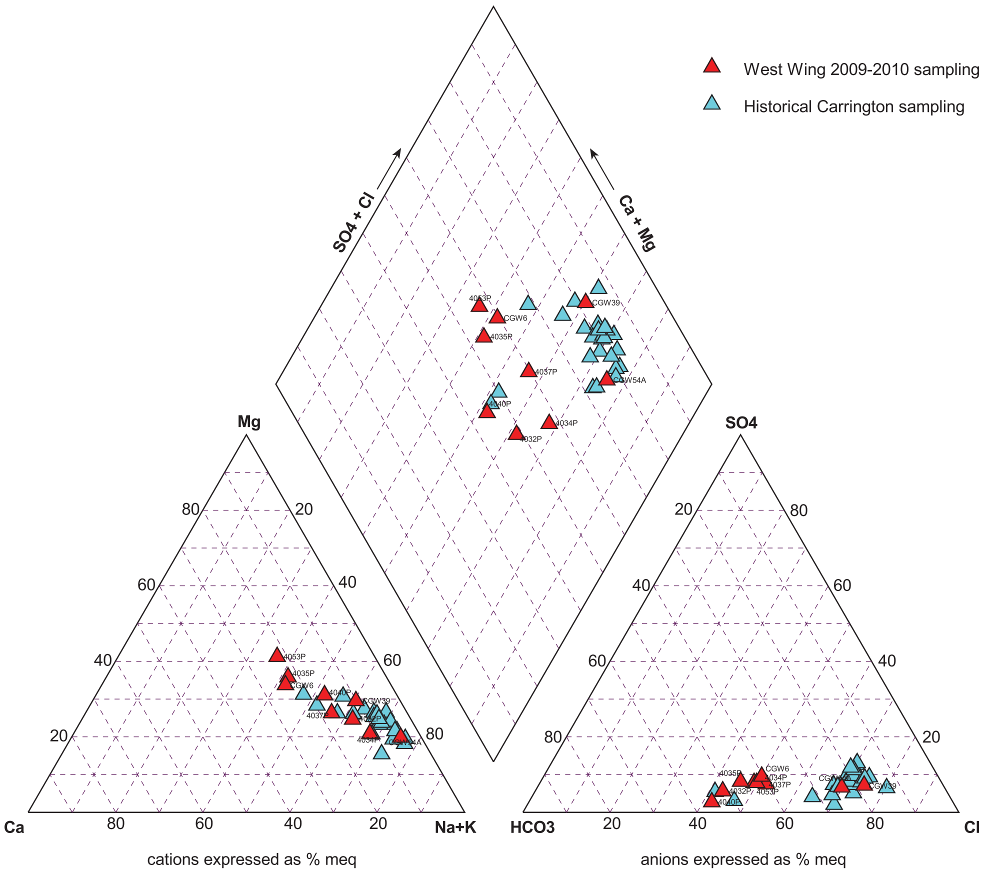
CARRINGTON WEST WING EXTENSION GROUNDWATER STUDY

Measured EC based on 2009-2010 historical monitoring

Figure B5





CARRINGTON EXTENDED - WATER MANAGEMENT STUDIES

Speciation of major ions for groundwaters

Figure B6

APPENDIX C: STRATA HYDRAULIC PROPERTIES

Aquifer testing provides a means of estimating the groundwater transmission and storage characteristics of the coal measures and shallow alluvium. Various procedures can be employed depending upon the saturated aquifer thickness, regional extent, transmission properties and bore completions. Procedures in the Carrington area and surrounding project areas have included airlift measurements in exploration holes (Ravensworth West open cut), packer testing of coal seams and other selected strata (MER, 2009), and laboratory core testing of interburden (see Figure C1 for locations).

C1.1 Interburden air lift measurements

MER (1997) reports airlift measurements at numerous bore locations conducted as part of exploration drilling down to the Bayswater seam for the Ravensworth West pit. These tests provide a first approximation to the hydraulic conductivity of strata and are generally biased towards the coal seams or to joint and fracture enhancement of permeability since the interburden (sandstones, siltstones etc.) exhibit very low hydraulic conductivities. Table C1 provides a summary and suggests seam conductivities are in the range 1.0E-04 to 1.0E-01 m/day.

C1.2 Interburden core tests

Laboratory core testing provides a means of determining the hydraulic conductivity of materials at an intergranular scale consistent with porous media flow. This estimate is typically the lowest conductivity for a specific rock type and is most representative of strata where fracturing and jointing are absent, or where fractures and joints are present but relatively disconnected and unlikely to enhance the bulk permeability of strata.

Core has been previously examined and tested by MER (1997, 2003) at borehole locations identified as RW1536C, RW1540C, RW1543C, RW1547C in the Ravensworth West pit area and EL5423 just north of the project area (see Figure C1). In addition, core from borehole locations 4036C and drilled as part of the current study, was inspected and representative samples taken from sections displaying relatively uniform properties in respect of rock type, grain size and cementation. These samples comprised sandstones, siltstones and claystones.

All recent core samples were tested by Core Laboratories Australia at a confining pressure of 5.5 MPa. The test method employed helium gas as the test 'fluid' and generated an estimate of Klinkenberg permeability (K_{inf}). Conversion has provided a measure of the saturated hydraulic conductivity at 20^{o}C. Results are summarised in the following Table C2 together with a summary of similar earlier testing in the region. The low hydraulic conductivities are consistent with results of similar tests conducted at numerous locations throughout the Upper Hunter region.

All data has been used to generate the histograms shown in Figure C2 which are based on results sorted by lithology. A ratio of anisotropy (Kxy/Kz) of 2 has been used in order to generate both Kxy and Kz estimates.

C1.3 Alluvium pump and falling head test

Pumping tests in piezometers installed in the paleochannel alluvium, were conducted at boreholes CGW1 to CGW10 (MER, 1999). More recently, slug tests were undertaken in piezometers 4032P to 4053P installed in the West Wing extension area. The KGS analytical method has been used to generate estimates of permeability. Results are summarised in Table C3.

Table C1: Permeability estimates from regional air lift tests

Bore	Q	Drawdown	Kd	K
	L/sec	m	kL/day/m	m/day
RW1501	0.28	46.5	6.3E-01	1.4E-02
RW1502	0.32	35.5	9.5E-01	2.7E-02
RW1503	0.08	31	2.7E-01	8.8E-03
RW1504	0.37	36	1.1E+00	3.0E-02
RW1505	0.37	35.5	1.1E+00	3.1E-02
RW1506	0.22	15.5	1.5E+00	9.7E-02
RW1508	0.04	19.5	2.2E-01	1.1E-02
RW1510	0.14	27.5	5.4E-01	2.0E-02
RW1511	0.04	9	4.7E-01	5.2E-02
RW1513	0.45	24	2.0E+00	8.2E-02
RW1516	0.18	23.5	8.1E-01	3.4E-02
RW1517	0.22	58	4.0E-01	6.9E-03
RW1518	0.45	45	1.1E+00	2.3E-02
RW1519	0.32	35	9.6E-01	2.8E-02
RW1522	0.45	84	5.6E-01	6.7E-03
RW1523	0.08	64	1.3E-01	2.1E-03
RW1525	0.22	65	3.6E-01	5.5E-03
RW1527	0.08	57	1.5E-01	2.6E-03
RW1528	0.02	55	3.8E-02	7.0E-04
RW1530	0.08	80	1.1E-01	1.3E-03
RW1531	1.82	87	2.2E+00	2.5E-02
RW1532	0.24	88	2.9E-01	3.3E-03
RW1533	0.14	91	1.6E-01	1.8E-03
RW1534	0.57	78	7.7E-01	9.9E-03
PC7505	0.04	27	1.6E-01	5.8E-03
PC7506	0.04	12.5	3.4E-01	2.7E-02
PC7507	0.22	20	1.2E+00	5.8E-02
PC7508	0.14	20.5	7.2E-01	3.5E-02
PC7509	0.09	25	3.8E-01	1.5E-02
PC7510	0.22	23	1.0E+00	4.4E-02
PC7513	0.05	31	1.7E-01	5.5E-03
PC7515	0.14	29	5.1E-01	1.8E-02
PC7516	0.14	31.5	4.7E-01	1.5E-02
PC7517	0.08	21	4.0E-01	1.9E-02
PC7518	0.06	19	3.3E-01	1.8E-02
PC7519	0.1	34	3.1E-01	9.1E-03
PC7531	0.2	13.5	1.6E+00	1.2E-01

Table C2: Permeability estimates from core tests

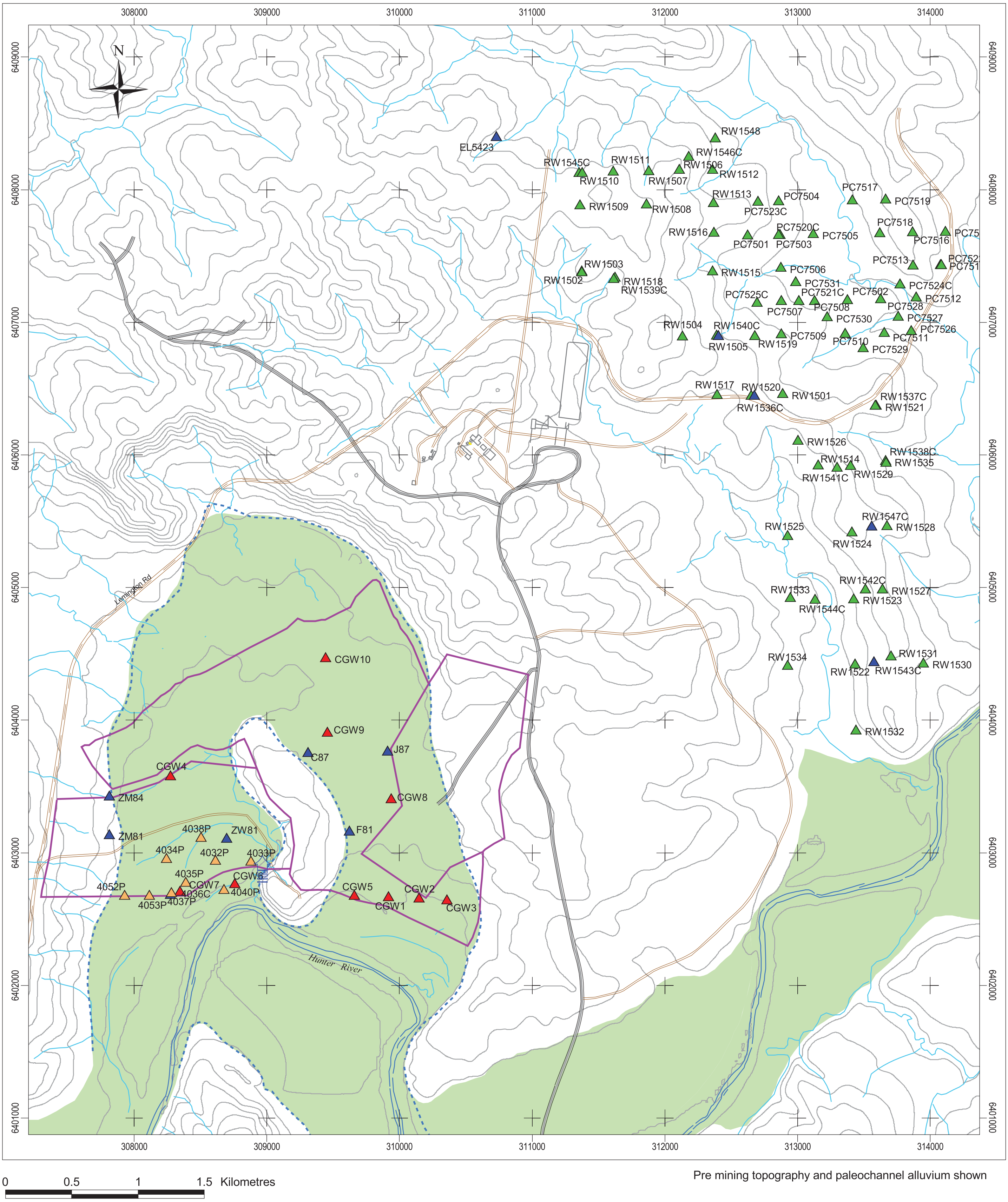
Bore ID		Depth m	Description	Stratigraphic location	Kxy (m/day)	Kz (m/day)
EL5243	C&A West Pit	13.8	sandstone, fine grained with siltstone bands	between Lemington seams	7.67E-06	6.60E-06
		33.3	sandstone, fine grained with siltstone bands	between Lemington seams	4.92E-06	
		47.6	sandstone, fine grained with siltstone bands	between Lemington seams		2.16E-06
		66.3	sandstone, fine grained	between Pikes Gully seams	1.00E-05	2.57E-06
		77	siltstone with finer silty bands	below Pikes Gully seams		2.03E-06
		86	sandstone, medium to fine grained	above Arties seam		1.20E-05
		101.4	sandstone with silty bands	between Arties seam	1.05E-05	3.74E-06
		115	siltstone, laminated	below Arties seam		8.00E-07
		117.5	sandstone, siltstone interbedded	below Arties seam		1.18E-06
		126.4	sandstone, medium grained	above Liddell seam	4.60E-05	
		145.6	sandstone, medium grained, carb. Lams.	between Liddell seam	2.80E-06	2.46E-06
		166.3	sandstone, medium grained, carb. Lams.	above Barrett seam	2.67E-06	
		178	sandstone, medium grained, carb. lams	below Barrett seam	1.66E-06	1.49E-06
1536C	Ravensworth West O/C	70.3	sandstone, medium grained	Archerfield sandstone	1.25E-05	1.99E-05
		52.3	Siltstone	between Broonie seams	2.49E-06	
1540C	Ravensworth West O/C	56.5	sandstone, medium grained	between Broonie seams	2.32E-05	1.08E-05
		51.6	sandstone, medium grained	between Broonie seams	3.82E-05	2.82E-05
		97.5	Siltstone	above Bayswater seam		8.30E-07
1543C	Ravensworth West O/C	60.9	sandstone, with siltstone bands	between Broonie seams	8.30E-07	8.30E-07
		90.5	sandstone, medium to fine grained	between Broonie seams		5.93E-06
		91	sandstone, medium grained	between Broonie seams	1.25E-05	7.47E-06
1547C	Ravensworth West O/C	63	sandstone, medium grained	between Broonie seams		1.58E-05
		59	sandstone, medium grained	between Broonie seams		5.06E-05
		84.1	sandstone, coarse grained	between Broonie seams	1.29E-04	1.11E-04
		88.9	sandstone, medium grained	Archerfield sandstone	8.30E-06	
C87	Carrington O/C	45	sandstone, medium to fine grained	between Broonie seams	4.76E-04	4.10E-05
F81	Carrington O/C	34.9	sandstone, with silty bands	above Broonie seam	4.19E-06	3.46E-06
J87	Carrington O/C	52	sandstone, medium grained	between Broonie seams	4.57E-05	3.02E-05

Bore ID		Depth m	Description	Stratigraphic location	Kxy (m/day)	Kz (m/day)
		62.5	sandstone, medium grained	between Broonie seams	3.15E-04	2.04E-04
ZM81	Carrington O/C	51	sandstone, medium grained	above Bayswater seam		2.13E-05
ZM84	Carrington O/C	33.2	sandstone, medium grained weathered	between Broonie seams	8.07E-03	2.32E-03
		35.8	sandstone, medium grained weathered	between Broonie seams	6.77E-03	2.37E-03
ZW81	Carrington O/C	63	sandstone, medium grained	above Bayswater seam	4.60E-04	5.08E-04
4036C	Carrington West Wing	18.6	sandstone, grey, medium grained quartzose, well cemented	between Broonie and Bayswater	1.39E-03	9.13E-04
		25.6	sandstone, grey, medium grained quartzose, well cemented	between Broonie and Bayswater	1.64E-03	1.62E-03
		27.7	sandstone, light grey, medium grained quartzose, well cemented	between Broonie and Bayswater		6.24E-04
		32.4	sandstone-laminite, grey to dark grey, medium to fine grained, quartzose	between Broonie and Bayswater		2.15E-04
		39.7	siltstone, grey, with weak banding of fine grained sandstone, quartzose	between Broonie and Bayswater		1.81E-04
		45.6	sandstone, light grey, medium grained quartzose, well cemented	between Broonie and Bayswater		1.39E-03
		54.9	sandstone, grey, fine grained quartzose with weak banding of siltstone	between Broonie and Bayswater		2.79E-05
		56.4	sandstone, grey, fine grained quartzose with weak banding of siltstone	between Broonie and Bayswater		3.64E-04
		65.3	sandstone, grey, coarse to medium grained lithic, well cemented	between Broonie and Bayswater	7.84E-04	3.27E-04
		70.6	siltstone, grey, with weak banding of fine grained sandstone, quartzose	between Broonie and Bayswater		2.20E-04
		74.4	sandstone-laminite, grey to dary grey, medium to fine grained, quartzose	between Broonie and Bayswater		2.64E-04

Table C3: Permeability estimates from pumping and slug tests

Borehole	Material	Kxy m/day	Sy
4032P	alluvium	1.30E+01	1.60E-01
4033P	alluvium	8.60E+00	2.20E-01
4034P	alluvium	2.60E-01	7.20E-05
4035P	alluvium	7.00E-01	4.50E-04
4037P	alluvium	6.90E+00	1.30E-01
4038P	alluvium	5.20E-01	6.00E-05
4040P	alluvium	3.70E-06	5.00E-05
4052P	alluvium	1.50E+02	6.00E-04
4053P	alluvium	9.50E+01	3.30E-02
CGW1	alluvium	5.70E+00	nd
CGW2	alluvium	5.00E-01	nd
CGW3	alluvium	1.50E+00	nd
CGW4	alluvium	3.10E+00	nd
CGW5	alluvium	1.43E+01	nd
CGW6	alluvium	5.50E+01	nd
CGW7	alluvium	7.20E+00	nd
CGW8	alluvium	1.99E+01	nd
CGW9	alluvium	3.52E+01	nd
CGW10	alluvium	9.30E+00	nd

nd = not determined



Pre mining topography and paleochannel alluvium shown

alluvium

current and proposed pit crests

haul roads

approximate paleochannel extents

pre-mining topography (10m contour interval)

ephemeral drainage

site road

main road

airlift test in exploration hole

laboratory core test

pumping test

slug test

CARRINGTON WEST WING EXTENSION GROUNDWATER STUDY

Permeability test locations

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Figure C1

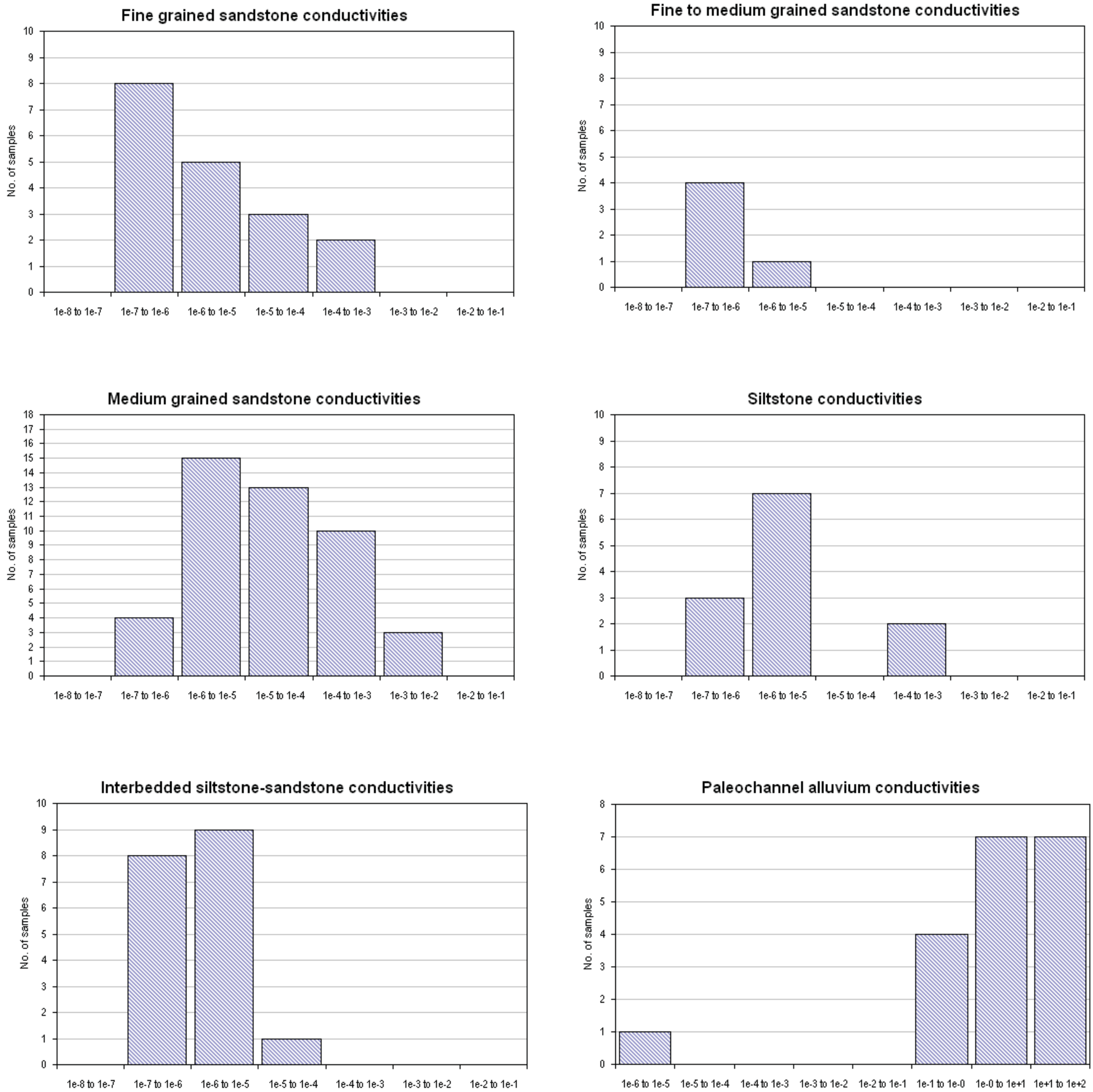

Fine grained sandstone conductivities
Fine to medium grained sandstone conductivities
Medium grained sandstone conductivities
Siltstone conductivities
Interbedded siltstone-sandstone conductivities
Paleochannel alluvium conductivities
No. of samples
1e-8 to 1e-7
1e-7 to 1e-6
1e-6 to 1e-5
1e-5 to 1e-4
1e-4 to 1e-3
1e-3 to 1e-2
1e-2 to 1e-1
1e-1 to 1e-0
1e-0 to 1e+1
1e+1 to 1e+2

Figure C2

APPENDIX D: AQUIFER NUMERICAL MODEL DEVELOPMENT

The application of computer based numerical models to problem solving in groundwater engineering provides a powerful tool for the rationalization of spatially and temporally varying field conditions. The modelling process utilizes a system of mathematical equations for water flow through porous media subject to prescribed boundary conditions. The process requires definition of the aquifer system in respect of geometry, hydraulic properties and applied stresses including rainfall, pumpage, creek and alluvium leakage and pit seepage.

MER (2005, 2007) utilised two groundwater models to assess impacts of the Carrington project. These were a single layer model representing the alluvium, and a four layer model representing the regional hardrock system. This approach expedited simulations of the alluvial aquifer system where the greatest interactions with the Hunter River were identified. The models utilised a finite difference scheme (ModFlow-Surfact).

The current model consolidates the earlier models into a single model utilising the same finite difference code but with a change in the co-ordinate system from ISG to MGA. The model scheme divides the overall area of interest into a large number of separate cells defined by a nodal point at the centre of each cell. The model is a variably saturated scheme and comprises 7 transversely anisotropic layers with 96000 cells per layer. Total modelled area is 110 sq. km with cell areas varying from 0.0625 ha (25 m x 25 m) to 0.25 ha (50 m x 50 m). Cells have been designed to give increased detail to the existing and proposed pit areas and drainages together with the alluvial aquifers associated with the Hunter River.

Four variations on the model have been utilised to represent different conditions:

- ***steady state conditions*** for the period before mining activity commences – employs basic model properties distribution;
- ***transient simulation of Carrington Pit*** - simulation of mining related depressurisation from the commencement of Carrington Pit in 2000 to the completion of the pit in 2010;
- ***transient simulation of the West Wing extension*** – same basic model properties distribution and time varying boundary conditions as above but including barrier walls across the paleochannel to isolate and mitigate river leakage;
- ***post mining recovery*** with a final void located in the north-eastern area of Carrington Pit. Transient recovery with changed material properties in the pit area and steady state simulations to design/assess the evaporative sink.

D1. Model geometry

Layer 1 represents the regional regolith and the alluvial deposits associated with the paleochannel and the Hunter River. Ground surface for the pre-mining steady state (top of layer 1) has been determined by direct interpolation from a regional digital terrain model. This model was generated at 10 m pixel resolution over the entire region from original 1:25000 data sourced from Department of Lands. The base of layer 1 is defined at 10 below the land surface for weathered rocks and the regolith, and 18m below the land surface in unmapped Hunter River alluvium areas. These two surfaces have been merged then adjusted to include the mapped paleochannel base. Merging of the data sets was achieved using spatial filtering techniques.

Remaining layers have been interpolated from regional stratigraphic horizons (as floor structure contours on key coal seams), or assigned in a manner that increases the vertical discretisation of the model for improved estimation of regional pore pressures.

Figure D1 provides perspectives of the model looking in north-easterly and north-westerly directions. These perspectives illustrate the easterly limb of the Muswellbrook Anticline, the southward dipping strata, local drainage lines and the course of the Hunter River.

D2. Model hydraulic properties

Permeabilities assigned to each model layer (excluding layer 1) have been calculated by a process of consolidation of geologically logged rock types, into representative model layers. The methodology involved calculation of the permeability distribution at borehole 4036C deemed as a ‘type borehole’ for the West Wing extension. Permeabilities considered to best represent different lithologies based on laboratory core analyses, were used in generating summary horizontal values (Kxy) for the different logged rock types - Table D1. These permeabilities were then used to develop full vertical profiles for borehole 4036C based on detailed core logging of strata for litho sections ranging in thickness from about 10 mm to more than 3 m. The full borehole profile was then analytically reduced to hydraulically equivalent permeabilities in both the horizontal and vertical directions for the stratigraphic layers adopted in the numerical model.

Permeabilities used as initial values in the numerical model, are summarised in Table D2. These values were then adjusted within a reasonably narrow range as part of the model calibration process discussed below. Layer 1 paleochannel alluvium permeabilities were adopted from prior modelling (MER, 2007) with changes in the western channel distribution (see Figure D2).

Table D1: Adopted permeabilities for different lithologies

Lithology	Kxy (m/day)
carb mudstone	1.0E-07
mudstone	1.0E-07
clay	2.0E-07
sand	2.0E-02
claystone/mudstone	2.0E-07
claystone/tuff	3.0E-07
siltstone lam	2.0E-06
siltstone	5.0E-06
sandstone lam	5.0E-06
siltstone cg	5.0E-06
shaley coal	1.0E-05
tuff	2.0E-05
sandstone vfg-fg	5.0E-05
sandstone fg	7.0E-05
sandstone fg-mg	9.0E-05
sandstone	1.0E-04
sandstone cg-fg	2.0E-04
sandstone mg	2.0E-04
coal dull	8.0E-03
sandstone cg-mg	3.0E-04
coal dull numerous bright bands	3.0E-02
sandstone cg	5.0E-04
sandstone mg-vcg	5.0E-04
sandstone vcg-cg	8.0E-04
coal dull minor bright	1.0E-02
stony coal	3.0E-03
coal dull and bright	2.0E-02
conglomerate	3.0E-03
coal bright minor dull	4.0E-02
coal bright	6.0E-02

Compressible storage (S_s) has been estimated from regional data (Mackie, 2009). A specific storage range from 1.0E-06 to 5.0E-05 1/m has been calculated for a modulus range from 18 down to 1 GPa. Values for certain strata were then adjusted slightly (within an expected range) during the model re-calibration process.

Specific yield estimates for the paleochannel alluvium have been incorporated from previous modelling. Permian strata specific yields are assumed to be very low based on a permeability-porosity relationship derived for Permian coal measures elsewhere.

Table D2: Hydraulic properties assigned to the aquifer model

Model Layer	Strata	Kxy (m/day)	Kz (m/day)	Ss (1/m)	Sy
1	regolith	1.0E+00	1.0E+00	1.0E-05	1.0E-02
1	alluvium	1.0E+00 to 8.0E+01	1.0E+01	1.0E-05	5.0E-02
2	PCM	5.0E-04	8.0E-05	3.0E-06	3.4E-03
3	PCM	1.0E-03	6.6E-05	3.0E-06	3.5E-03
4	PCM	5.1E-04	1.1E-05	2.0E-06	3.0E-03
5	PCM	1.1E-03	2.4E-05	2.0E-06	3.4E-03
6	Bayswater	6.0E-02	2.6E-04	3.0E-06	1.0E-02
7	PCM	5.0E-04	2.0E-05	2.0E-06	5.0E-03

Kxy = horiz. permeability, Kz = vert. permeability, Ss = specific storage, Sy = drainable porosity, PCM=Permian coal measures

D3. Model boundary conditions

Boundary conditions assigned to the aquifer model are those conditions that constrain or bound the model domain mathematically. Such conditions have been applied to the physical outer boundary of the model and throughout internal parts of the model.

Constrained fixed head river conditions have been imposed along the Hunter River (see Figure D3a). These conditions enforce seepage from surrounding areas of elevated water table to the river, or seepage from the river to surrounding strata if the piezometric elevations in those strata are lower than the river level. River bed levels assigned to specific model cells in the Carrington reach have been adopted from survey of the river. A uniform cell conductance of 1.0E+02 m^2/day has been applied to the river cells for simplicity. This value governs the rate of removal of groundwater from the model and ensures relatively rapid model response to changes in the piezometric surface should groundwater interaction occur.

Constrained head drain cells have been used to represent all other creeks which are assumed to be ephemeral (see Figure D3a). Assigning these conditions allows the model water table to drain to the creek lines if the elevation of the groundwater surface is higher than the creek bed elevations, or to fall below the creek bed without inducing leakage from the creek. A uniform cell conductance of 1.0E+02 m^2/day has been applied for simplicity.

Drain cells have also been employed to represent open cut pit areas. The constrained head has been assigned an elevation at the base of specific cells in pit areas. These cells have been carefully scheduled to attract groundwater seepage in accordance with historical mining operations and the proposed mine plan. A uniform cell conductance of 1.0E+02 m^2/day has been applied for simplicity. This value ensures rapid and free drainage only when specific model cells are triggered to impose zero pore pressures consistent with the mining process.

Distributed flux conditions have been employed to represent regional rainfall recharge. This net recharge has been applied at differing rates depending on the shallow and surficial geology. The rates for the paleochannel areas have been determined from prior modelling (MER, 2007) and from steady state and transient simulation trials for alluvium and hardrock areas (Figure D3b).

D4. Model calibration – steady state

Calibration is the process involving adjustment of certain parameters until model generated groundwater flows and piezometric levels reasonably match the measured flows and levels. In adjusting parameters it is important to maintain reasonable correlation between 'calibrated' and measured aquifer properties.

Model calibration has been previously undertaken for the paleochannel alluvial system (MER2007). The process involved simulation of mining operations at Carrington and comparison of observed and predicted head and pressure distributions as part of a transient calibration process. The resulting permeability and storage parameters were imported directly into the new model which was then re-run to check the calibration. Adjustments to permeability and rainfall recharge were required in some areas of the model. Results of re-calibrations are demonstrated by hydrographic plots provided as Figure D4. The locations of these observation bores within the model domain are shown on Figure D3b

Recharge at a rate of 80 mm/annum (June 2007 rainfall event) has been applied to alluvial materials along the Hunter River. Recharge to hard rock strata is less than 0.1 per cent of average annual rainfall. In reality, there are likely to be some very shallow and localised higher permeability rock systems that may be perched in some elevated parts of the area. These systems will tend to be governed by localised weathering and jointing which facilitates higher rainfall recharge and probably supports occasional and localised springs and seeps. These systems are also likely to provide ineffectual recharge contributions to the deeper hard rock systems and have not been included in the numerical modelling effort.

Pre-mining steady state dry weather baseflow contributions to the Hunter River predicted by the model for the eastern and western arms of the paleochannel are 0.17 ML/day and 0.22 ML/day respectively. These southward flows are almost entirely within the alluvium and would have been higher during sustained periods of rainfall, and lower during drought conditions when water levels and hydraulic gradients subsided.

Currently (January 2010), the prevailing piezometric surfaces within the paleochannel alluvium support northwards flows in both the eastern and western channels towards the existing mine pits (see Figure 9). Flow rates in the alluvium are estimated to be of the order of 0.1 ML/day in the eastern channel and 0.2 ML/day in the western channel at the present time (no barriers). These flows are sourced predominantly from drainage of porous storage within the alluvium, supplementary rainfall recharge to the alluvium, and a small component from the Hunter River as leakage loss from baseflow.

Leakage emanating in the current pit highwall is generally observed as localised dampness and minor weeps. It is too low to measure by conventional weir or flow meter in a capture channel. Anecdotally, it would be consistent with (or lower than) the predicted rate of 0.1 ML/day for the eastern channel.

The impact of the June 2007 rainfall event is clearly evident in the leakage estimates. Future rainfall and flood events will also act to mitigate river leakage losses until the water table within the mined pit shell, recovers.

D6. Simulation of open cut mining in the West Wing extension

Future mining in the West Wing extension has been simulated by adopting the scenario described above as an initial condition. This subsequent West Wing model includes barrier walls across both the eastern and western channels prior to commencement of alluvium stripping in the area. These walls act to isolate long term exchange of groundwaters contained within the alluvial lands. As such northwards flow in the alluvium is predicted to reduce from a total of 0.3 ML/day (east + west channels) to zero. The walls have no impact on deeper flow systems within the Permian coal measures which continue to induce leakage (as baseflow) from the river. The permeability of the barrier walls is nominally 1.0E-06 m/day.

Mining progression over a period of 6 years has been simulated in the same manner as Carrington Pit with alluvium stripping (model layer 1) in advance of hardrock removal (model layers 2 through 6). The resulting impact on groundwater systems has been assessed by generating:

- water table plots for the alluvial aquifers beyond the mining area;
- piezometric head plots for the Bayswater seam;
- vertical sections showing pore pressures.

Figure D5 illustrates the water table surface (zero pore pressure) for the progression of mining at approximately 2 yearly intervals with the initial plot showing the water table immediately prior to stripping of the alluvium. Mining is planned to progress from west to east until the pit merges with the existing Carrington Pit. The water table plots illustrate progressive and complete dewatering of the pit area with negligible impact on the alluvial aquifers beyond the barrier walls. Steep hydraulic gradients are evident along the barrier walls.

Figure D6 provides the calculated drawdown in the water table over the same period. The drawdown has been calculated by subtracting each stage of mining (Figure D5) from the simulated pre-mining water table (prior to any mining in the Carrington area).

Figure D7 illustrates the progressive depressurisation of the Bayswater seam as piezometric heads while Figure D8 provides the calculated drawdown from pre-mining conditions. These plots clearly show the extensive depressurisation that has occurred within the seam as a result of mining in Carrington Pit and the adjacent North Pit (shallower Vaux seam floor) prior to extraction of coal in the West Wing extension.

Figure D9 provides pore pressure distributions at the end of mining in the West Wing extension for a south-north vertical section located at 308560E (see Figure D3a for location). The calculated pressures demonstrate the isolation of groundwater exchange within the alluvium by the presence of a barrier wall. Leakage at a relatively low rate remains evident through the coal measures strata. Figure D9b gives the pore pressure distribution for a west-east vertical section located at 640040N (see Figure D3a for location).

As noted previously, the barrier walls arrest northwards flow through the alluvial materials but depressurisation of strata nearby and below the river will continue to affect the baseflow of the river. Figure D10 provides the river seepage and leakage flux estimates for both the eastern and western channels derived from both the Carrington re-calibrated model and the subsequent West Wing extension model. The seepage component represents flows reporting to the river (river gains), while the leakage component represents flows from the river to the adjacent and underlying strata (river losses). Both seepage and leakage can prevail in a river reach at the same time due to differences in river stage. For this reason both types of flux are represented on the same plot. Where the two responses cross over, seepage is exactly balanced by leakage for the considered reach.

Reference to Figure D10 illustrates a trend from a river seepage system (gaining river) to a river leakage system over the course of mining in the western channel with a steady leakage loss rate of about 0.050 ML/day at the commencement of mining in the West Wing extension, and a slight decline of about 0.002 ML/day to about 0.048 ML/day after installation of the barrier wall in the alluvium. This slight change indicates most leakage loss will occur via the coal measures and that mining of the resource is unlikely to significantly affect baseflow losses in the Hunter River.

D7. Simulation of recovery of coal measures water table

Recovery of the water table within the coal measures has been simulated by adopting the regional groundwater head distribution at the completion of mining as the initial condition in a separate model, and allowing the that model to recover assuming all regional mining operations cease at the same time. Model hydraulic properties have been changed in the combined West Wing extension and Carrington Pit areas to reflect emplaced spoils where a conservative fragmentation permeability of 1 m/day has been assigned. An expected range is 1 to 20 m/day. A drainable porosity of 20 per cent has also been adopted – variation in this property affects the rate of recovery.

Rainfall infiltration through spoils has been applied at a rate of 5 per cent of annual rainfall or 32 mm/annum. Direct rainfall has been applied at an annual average rate of 640 mm over the final void area. Model simulations for these conditions indicate a recovery period of at least 50 years before a free water surface is sustained over the entire open void.

The long term equilibrated operation of the evaporative sink has been examined using a steady state simulation of the fully recovered system. The recovered water table is designed to exhibit a free water surface in the final void-sink at an elevation of 40 mAHD with flow gradients towards the sink from surrounding spoils within the pit shell. This open water elevation ensures that recovered groundwater levels in more distant parts (from the void) of the pit shell do not attain elevations above 65 mAHD which is the design crest of the barrier walls) – over-topping is not predicted.

D8. Sensitivity analysis

This type of analysis is often conducted in order to establish parameter sensitivity within a numerical model where calibration is undertaken against prevailing stressors within a system. Specific parameters like hydraulic conductivity or storativity are adjusted and the influence of those adjustments on the calibration, is measured by comparing the calculated error in matching the predicted piezometric heads in monitoring boreholes to the observed heads. Significant change in this measure is normally associated with parameters exhibiting the highest sensitivity. In this regard it is apparent from the adjustments made during the calibration process (over many re-calibrations) that the extent of model dewatering in the alluvium and pressurisation in the hardrock strata is more sensitive to hydraulic conductivities (Kxyz) than any other parameter. However with isolation of the mining operations through installation of barrier walls, the sensitivities with respect to the paleochannel alluvium, are less relevant while sensitivities with respect to vertical conductivity (Kz) throughout the coal measures, are more relevant.

D9. Factors affecting accuracy of numerical model

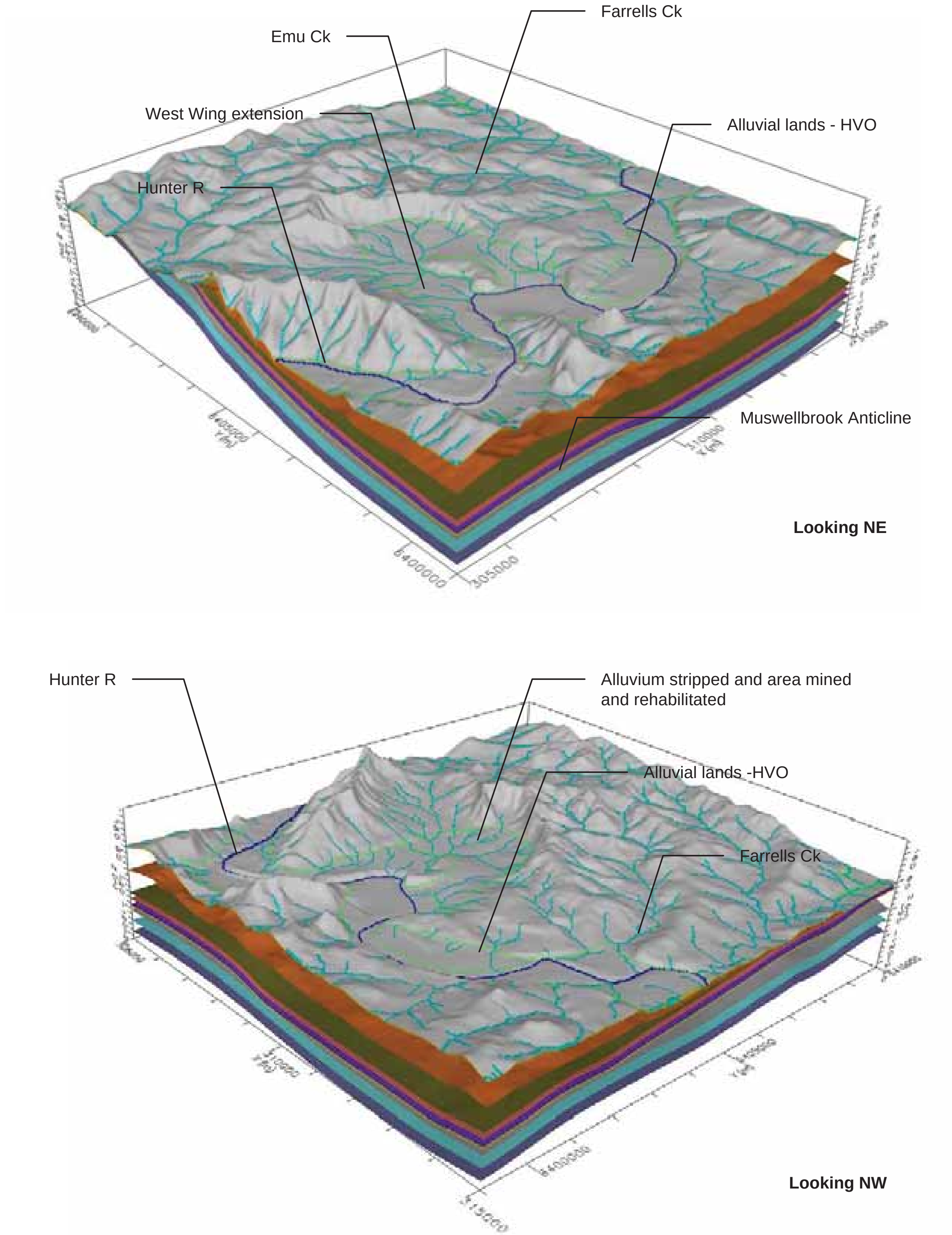
It is not possible to completely represent aquifer systems using numerical modelling methods due to the many complexities associated with natural processes, the discrete sampling of rock material properties that govern groundwater flow, and the limitations imposed by numerical modelling methods. A simplified representation of the aquifer systems is therefore required. While this has been undertaken in a measured and structured way in the current study, it is always possible that unidentified features of a system, or properties assigned to a particular part of the system, may affect predictions either more favourably or more adversely at some future time.

The numerical modelling effort has been designed and calibrated to account for conditions that have been observed over time. While the calibration is considered to be acceptable, the following constraints are noteworthy:

1. Key stratigraphic horizons in the model have been interpolated to reasonable accuracy within the project area but data beyond this area is drawn from information supplied in previous EIS and EA documents. In some areas where no data is available, projections supported by hand contouring have been invoked in order to extend stratigraphic horizons to the aquifer model boundaries. It is possible that these surfaces may affect predictions of groundwater flow and mining related impacts to some extent.
2. Adopted model permeabilities for hard rock strata tend to reflect core measurements based on the assumption that permeabilities are matrix dominated rather than fracture dominated. This is consistent with observations of drillhole core where fractures are observed to be generally infrequent except occasionally at shallower depths where strata are less confined. If fracture flow is the dominant mechanism in a particular (but unidentified) area then piezometric head distributions and groundwater flows may differ from those derived from the current model.

3. Permeabilities are known to reduce with increasing effective stress which will result from strata depressurisation. Such reductions have not been included in the model due limitations of the model code. The model predicted extent of depressurisation at a given time may therefore be greater in some areas, than may be measured under future field conditions. This may be the case for the Bayswater and Broonie seams where increasing confinement beneath and south of the river, could serve to reduce permeabilities. Any reductions in permeability would act to reduce leakage losses from the overlying river-alluvium.
4. Boundary conditions applied to the model drainage network are fixed head (constrained to simulate drain or river type boundaries according to Hydrogeologic, 1996). Assigned heads beyond the river reach adjacent to the project area, are derived from the gridded regional topography data set. Where drainages are incised and the drainage axis does not coincide with the digital terrain grid, the topographic data commonly fails to accurately reflect stream bed elevations and hence assigned heads could be in error by as much as 1 m or more depending upon the terrain and the interpolating algorithm. These heads ultimately govern the model ‘calibrated’ steady state water table which may not agree with field measured conditions everywhere. Since the error cannot be determined at each location, it is retained within the modelling process. However the consequences are considered to be minor.

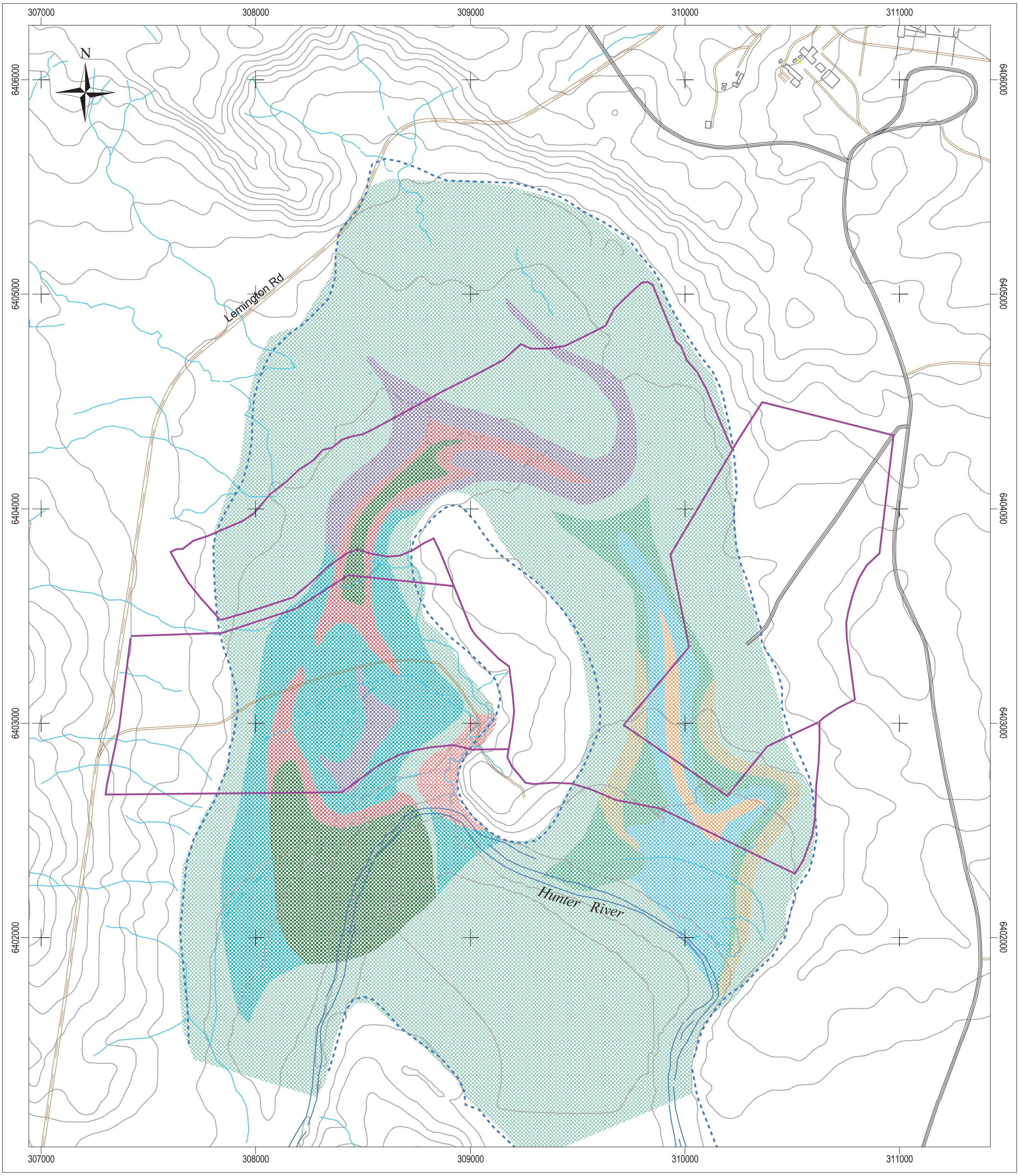
In addition to the above noted constraints, numerical model predictions are inevitably affected by increasing uncertainty for longer prediction intervals. The prediction error is governed by a multitude of variables associated with all of the elements of model input – the more accurately the inputs reflect field conditions, the more accurate the output predictions will be. Model verification therefore becomes an important post analytical procedure and is strongly recommended.



1 Model comprises 9 layers
2 Layer slices shown – top slice is pre-mining topography
3 Coal seams not shown
4 Ephemeral drainage system in light blue, alluvium outline in green

Groundwater model perspectives

Figure D1



Final distribution based on groundwater model calibration

0 0.5 1 1.5 Kilometres

1 m/day	15
5	25
6	30
7	50
12	80

- Current and proposed pit crests
- haul roads
- approximate paleochannel extents
- pre-mining topography (10m contour interval)
- ephemeral drainage
- site road
- main road

CARRINGTON WEST WING EXTENSION GROUNDWATER STUDY

Pre-mining paleochannel permeability distribution

Figure D2

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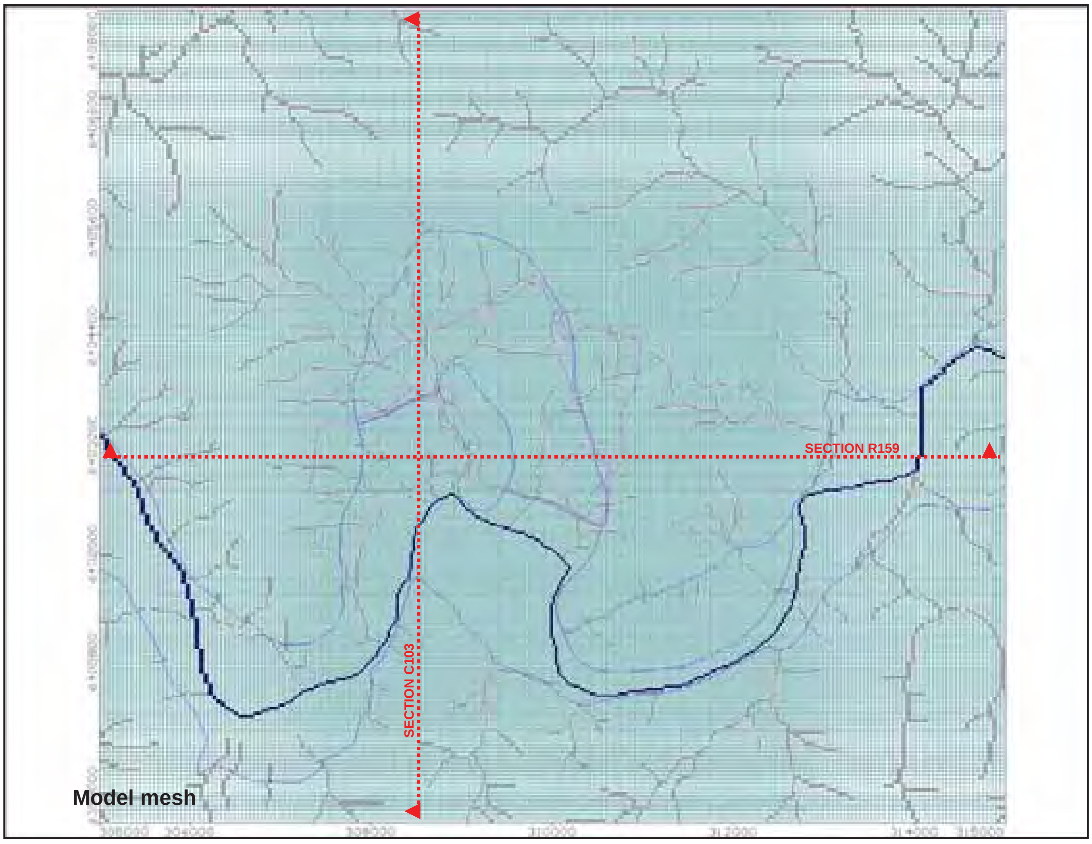
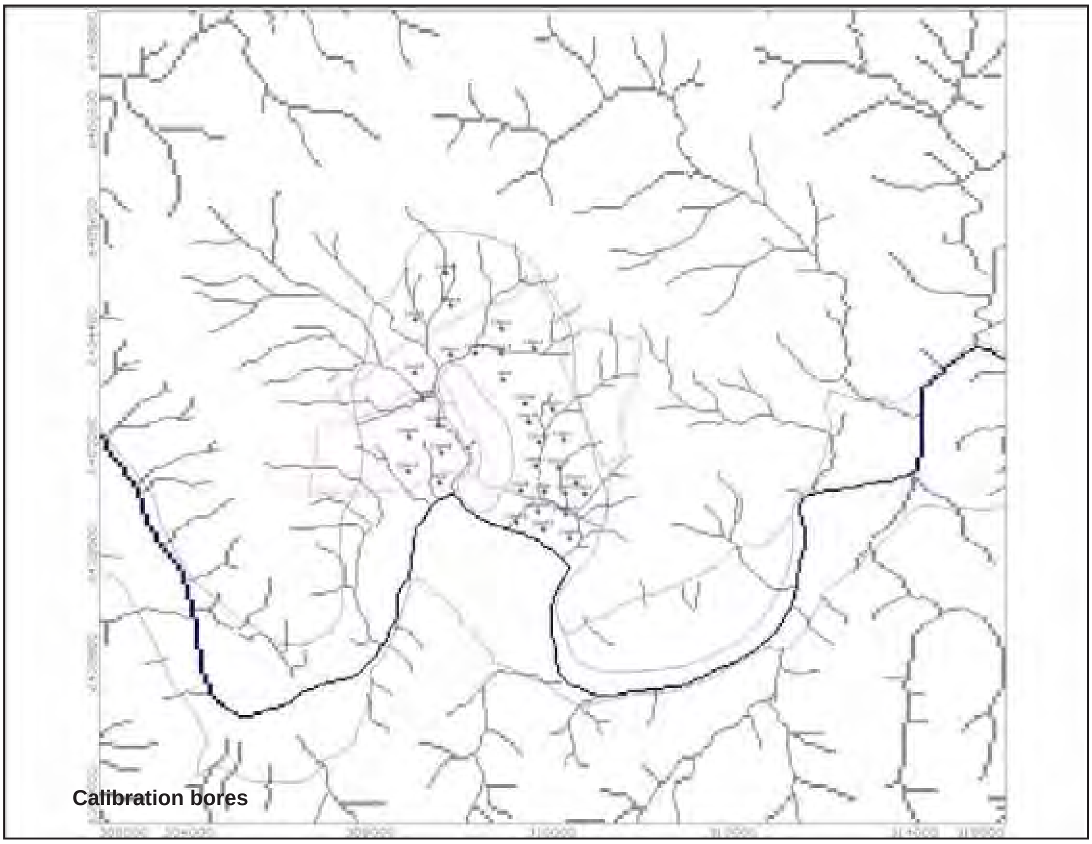
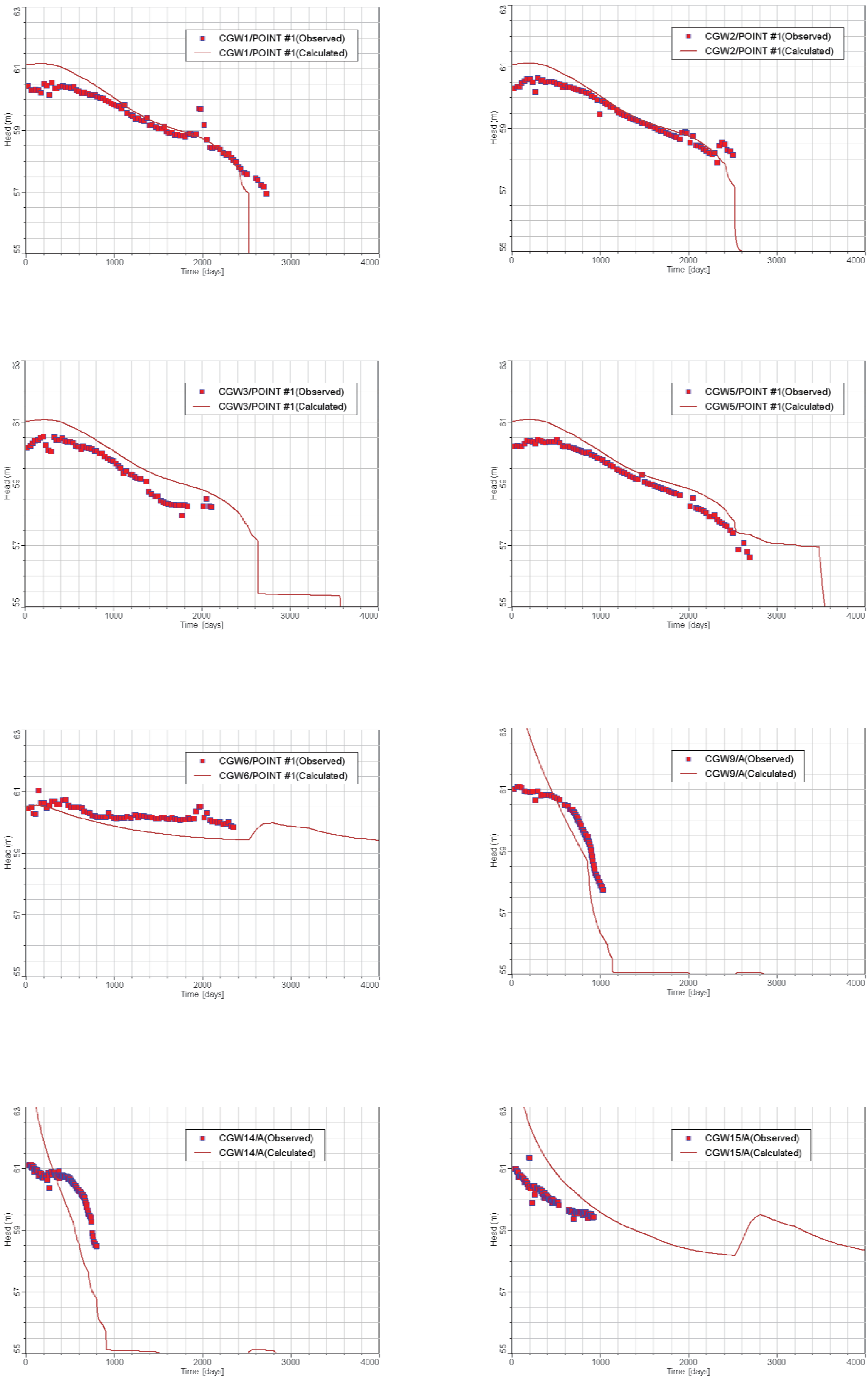




Groundwater model mesh and boundary conditions

Figure D3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CGW5/POINT #1(Calculated)
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CGW6/POINT #1(Calculated)
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CGW9/A(Calculated)
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CGW15/A(Observed)
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Head (m)
Time [days]
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57
59
61
63
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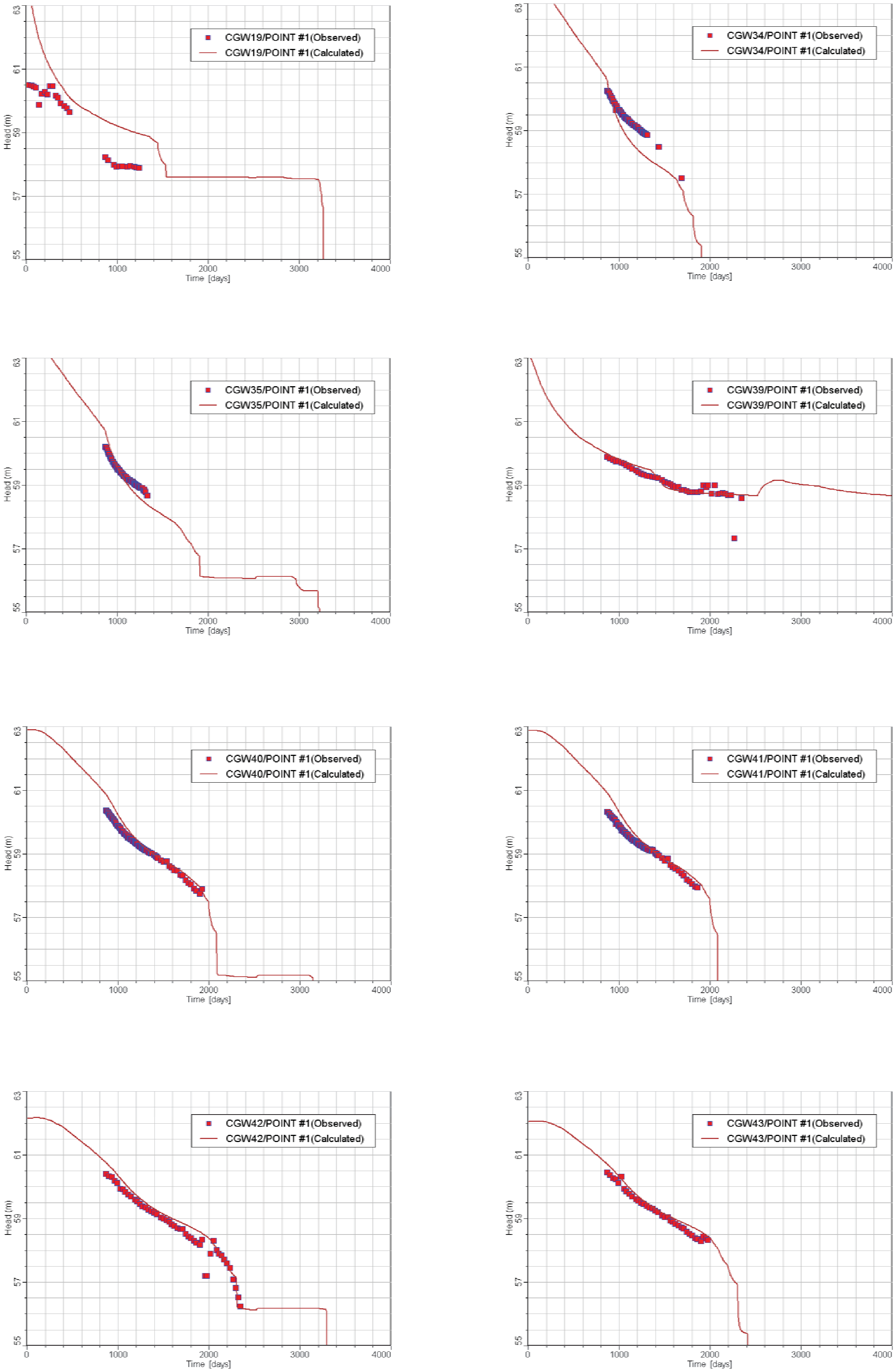
1000
2000
3000
4000

Figure D4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CGW43/POINT #1(Observed)
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Time [days]
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3000
4000
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57
59
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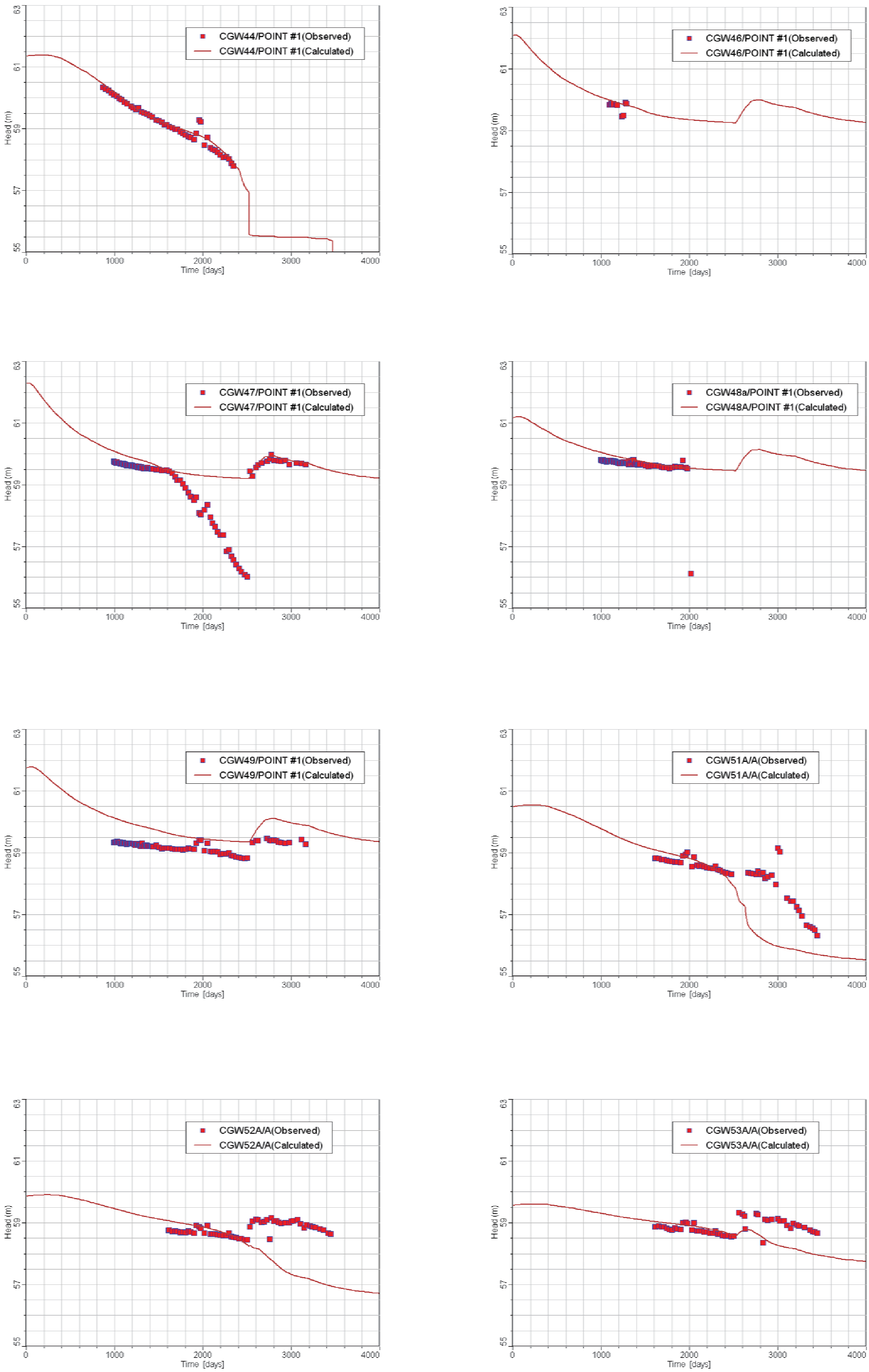
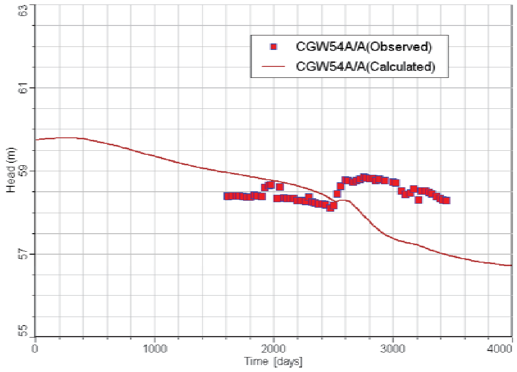
63



Mackie Environmental Research

Figure D4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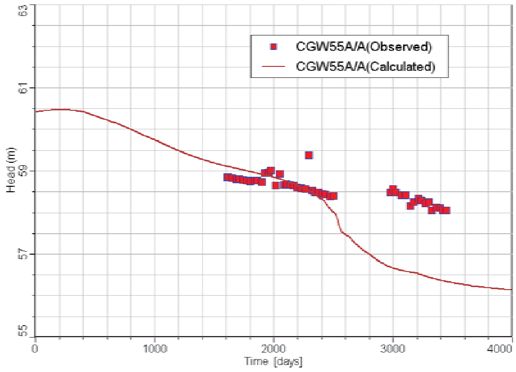
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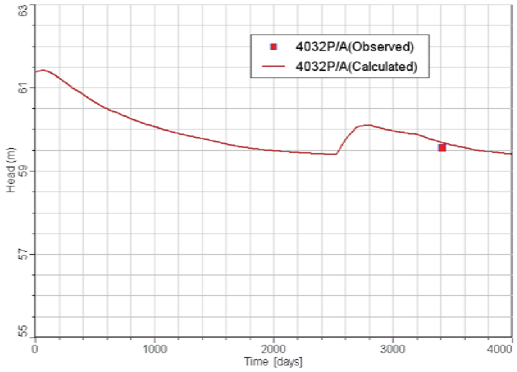
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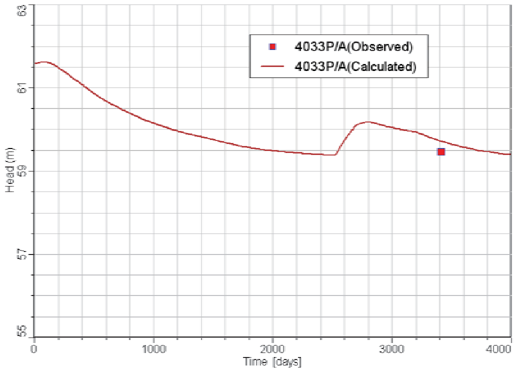
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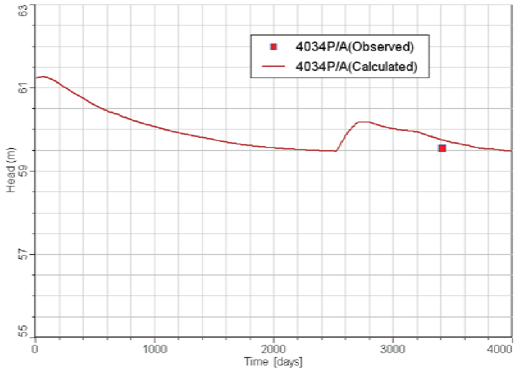
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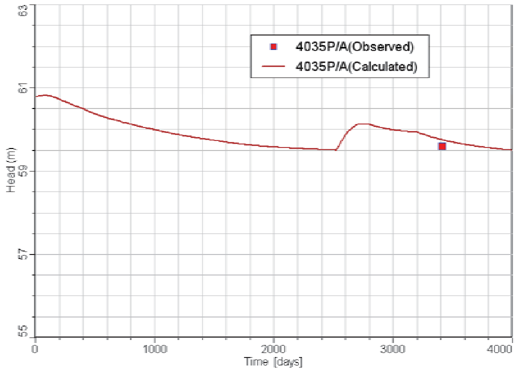
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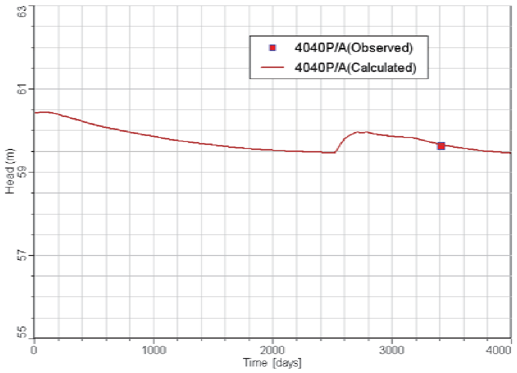
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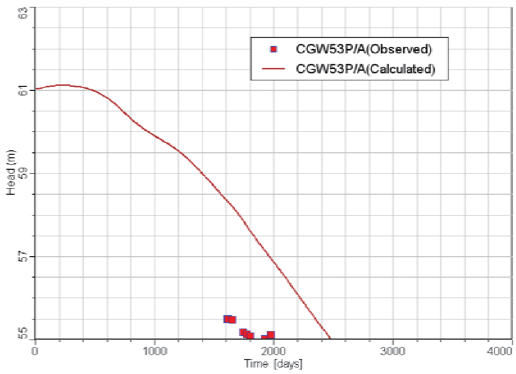
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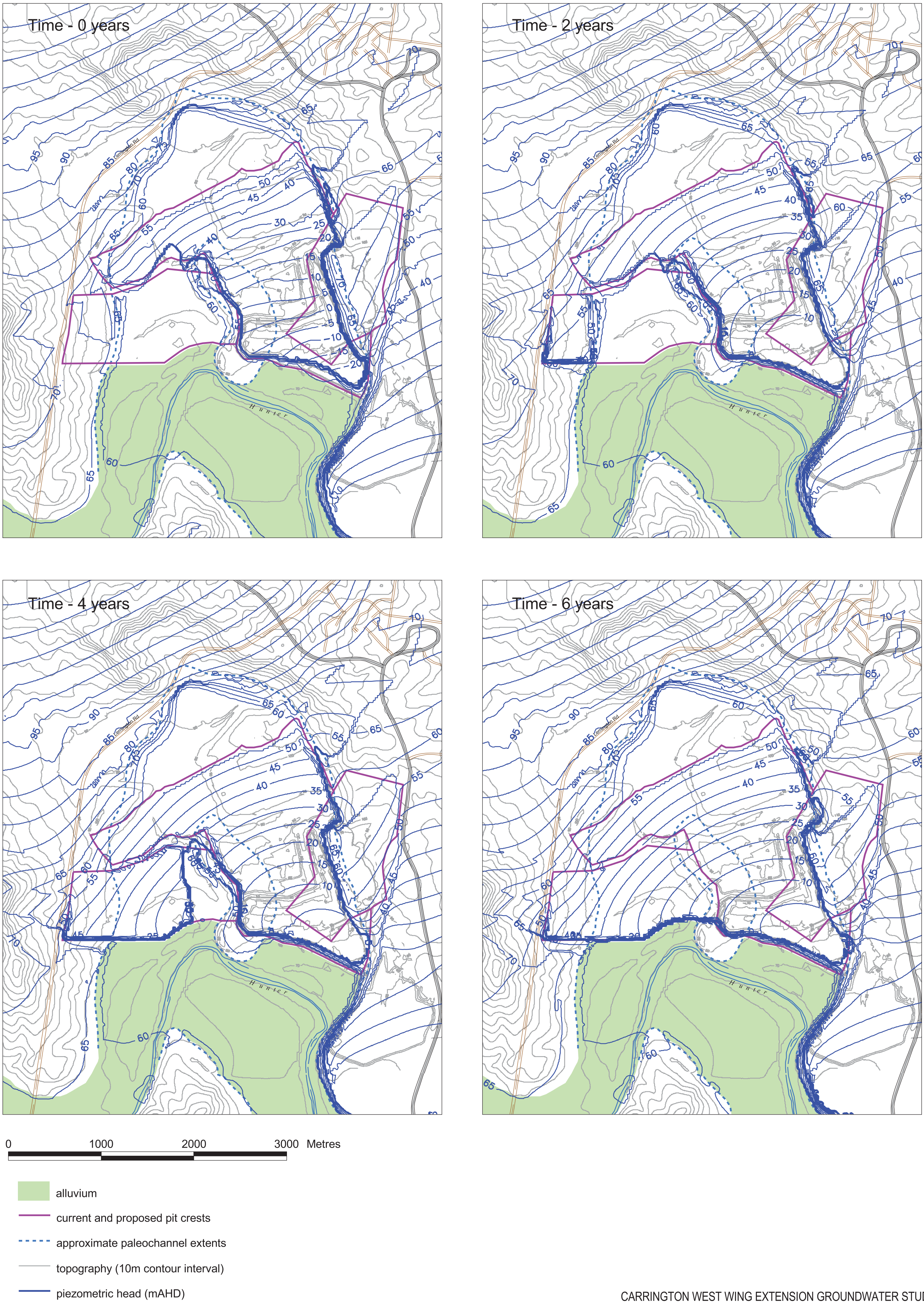
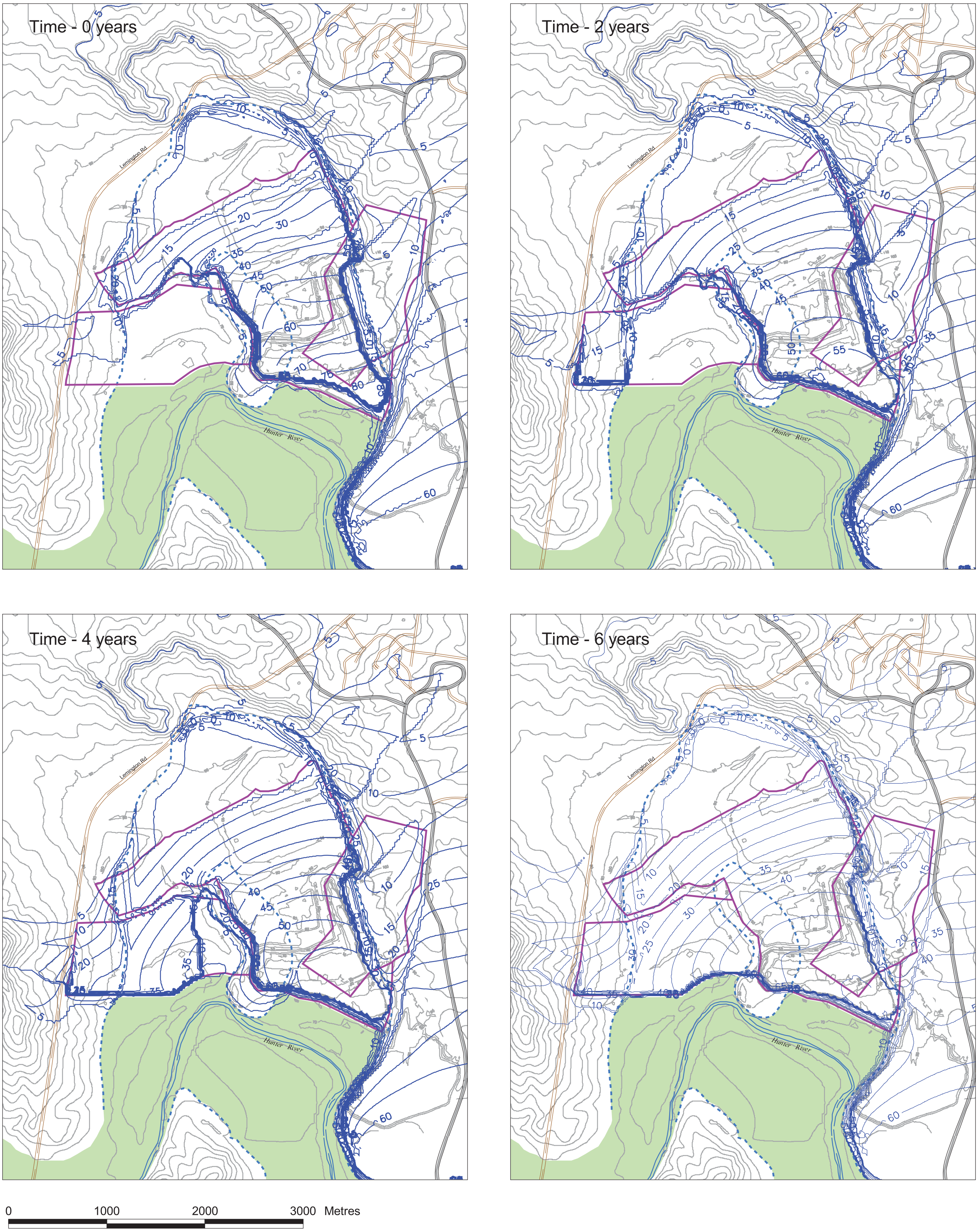


CARRINGTON WEST WING EXTENSION GROUNDWATER STUDY

Shallow hardrock and alluvium water table over period of mining

Figure D5

Mackie Environmental Research



alluvium

current and proposed pit crests

approximate paleochannel extents

pre-mining topography (10m contour interval)

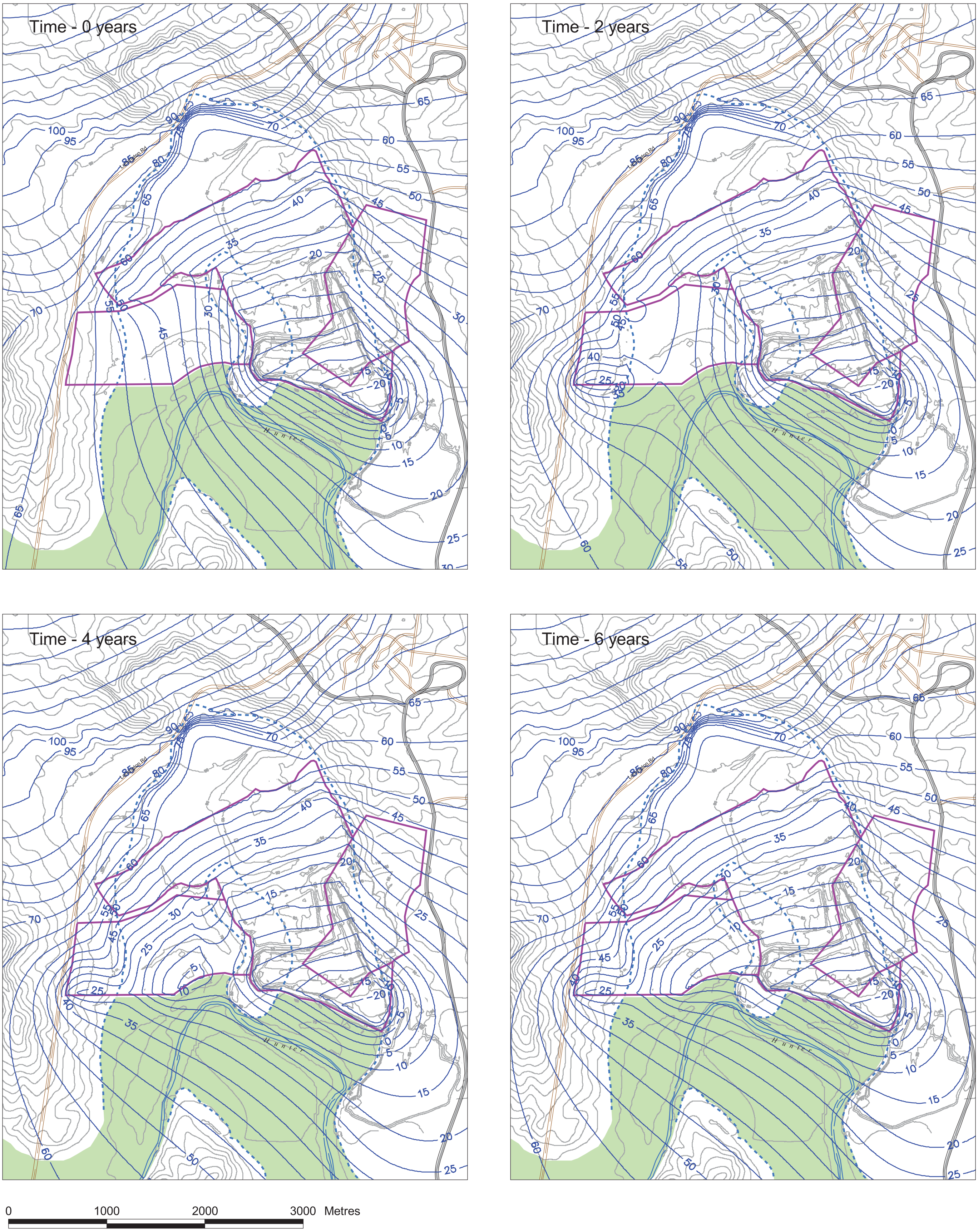
drawdown in piezometric head (m)

CARRINGTON WEST WING EXTENSION GROUNDWATER STUDY

Shallow hardrock and alluvium drawdown in water table over period of mining

Figure D6

Mackie Environmental Research



alluvium

current and proposed pit crests

approximate paleochannel extents

pre-mining topography (10m contour interval)

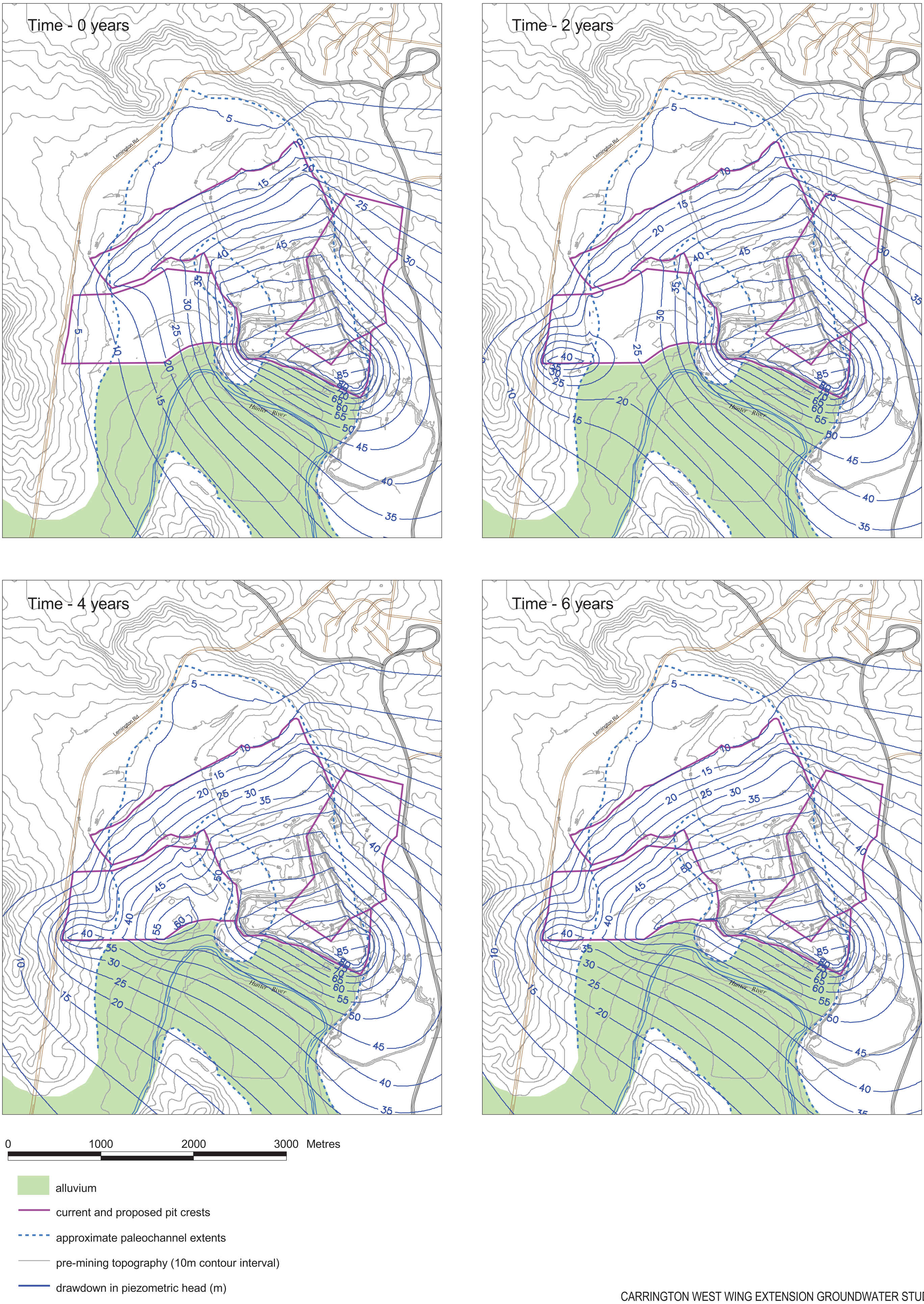
piezometric head (mAHD)

CARRINGTON WEST WING EXTENSION GROUNDWATER STUDY

Bayswater seam piezometric heads over period of mining

Figure D7

Mackie Environmental Research

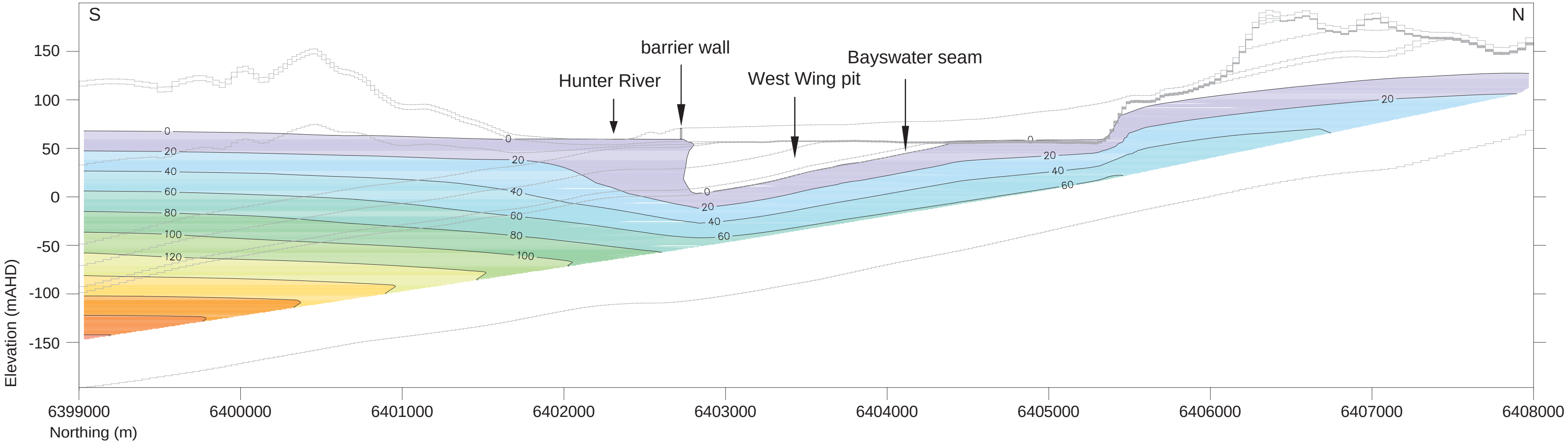


CARRINGTON WEST WING EXTENSION GROUNDWATER STUDY

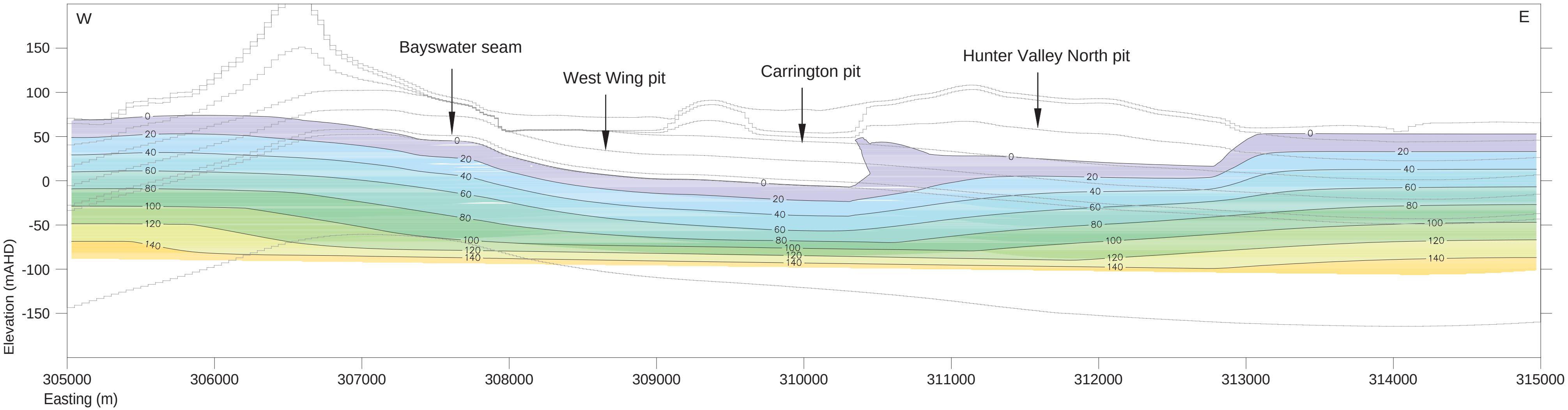
Bayswater seam drawdown in piezometric heads over period of mining

Figure D8

Mackie Environmental Research



Section C103 - 308560E



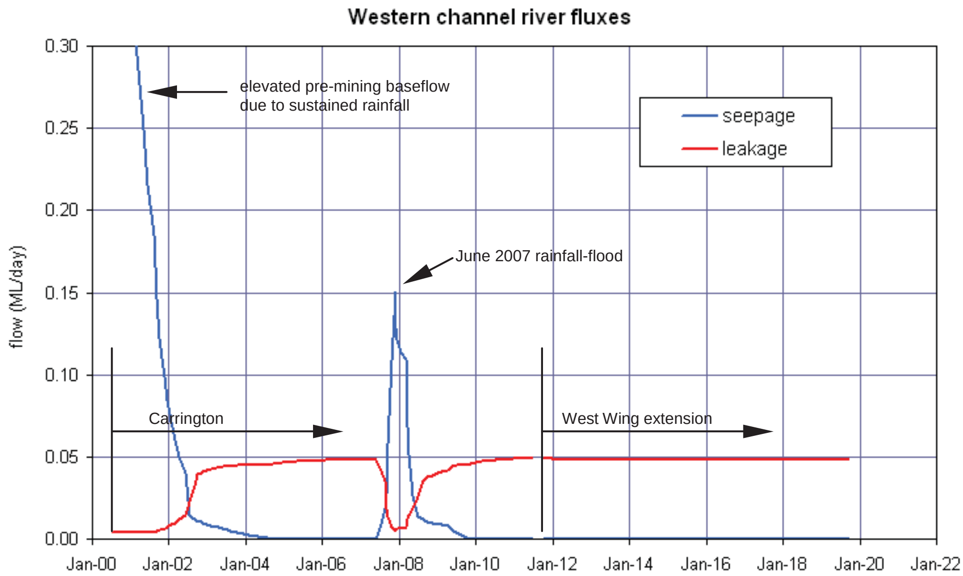
Section R159 -6403040N

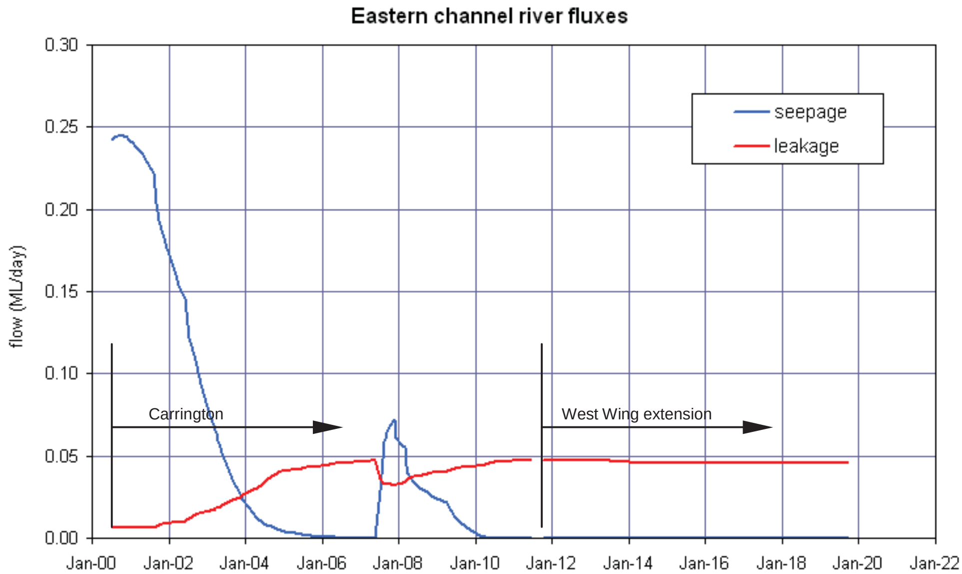
Vertical exaggeration 6x
Pore pressures in mH20 (black contour)

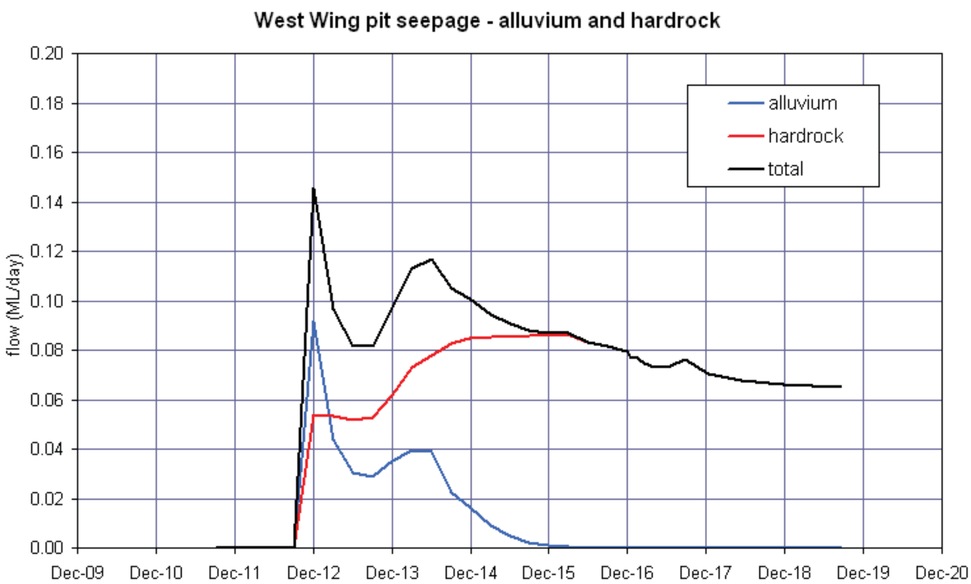
Mackie Environmental Research

Pore pressures at vertical sections R159 and C103 at the end of mining

Figure D9







River-alluvium groundwater exchanges and pit seepage

Figure D10

APPENDIX E: SPOILS LEACHATE

Interburden spoils have the potential to generate leachate in the long term. The process comprises two phases – leachate generation during mining, and leachate generation after cessation of mining.

During mining, rainfall percolates into mine spoils areas through unshaped, shaped and rehabilitated areas. The rate of infiltration/percolation can vary depending upon ground conditions at a particular location but percolating rainfall below about 5 metres depth (beyond evaporative and root zone influences in rehabilitated spoils) is most likely to remain as deep moisture and if sustained, will migrate to the base of the spoils.

The pathway adopted by infiltrating rainfall is 'preferential' due to the nature of spoils emplacement. That is, highly variable fragmentation from blasting delivers fragments ranging from less than 1 mm to more than 1 metre diameter leaving numerous open pathways within the dumps. Leaching of salts occurs along these pathways, the efficiency of the leaching process being governed by the fragment size distribution. Large rock fragments remain essentially impermeable and have poor leaching characteristics while crushed rocks offer improved leaching characteristics due to the reduced grain size and increased surface area per unit volume.

While leachate generation will occur during the 6 year mine period, all leachate during this period would be retained within the mine water system since it would generally emanate at the toe of the spoils low wall as mining progresses down dip in a southward direction. When mine pit operations cease and rainfall or groundwater begins to accumulate in the final void, the groundwater quality is expected to reflect a mixture of rainfall directly falling on void areas, runoff from the reshaped areas surrounding the voids, percolating rainfall (through spoils), and a minor component of groundwater seeping from the coal measures.

The long term ionic speciation of leachate has been considered by conducting reaction path modelling based on mineralogy of interburden waste rock. Leachate trials for the nearby Coal & Allied West pit have also been overviewed.

E1. LEACHATE CHARACTERISATION FROM MINERALOGY

Characterisation using reaction path modelling provides a means of exploring the progressive change in water quality as a result of water-rock interactions with increasing contributions from specific minerals or with changes in mineralogy, cation exchange or gas phase. In applying this technique it is recognised that each stage in a reaction path represents an equilibration without regard for reaction kinetics. It is in effect a titration of a suite of minerals (with a solution) and has been conducted using the modelling code known as Phreeqc (Parkhurst and Apelo, 1999). Accordingly it is approximate in nature.

E1.1 Mineralogical assessments

The mineralogy of interburden has been examined by utilising X-Ray Diffraction Analysis (XRD). Sixteen core samples were selected for XRD analysis from 'type' hole 4036C located centrally in the project area (see Figure B1 in Appendix B for location). Samples were generally taken from the thicker and more representative lithologies rather than from thin discrete layers (see Figure E1). These lithologies included sandstones, siltstones and shales.

Samples were analysed by Sietronics laboratory using a Bruker-AXS D4 XRD with copper radiation at 40 kV and 30 mA, over a range of 1.3 to $70^{o}2\theta$, with a 0.02 degree step and a 2 second per step count time. A graphite monochromator was used in the diffracted beam. The search/match was carried out with the aid of the Bruker Diffrac*plus* Search/Match software and the ICDD PDF-2 database. The quantitative phase analysis was performed using Siroquant version 3.

Table E1 gives results which suggest essentially two or three types of interburden waste rock will dominate spoils. The most common mineralogy comprises high proportions of quartz, modest proportions of kaolinite, variable proportions of mixed layer illite-smectite clays, with minor carbonate (siderite, calcite, dolomite, ankerite). The other dominant mineralogy has an increased and often substantial presence of illite-smectite and/or modest to high presence of carbonate minerals, especially siderite. The carbonate minerals act to provide the acid neutralising (buffering) capacity for any pyrite presence in spoils which when oxidised, generates sulphuric acid.

E1.2 Reaction path modelling

Two fundamental mineralogies have been adopted for modelling purposes from the core results. These are highlighted in yellow in Table E1 and are quartz, kaolinite, illite-smectite either (1) minor carbonate, or (2) elevated carbonate (as siderite/ankerite and minor dolomite and calcite). The presence of kaolinite and smectite is likely to invoke ion exchange leading to the enhancement of Na and depletion of Ca ions in solution. To address this potential exchange process, three scenarios have been considered for each of the two selected mineralogies in Table E1 – no exchange, low exchange and moderate exchange where the levels of ion exchange (Ca for Na) have been defined by molarity. For simplicity, 1 mole of reaction has been spread/titrated over 50 steps at a rate of 0.02 moles per step. This is considered to reflect a reasonable maximum over the long term assuming the mineral availability is governed principally by the surface area of fragments within a spoils emplacement.

While not identified in the XRD analyses, it is also assumed that most strata are likely to exhibit small amounts of the more soluble minerals halite and possibly gypsum leading to the presence of Cl and SO_4 ions. Accordingly small amounts of these minerals have been included in the reaction modelling - pure water has been defined as a surrogate for rainwater.

Figure E2 provides tri-linear, pH and TDS plots It illustrates an initial water type reflecting the influence of siderite solubility where HCO_3 plots above 50 per cent but with increasing dissolution of halite and gypsum, the relative contribution of HCO_3 as percentage milli-equivalents, declines allowing Cl and SO_4 to dominate (arrows define the direction of water quality change). With no cation exchange, Ca presence is higher but with increasing exchange, Ca is reduced. Mg presence is noted to be very minor but this may be attributable to the database underpinning the modelling effort – the minerals listing and thermodynamic data are not all encompassing. Mg is most likely sourced from dolomite or smectite. The resultant water quality is Na,Ca>>Mg depending on exchange capacity, and SO_4,Cl>>HCO_3. pH falls to a longer term range of 8.0 to 9.0 while TDS rises above 1500 mg/l depending upon mineral availability and type. Calcite, dolomite and kaolinite remain in a saturated state – dissolution and precipitation are in equilibtium.

E2. HISTORICAL LEACHATE TRIALS

MER (1999) reports the characterisation of leachate for 10 core samples taken from 4 locations within the Carrington project area. Leachate trials comprised batch reaction dissolution of crushed core over a period of 18 hours (Dept. Mineral Resources Development Laboratory). Results of trials indicated a total dissolved salts average of 320 mg/l and a pH average of 9.0 after the test period. Single measurement does not facilitate projection in the longer term but ionic speciation of the samples provides a useful indicator of the likely characterisation of water quality. Figure E2 includes plotting of these leachate samples where Na>Mg>>Ca and HCO_3>>Cl,SO_4 .

MER (2003) reports the characterisation of leachate for 8 core samples taken from a borehole EL5243 located just north of the project area for characterisation of West Pit. That pit intersects deeper strata than those intercepted in the proposed West Wing extension but findings are considered to be relevant to the present study. Leachate trials comprised batch reaction dissolution monitoring of crushed core samples submerged in distilled water (as a surrogate for rainfall). The fragmentation range was from less than 0.1mm to a maximum of 25mm dia. in separate sieved ranges. Separate ranges were adopted to establish a generalised relationship between grain size and dissolution efficiency. Results of trials indicated a long term leachate total dissolved salts of about 1950 mg/l.

It is noted however, that longer term leachate quality may exhibit higher (or lower) dissolved salts due to the sensitivity of projecting laboratory responses (6 months duration) forward in time over more than 100 years. pH range was projected to be 7.5 to 8.5. Figure E2 includes ionic speciation plotting of these leachate samples where Na>Mg>>Ca and HCO_3>Cl,SO_4. This characterisation is very similar to the above noted Carrington samples.

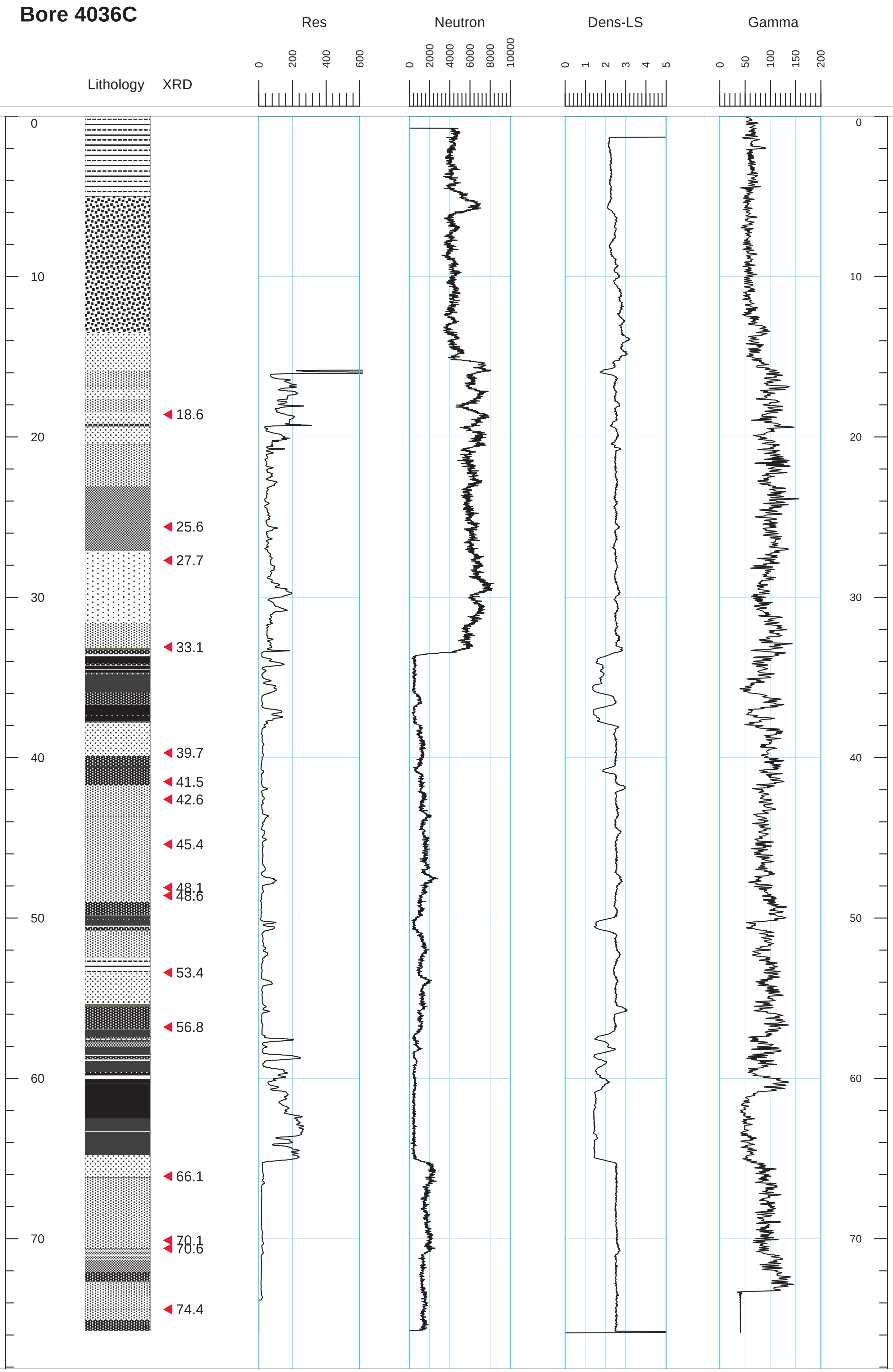
MER (2005) reports the analysis of leachate for 9 coarse rejects samples taken from the coal washery discharge at Hunter Valley Operations. These samples are mostly shales and carbonaceous shales typically forming coal seam roof or seam interbeds. The samples were isolated from product coal during the washing process. Batch leachate trials were conducted on these samples in a manner consistent with the above description for EL5243. Speciated leachate samples are similarly plotted on Figure E2. These samples tend to exhibit a similar range of water qualities to previous samples where Na>Mg>>Ca and HCO_3, SO_4>Cl. Increased SO_4 presence is evident

The batch reaction trials are regarded as reasonable indicators of the likely long term leachate quality in the West Wing void.

Table F1: Summary of X-Ray diffraction analyses on samples taken from cored borehole 4036C

Depth-m	Description	quartz	kaolinite	illite-smectite	illite	albite	anorthite	calcite	dolomite	siderite	anatase	ankerite
18.6	sandstone, light grey, medium to coarse grained, with coal flecks	65	14	7	6			3	2	2	<1	
25.6	siltstone, light grey, fine-grained, well cemented with coal flecks	50	8	7	7	4				8	1	16
27.7	sandstone, light grey, quartzose, medium grained, well cemented	64	14	8	6			2		5	1	1
33.1	shale, grey, with coal flecks	23	1	8	13					56		
39.7	shale, grey to dark grey, with coal flecks	60	16	13	7					4	1	
41.5	siltstone, laminated, light to dark grey, very fine-grained	32	6	5	9					21	1	27
42.6	siltstone shale, light grey interbedded with carbonaceous material	65	14	10	6			<1		3	1	
45.4	sandstone, fine to medium grained, quartzose, well cemented	65	11	8	6			6		2		3
48.1	siltstone laminite, light to dark grey interbedded with carbonaceous shale	55	12	9	6		11			2		4
48.6	shale, light grey	53	8	29	6					2		1
53.4	carbonaceous shale	50	10	29	6					3	1	
56.8	carbonaceous shale, with coal fragments	54	8	25	6					6	1	
66.1	sandstone conglomerate, light grey, pebbles to 8 mm	77	3	18						3		
70.1	siltstone shale, light grey interbedded with carbonaceous material	57	8	28	6			1		1	1	
70.6	shale, grey, with coal flecks	51	6	22	6		9			5	1	
74.4	siltstone, light grey laminated with carbonaceous shale and coal flecks	56	7	28	6			1		2	1	

All values are % by weight
Representative mineralogies shaded yellow


Bore 4036C
Res
Neutron
Dens-LS
Gamma
Lithology
XRD
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25.6
27.7
33.1
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45.4
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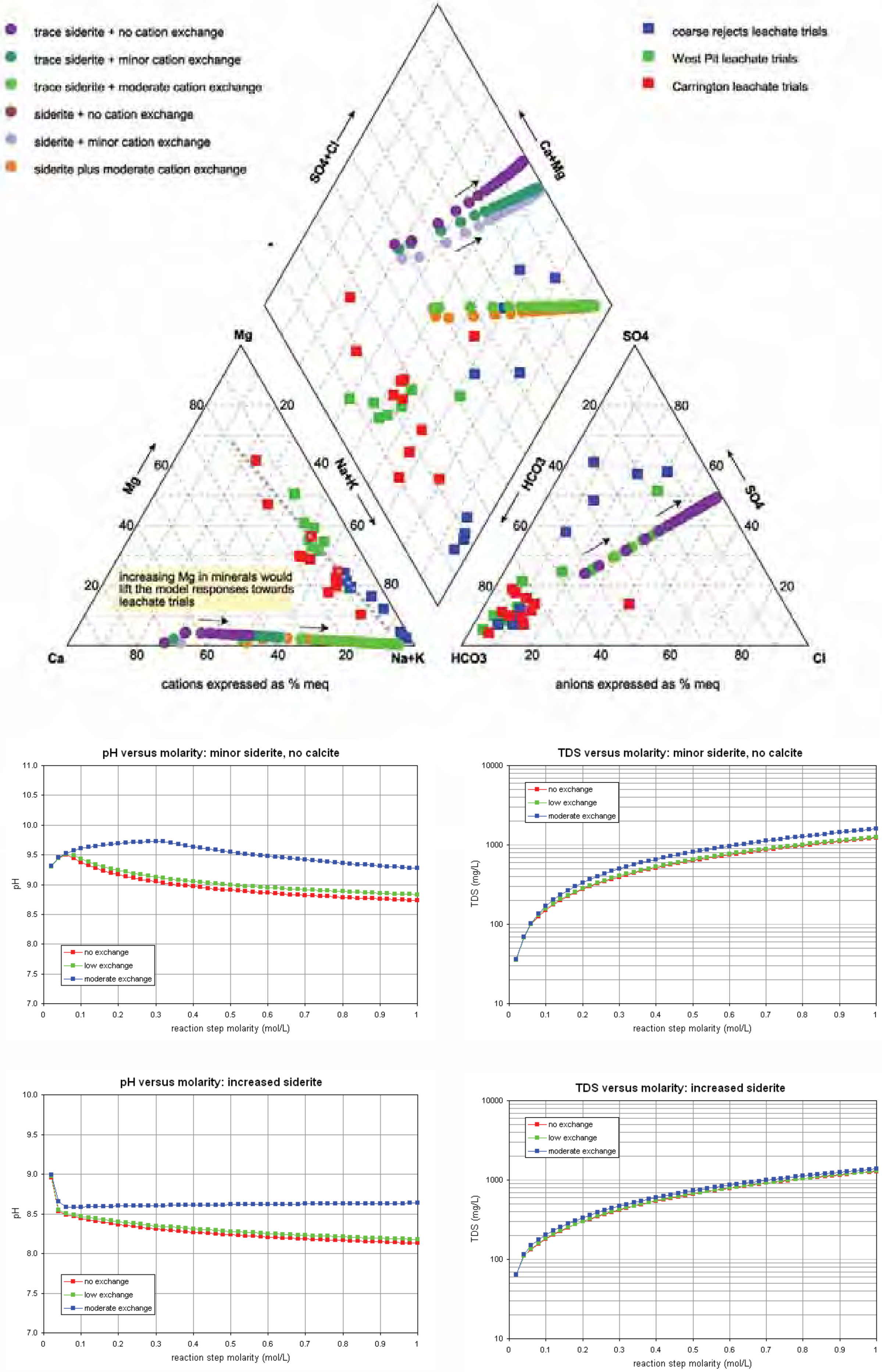
48.6
53.4
56.8
66.1
70.1
70.6
74.4

Figure E1



Reaction path model results and comparison to leachate trials

Figure E2

Appendix D

Surface Water Study

www.coalandallied.com.au

Water Solutions Pty Ltd
ACN 070 875 553

wrm water + environment

CARRINGTON WEST WING – SURFACE WATER ASSESSEMENT

Coal & Allied Operations Pty Ltd
August 2010

www.wrmwater.com.au

Water Solutions Pty Ltd
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wrm
water + environment

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REPORT TITLE: Carrington West Wing– Surface Water Assessment
CLIENT: Coal & Allied Operations Pty Limited
REPORT NUMBER: 0594-01-D(rev 5)

Revision Number	Report Date	Report Author	Reviewer
0	3 March 2010	AH	GR
1	23 March 2010	AH/MB	GR/JM
2	30 April 2010	AH/MB/GR	GR
3	20 May 2010		GR
4	25 May 2010		GR
5	18 June 2010		DN
6	24 August 2010	GR	GR

For and on behalf of
WRM Water & Environment Pty Ltd

Greg Roads
Director

EXECUTIVE SUMMARY

Proposal Overview

Coal & Allied Operations Pty Limited (Coal & Allied) proposes to extend the existing approved Carrington Pit by approximately 137ha to the south-west, into land which is predominantly cleared of native vegetation. The Carrington Pit is located within the Hunter Valley Operations (HVO) north of the Hunter River (HVO North) approximately 18km west of Singleton.

The proposal would allow for the extraction of approximately 17Mt of in-situ coal from the Broonie, Bayswater and Vaux seams. Mining in the extended pit will have a life of approximately six years and will be completed within the existing development consent period, which is currently approved to 2025.

Overburden will be disposed of in-pit, as well as at two out-of-pit overburden emplacement areas to be established on previously disturbed and rehabilitated land immediately north of the proposed extension area.

Supplementary activities proposed to support the extension include the following.

- The approved footprint of the Carrington Pit evaporative sink will be extended, for long term groundwater management purposes.
- A two stage, temporary levee and diversion system will be established to ensure that the proposed extension area is protected from flooding, and to enable the temporary diversion of an unnamed tributary of the Hunter River that presently runs in a southerly direction across the proposed extension area.
- The impermeable groundwater barrier wall previously assessed for the western paleochannel will be realigned further south from its approved location, to prevent groundwater migration from the Hunter River into the mine, and migration of water from the mine into the Hunter River alluvium.
- A service corridor will be constructed along the southern boundary of the proposed extension area, which may incorporate water pipelines, an all weather access road, mining equipment, substations and other services.

This report, prepared by WRM Water & Environment Pty Ltd, presents the methodology and results of the surface water investigations undertaken to assess the potential impacts of the proposal on local surface hydrology and the mine water management system. It incorporates a mine water assessment undertaken by Water Solutions Pty Ltd.

Assessment of Impacts on Minesite Water Management

The potential impacts of the proposal on the HVO North surface water management system have been assessed using the OPSIM water balance model. The outcomes from the surface water impact assessment are summarised as follows:

- Releases of water from the mine to the Hunter River can be managed in compliance with the Hunter River Salinity Trading Scheme (HRSTS) rules.
- Raw water consumption is expected to decrease due to the reduction in production at HVCPP based on the production forecasts at the time of preparing this report, which reduces overall water consumption at HVO North.
- The overall mine water inventory and risk of pit inundation is expected to slightly increase due to the additional groundwater inflow and catchment area reporting to the pit. However, sufficient capacity is available within HVO North to accommodate the potential increase in inventory.

- Long-term modelling indicates an increase in the annual exceedance probability of site spillway discharge from 9% to 17% in any one year. This impact could potentially be mitigated by transferring excess mine water to other mining areas within HVO.
- Loss of catchment runoff to the Hunter River during the life of the project is considered negligible due to the relative magnitude of flows in the Hunter River.
- It is expected that there would be little impact on runoff water quality to the Hunter River due to the proposed diversions and levees associated with the proposal. Also, it is proposed that all areas are to be returned to a rehabilitated catchment after mining.

Based on the above assessment outcomes, it is expected that the proposal would have little impact on the existing HVO North water management system. There are no substantial changes proposed to the HVO North water management system to accommodate the proposal. It is recommended that surface and groundwater monitoring be reviewed regularly, and existing water management tools be updated as appropriate to ensure currency with the operational configuration of the mine water management system.

This assessment has been undertaken using the forward projected production rates for HVO North. Should overall production increase to the maximum allowable under the Mining Consent, the following impacts would be expected:

- Raw water consumption would increase;
- Overall minesite storage inventory (and associated site discharge characteristics) would decrease.

Note that detailed modelling of this scenario has not been undertaken as part of the current study scope.

Assessment of Impacts on Flooding

The proposed extension area is potentially susceptible to flooding from the Hunter River to the south and an Unnamed Tributary to the north. A detailed flood assessment was undertaken of both systems to estimate design flood levels adjacent to the mine and to determine the potential impacts associated with the proposed diversion and levees. The hydrologic and hydraulic modelling of the Hunter River and its floodplain in the vicinity of the proposed extension area has found the following:

- The 2 year ARI Hunter River design flood is generally confined to the main channel. The Hunter River flood flows exceed the capacity of the channel and inundate the floodplain in the vicinity of the proposed extension area for the 5 year ARI design event.
- The Hunter River dominates flood levels across the proposed extension area for floods greater than and equal to the 10 year ARI event. Local catchment flows from the Unnamed Tributary dominate for the more frequent floods.
- The 100 year ARI design flood levels across the proposed extension area are about 75m AHD. Ground levels across the proposed extension area range from 70m AHD to 74m AHD.
- The 100 year ARI flood velocities along the Hunter River channel adjacent to the proposed extension area vary from 1.4m/s at the northern most corner of the meander (location D) to 2.2m/s immediately to the east. It appears that the high ridge separating the Hunter River from the existing Carrington Pit causes a minor constriction in the flood flows effectively creating a zone of low velocity immediately upstream on the bend in the river.
- The Stage 1 and Stage 2 flood levees effectively prevent flooding of the proposed extension area for events up to the 100 year ARI event.

- The 100 year ARI flood levels along the proposed levees are within 0.1m of existing conditions.
- Flood velocities along the Hunter River channel generally remain unchanged from existing conditions.
- Runoff from the Unnamed Tributary catchment is effectively conveyed around the levees by the proposed diversion. The proposed diversion effectively conveys the 10 year ARI channel within bank.
- It is likely that the finished levels of the overbank area in the vicinity of the proposed diversion channel would be lowered to reduce the in-bank capacity of the channel to the recommended 2m depth in accordance with the recommended channel design principles. This will be determined during the detailed design of the filled in pit. For the purposes of this report, the finished ground levels are assumed to be the same as existing conditions.
- There is no impact on flood levels along the Hunter River main channel for the 10 year ARI design flood and a minor (<0.1m) impact on the floodplain immediately adjacent to the south-western corner of the levee
- The extent of the flood impact for the 100 year ARI design flood is confined to the two parcels on Hunter River floodplain immediately to the south of the proposed levee. The 100 year ARI flood levels along the proposed diversion drain are up to 0.14m higher than existing conditions.
- The increase in flood depth is insignificant when compared to the overall flood depths in this region of 5 to 6m.
- There are no buildings located within the zone of impact of the proposed levees on these two parcels.
- It is expected that elevated flood levels would remain in these areas for 12 hours to 48 hours, depending upon the duration and severity of the flood event.

Given the minor changes in flood levels and flood velocities associated with the proposed levees, there would be no increase in erosion potential of the Hunter River channel as a result of the proposal. However, the Hunter River channel adjacent to the proposed extension area is located on an alluvial floodplain and is poorly aligned and is therefore susceptible to erosion under existing conditions.

Based on an assessment of historical river alignments from aerial photography, and assuming the average rate of channel movement over this period were to continue, it would take between 521 to 782 years for the Hunter River to reach the groundwater barrier wall. However, if this occurred, the alignment of the Hunter River at this location would be so poor, the channel would almost certainly cut across the gravel bar and create a new channel in a similar location to the existing channel. In other words, the risk that the Hunter River could continue to erode northward to reach the groundwater cut off wall is extremely low.

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1 INTRODUCTION

1.1 GENERAL

Coal & Allied Operations Pty Ltd (Coal & Allied) is proposing to extend mining operations at the existing Carrington Pit to the south west into Authorisation (AU) 435, Exploration Licence (EL) 5418 and EL 5417. The Carrington Pit is located within the Hunter Valley Operations (HVO) north of the Hunter River (HVO North). The HVO North is located approximately 18km west of Singleton as shown in Figure 1.1.

This report, prepared by WRM Water & Environment Pty Ltd, presents the methodology and results of the surface water investigations undertaken to assess the potential impacts of the proposal on local surface hydrology and the mine water management system. It incorporates a mine water assessment undertaken by Water Solutions Pty Ltd. The report will provide the basis for the surface water component of the Environmental Assessment (EA) for the Carrington West Wing proposal.

1.2 PROPOSAL OVERVIEW

It is proposed to extend the existing approved Carrington Pit by approximately 137ha to the south-west, into land which is predominantly cleared of native vegetation. The location of the proposed extension area is shown in Figure 1.2. The proposal would allow for the extraction of approximately 17Mt of in-situ coal from the Broonie, Bayswater and Vaux seams.

Mining in the proposed extension area will have a life of approximately six years and will be completed within the existing development consent period, which is currently approved to 2025.

Overburden will be disposed of in-pit, as well as at two out-of-pit overburden emplacement areas to be established on previously disturbed and rehabilitated land immediately north of the proposed extension area.

Supplementary activities proposed to support the extension include the following.

- The approved footprint of the Carrington Pit evaporative sink will be extended for the long term management of groundwater post-mining.
- A two stage, temporary levee and diversion system will be established to ensure that the proposed extension area is protected from flooding and to enable the diversion of an unnamed tributary of the Hunter River (referred to herein as the ‘Unnamed Tributary’) that presently runs in a southerly direction across the footprint of the extension.
- The impermeable groundwater barrier wall previously assessed for the western paleochannel will be realigned further south from its approved location, to prevent groundwater migration from the Hunter River into the mine, and migration of water from the mine into the Hunter River alluvium.

- A service corridor will be constructed along the southern boundary of the proposed extension area. This may incorporate water pipelines, an all weather access road, mining equipment, substations and other services.

1.3 REPORT STRUCTURE

This report is structured as follows.

- Section 2 describes the existing environment with respect to surface water resources and mine water management and summarises the existing water management at HVO North;
- Section 3 outlines the potential impacts of the proposal on surface water resources and identifies the proposed measures to mitigate the impacts;
- Section 4 describes the methodology and results of water balance modelling undertaken to assess the impact of the proposal on the minesite water management system;
- Section 5 describes the methodology and results of flood modelling undertaken to assess the impact of the proposed levees on flood levels, velocities and erosion potential along the Hunter River;
- Section 6 summarises the findings of the study;
- Section 7 is a list of references;
- Appendix A summarises the HVO North Water Management system including changes due to the proposal.
- Appendix B describes the hydrological and hydraulic model development and calibration used to assess the impact of the proposed levees.

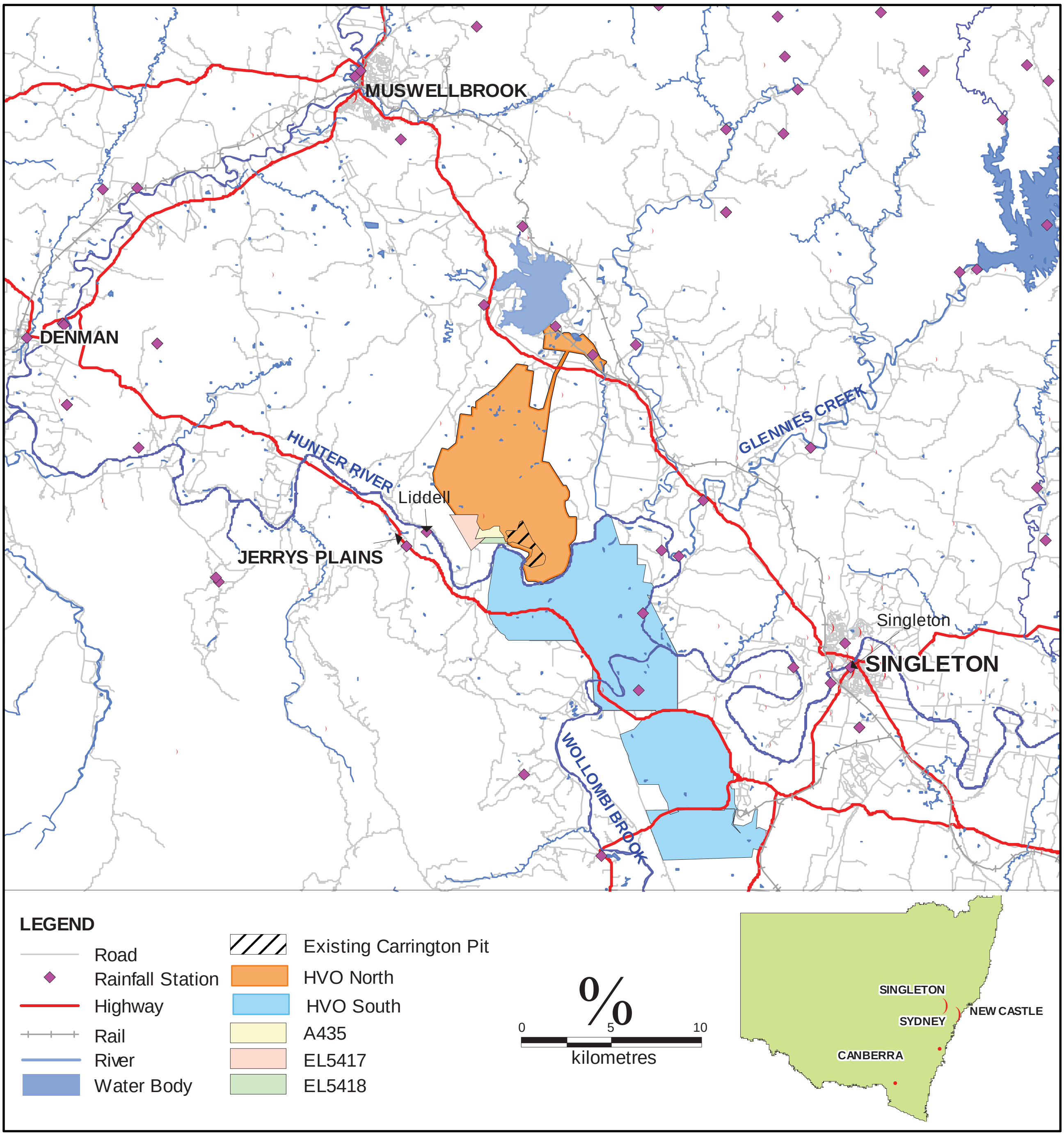

Figure 1.1 Carrington West Wing Locality

Figure 1.2 HVO North and the project area

2 EXISTING ENVIRONMENT

2.1 REGIONAL DRAINAGE NETWORK

The regional drainage network in the area of interest is shown in Figure 1.1. The project area is located on the northern floodplain of the Hunter River between the existing Carrington Pit and Lemington Road. The Hunter River has a catchment area of approximately 13,400km^2 to HVO. The catchment extends some 110km to the north and 140km to the west and includes the major tributaries of the Pages River, Dart Brook and the Goulburn River. The Hunter River is a regulated river supplying water from Glenbawn Dam to a range of industrial and agricultural users as well as town water supplies. Glenbawn Dam is located on the upper headwaters of the Hunter River. Two major tributaries, Glennies Creek and Wollombi Brook, drain into the Hunter River some 10km downstream of the mine. The total catchment area of the Hunter River to Singleton, located 20km downstream, is 16,400km^2.

2.2 LOCAL DRAINAGE NETWORK

The Hunter River in the vicinity of HVO North has a base width of between 80m and 150m and is about 10m deep. The bed of the river consists of mobile bars of sand and gravel separated by pools of water. The banks of the river are moderately steep particularly on the outside bends and are vegetated with a range of native and non native (willow) species. There is some evidence of active slumping of the high banks. The river floodplain varies in width from 700m to about 1.7km in the vicinity of HVO North. Much of the floodplain has been intensively cropped with significant areas under irrigation. Figure 2.1 shows a photograph of the Hunter River adjacent to the project area taken in June 2009.

The existing HVO North operation is located partly on the Hunter River floodplain and partly on the adjoining hillslopes. Levees are currently used to prevent Hunter River floodwater from entering areas of the mine. The existing licensed levees on HVO North are shown in Figure 1.2.

A local catchment of 13.75km^2 drains the existing mine site via an Unnamed Tributary as well as some minor tributary channels to the Hunter River, as shown in Figure 1.2. At its downstream end, the Unnamed Tributary is a fourth-order stream, based on the Strahler system of stream order classification. However, the stream is ephemeral, effectively functioning as a lower order stream. Upstream of the proposed extension area, the Unnamed Tributary has been constructed across previously mined areas and has been substantially realigned from pre-mining conditions. The realigned Unnamed Tributary consists of a small channel that is about 10m wide and 1 to 2 m deep and is well grassed. A licence under the Water Act 1912 has previously been obtained for these works.

Across the proposed extension area, the Unnamed Tributary drains along an ill defined paleo-channel to the Hunter River. The Unnamed Tributary has a bed slope of approximately 0.27% across the proposed extension area and is wide and denuded of vegetation. Downstream of the proposed extension area, the Unnamed Tributary falls along a relatively defined channel to the

Hunter River at a slope of 4%. The Unnamed Tributary is ephemeral, subject to gully erosion and lacks any significant riparian vegetation. It is of low aquatic significance, providing only poor quality to marginal habitat for aquatic species. Further discussion of riparian and ecological values of the watercourses on site and downstream of the project area is provided in the Biosis (2010) Carrington West Wing Ecology Assessment. Figure 2.2 shows a photograph of the Unnamed Tributary across the proposed extension area.

Figure 2.1 Hunter River Channel adjacent to the Carrington Pit

Figure 2.2 Unnamed Tributary across the Project Area

2.3 RAINFALL AND EVAPORATION

Table 2.1 shows summary details of Bureau of Meteorology rainfall recording stations in the vicinity of HVO North. The locations of the various stations are shown in Figure 1.1.

Table 2.1 Rainfall Stations

Station No.	Station Name	Elevation (m)	Lat. (°S)	Long. (°E)	Distance from Site (km)	Opened	Closed
061086	Jerrys Plains Post Office	90	32.497	150.909	7	1884	-
061070	Singleton Post Office	41	32.567	151.167	20	1881	1969
061100	Broke (Harrowby)	76	32.767	151.087	30	1887	-

Table 2.2 shows mean monthly rainfalls for the three rainfall stations shown in Table 2.1. Note that the mean monthly values are for different periods. The mean annual rainfall in the area of interest ranges from 643 to 701mm, with maximum monthly rainfalls occurring during the summer months.

Table 2.2 also shows mean monthly evaporation (based on a Class A evaporation pan) recorded at Jerry's Plains Post Office (Station No. 61086), located some 7km to the west of HVO North. Mean annual evaporation is 1613mm, which is more than double mean annual rainfall.

Figure 2.3 shows the annual distribution of average monthly rainfall and evaporation in the local area. Mean evaporation is similar to mean rainfall in the winter months, but substantially exceeds rainfall for the remainder of the year.

Table 2.2 Mean Monthly Rainfall and Evaporation

Month	Mean Monthly Rainfall (mm)			Mean Monthly Evaporation (mm)
	Singleton Post Office (061070) [1881 - 1969]	Jerrys Plains Post Office (061086) [1884 -]	Broke (Harrowby) (061100) [1887 -]	Jerrys Plains Post Office (061086) [8 years data]
January	75.3	76.9	71.2	212
February	72.1	72.5	75.3	165
March	71.3	59.1	65.5	143
April	55.8	44.1	50.0	113
May	46.4	40.4	43.0	86
June	57.1	47.6	53.3	59
July	51.4	43.3	40.4	68
August	41.5	36.4	35.6	81
September	44.7	41.7	39.4	112
October	50.8	52.2	50.6	169
November	58.4	59.9	60.1	196
December	73.6	67.6	68.9	210
Total	701	643	655	1613

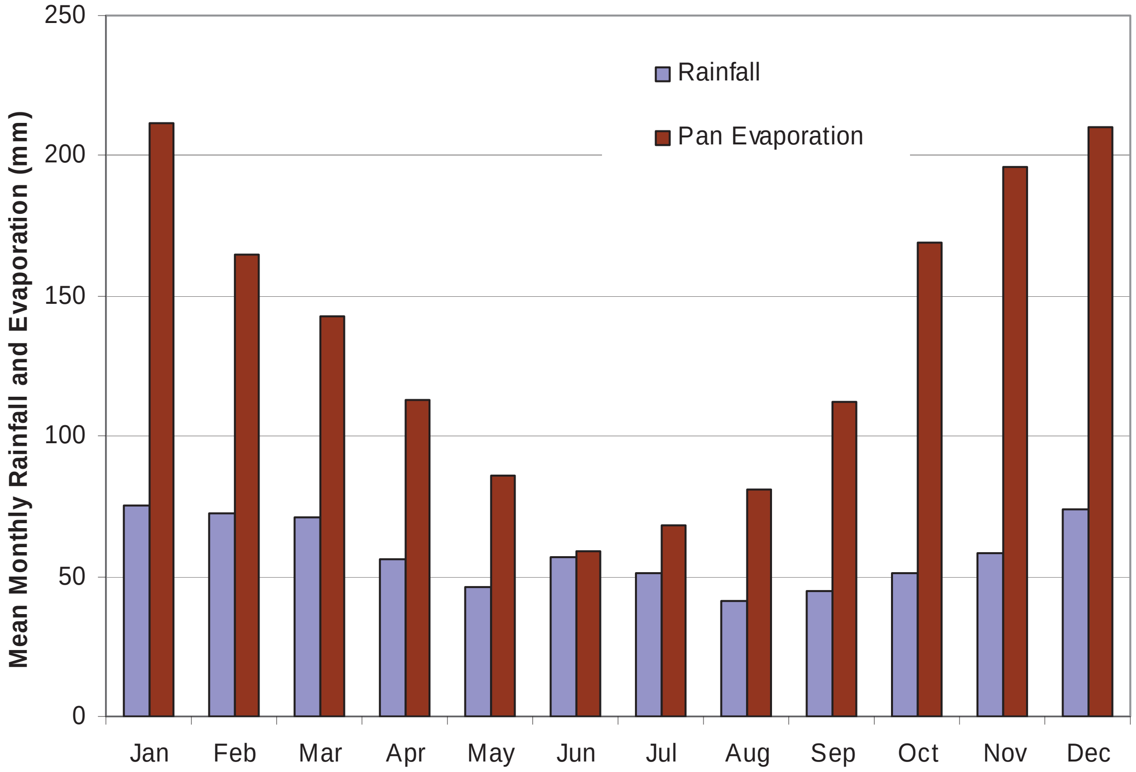

Figure 2.3 Distribution of Monthly Rainfall (Singleton Post Office) and Evaporation (Jerrys Plains Post Office)

2.4 STREAMFLOW

Table 2.3 shows the estimated annual runoff volumes for the Hunter River catchment to the Liddell gauge (Station No. 210083). The Liddell gauge is located approximately 7.0km upstream of HVO North and has a catchment area of 13,400km². Data has been collected at Liddell since 1969. The volumetric runoff coefficient (rainfall to runoff relationship) of the Hunter River flows to Liddell is approximately 4%. Figure 2.4 shows the flow-duration relationship for the Hunter River at the Liddell gauge which indicates that flow is non-zero almost 100% of the time, which is characteristic of regulated river systems.

Figure 2.5 shows a plot of annual runoff versus rainfall for the Hunter River at Liddell. Very little runoff is generated by the catchment when annual rainfall is less than about 400mm. Once annual rainfall exceeds this value, the volume of surface runoff increases substantially.

Table 2.3 Annual Rainfall and Runoff Volumes for Hunter River to Liddell Gauging Station

Year	Annual Rainfall [a] (mm)	Annual Runoff Volume		Volumetric Runoff Coefficient
		(GL)	(mm)	
1971	752	1465	109	0.145
1972	672	325	24	0.036
1973	724	420	31	0.043
1974	624	732	55	0.088
1975	556	166	12	0.022
1976	799	1105	82	0.103
1977	563	1037	77	0.138
1978	873	1030	77	0.088
1979	538	241	18	0.033
1980	331	87	7	0.020
1981	743	163	12	0.016
1982	501	146	11	0.022
1983	589	103	8	0.013
1986	542	94	7	0.013
1987	819	118	9	0.011
1988	838	284	21	0.025
1989	757	1056	79	0.104
1990	784	1100	82	0.105
1991	578	96	7	0.012
1992	711	594	44	0.062
1993	647	158	12	0.018
1994	469	52	4	0.008
1995	605	108	8	0.013
1996	569	228	17	0.030
1997	532	145	11	0.020
1998	838	1188	89	0.106
1999	631	195	15	0.023
2000	818	816	61	0.074
2001	757	391	29	0.039
2002	557	101	8	0.014
2003	674	104	8	0.012
2004	730	73	5	0.007
2005	641	84	6	0.010
2007	888	320	24	0.027
Mean	666	421	31	0.044

[a] Based on rainfall for the Jerrys Plains Post Office Station which has been adopted as representative of rainfall over the catchment.

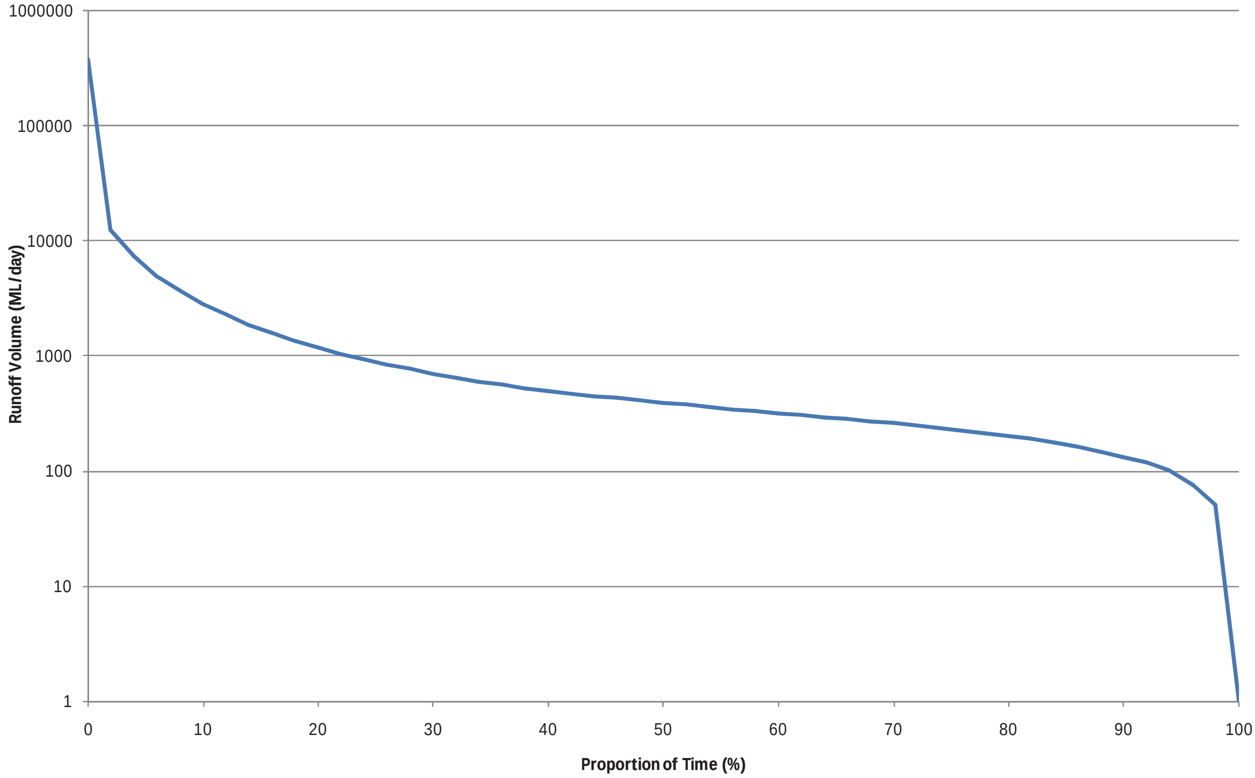

Figure 2.4 Derived Flow-Duration Relationship for the Hunter River at Liddell (1949-2009)

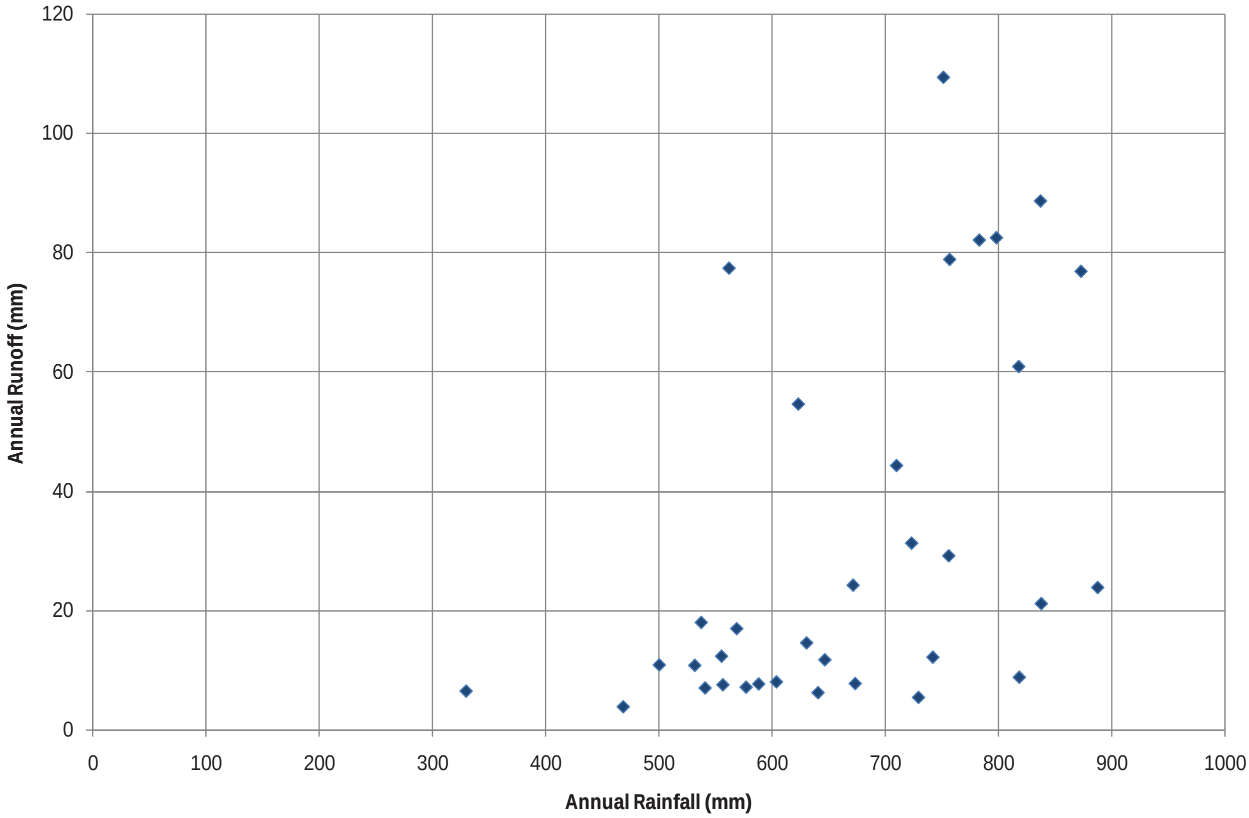

Figure 2.5 Annual Runoff versus Rainfall for the Hunter River at Liddell Gauging Station

2.5 SURFACE WATER QUALITY

Surface water quality is monitored at HVO in on-site dams and surrounding natural watercourses (including Wollombi Brook and the Hunter River) at 22 locations. The monitoring is managed under Rio Tinto Coal Australia's Health, Safety, Environment and Quality (HSEQ) Management System which is certified to the international standard ISO:14001(2004), and is reported to the Department of Planning annually through the Annual Environmental Management Report (AEMR).

The location of surface water monitoring points is shown in Figure 2.6. A summary of pH results at key monitoring points is shown in Table 2.4. Electrical conductivity (EC) results are shown in Table 2.5 and total suspended solids (TSS) are shown in Table 2.6.

The two water quality sampling locations, W109 and W1, are located upstream and downstream of the proposed extension area respectively. A comparison of results between W109 and W1 indicates that there is no significant change in water quality between these stations.

Table 2.4 pH Summary 2007-2008

	pH			
Location	Result Range 2007	Annual Average 2007	Result Range 2008	Annual Average 2008
W108[a]	7.2-8.5	7.9	-	-
W109	6.8-8.4	7.8	8.1-8.7	8.2
W1	6.8-8.5	7.9	7.9-8.7	8.2
W3[b]	7.9-8.2	8.1	7.8-8.5	8.3
W4	-	-	8.0-8.5	8.3
H1	7.3-9.1	7.9	7.8-8.4	8.1
H2	7.6-8.4	8.0	7.7-8.4	8.1
H3	6.5-8.2	7.6	7.1-8.6	7.9

a – W108 was decommissioned in October 2007. Therefore, the data in the table for this site was based on nine months of data

b – W3 (Hunter River) replaced the decommissioned site W108 in October 2007. Therefore, the data presented in the table for this site is based on two months of data. Note that the December sample was missed due to the inaccessibility of the site.

Table 2.5 Electrical Conductivity Summary 2007-2008

	EC (µS/cm)			
Location	Result Range 2007	Annual Average 2007	Result Range 2008	Annual Average 2008
W108[a]	500-1100	921	-	-
W109	igat1200	835	340-1200	804
W1	470-1330	878	330-1220	823
W3[b]	715-1310	1013	250-1160	855
W4	-	-	360-1180	870
H1	310-1180	636	345-945	742
H2	320-1200	652	450-915	793
H3	340-1200	604	390-695	561

a – W108 was decommissioned in October 2007. Therefore, the data in the table for this site was based on nine months of data
b – W3 (Hunter River) replaced the decommissioned site W108 in October 2007. Therefore, the data presented in the table for this site is based on two months of data. Note that the December sample was missed due to the inaccessibility of the site.

Table 2.6 TSS Summary 2007-2008

	TSS (mg/L)			
Location	Result Range 2007	Annual Average 2007	Result Range 2008	Annual Average 2008
W108[a]	2.0-59	22	-	-
W109	5.0-136	38	12-246	62
W1	4.0-140	39	7-240	62
W3[b]	9.0-132	71	9-440	103
W4	-	-	4-998	148
H1	<2.0-170	38	11-948	134
H2	4.0-125	29	6-405	60
H3	<2/0-82	22	2-130	21

a – W108 was decommissioned in October 2007. Therefore, the data in the table for this site was based on nine months of data
b – W3 (Hunter River) replaced the decommissioned site W108 in October 2007. Therefore, the data presented in the table for this site is based on two months of data. Note that the December sample was missed due to the inaccessibility of the site.

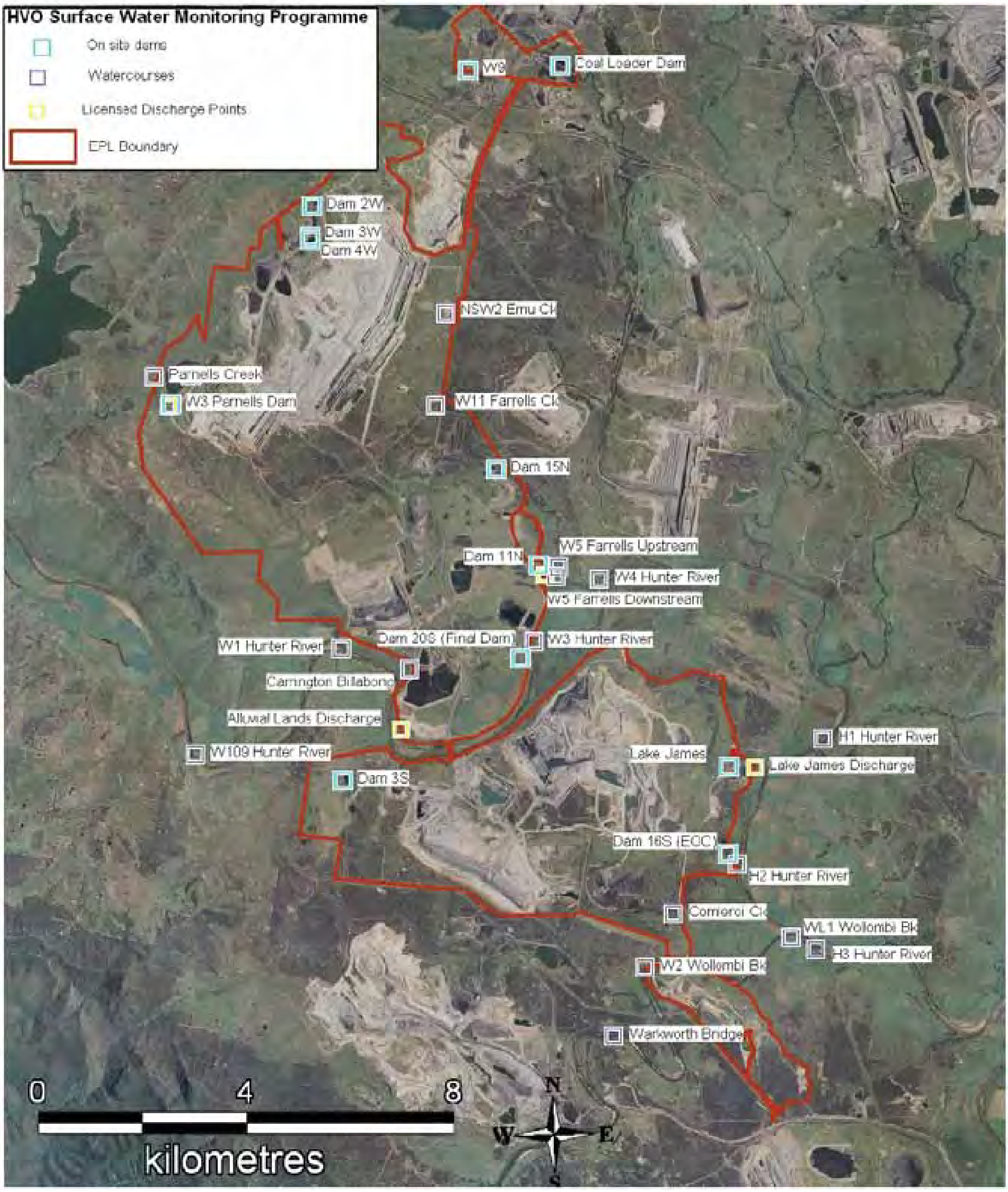

Figure 2.6 HVO Surface Water Monitoring Network

2.6 ENVIRONMENTAL VALUES OF RECEIVING WATERS

The Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) have prepared a guideline for water quality management for use throughout Australia and New

Zealand based on the philosophy of ecologically sustainable development (ESD). The guideline is called the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (2000) and is often referred to as the 'ANZECC guideline'.

The NSW Department of Environment Conservation (now DECCW) has prepared a booklet *Using the ANZECC Guidelines and Water Quality Objectives in NSW* (2006) to assist technical practitioners with applying the ANZECC guidelines in New South Wales (referred to herein as the NSW guideline).

The NSW guideline defines the 'Environmental values' of receiving waters as those values or uses of water that the community believes are important for a healthy ecosystem. The environmental values of the receiving waters of the Hunter River are regarded as:

- Aquatic ecosystem;
- Irrigation water supply;
- Livestock water supply;
- Primary and secondary contact recreation; and
- Visual amenity.

The ANZECC guidelines specify three levels of protection, from stringent to flexible, corresponding to whether the condition of the particular ecosystem is:

- of high conservation value;
- slightly to moderately disturbed; or
- highly disturbed.

The receiving waterways adjacent to the project area are regarded as slightly to moderately disturbed.

2.7 EXISTING MINESITE WATER MANAGEMENT SYSTEM

2.7.1 Overview

The mining and processing activities at HVO are geographically divided by the Hunter River into HVO South and HVO North, with movements of coal, coarse and fine reject, overburden, topsoil, equipment, water for operations, materials and personnel between the two areas. The HVO North comprises the active West, Carrington and North Pits. HVO South comprises the Chestnut Riverview Pit and South Lemington Pit. While HVO South and HVO North each have separate approvals, HVO is managed as an integrated operation.

The existing HVO North mine water management system is operated in accordance with the current HVO Water Management Plan, last updated in September 2009. The key objectives of the Water Management Plan are as follows:

- Diversion of clean surface water runoff away from areas disturbed by mining activities;
- Collection of surface water runoff from areas disturbed by mining activities to control suspended sediment prior to runoff from site or re-use via the mine water management system;
- Transfer of open cut pit water to storage dams for re-use in the mine water management system;
- Maximise the re-use and recycling of stored water on site, especially for use as the process supply to the CPP's and other related activities;

- Use stored water for dust suppression on haul roads, trafficable areas and stockpiles;
- Minimise extraction of water from the Hunter River during dry and drought periods; and
- Minimise offsite discharge under the Hunter River Salinity Trading Scheme (HRSTS) during wet periods.

A schematic of the HVO North mine water management system is provided in Figure 2.7.

2.7.2 Operational Guidelines

Representative operational guidelines for the HVO North water management system based on a review of available site operating protocol and discussions with HVO operational personnel is given in Appendix A.

Future water management will utilise the current water management system with minor changes.

2.8 HUNTER RIVER SALINITY TRADING SCHEME (HRSTS)

The HRSTS was introduced by the NSW Government to reduce salinity levels in the Hunter River and allows controlled water discharges into the Hunter River. The HRSTS operates under the *Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Regulation 2002*.

HVO North participates in the HRSTS and is allowed to discharge from Dam 11 (to Farnells Creek), Lake James (to the Hunter River) and Parnells Dam (to Parnells Creek) (see Figure 2.6) during periods of 'high' or 'flood' flows in accordance within the scheme rules.

Under the HRSTS, credit holders are permitted to discharge saline water to the Hunter River on a managed basis. The aim is to maintain river salinity levels below 600 µS/cm at Denman and 900 µS/cm at Singleton. This is achieved through:

- Discharge scheduling that allows discharge only at times when the river flow and salinity levels are such that salt can be discharged without breaching the salinity targets; and
- Sharing the allowable discharge according to licensed holdings of tradeable salinity credits.

The discharge schedule prohibits discharges during low flow periods. Discharges are regulated in proportion to credit holdings during high flow periods and unlimited discharges are permitted during flood flow periods, subject to tributary protection limits and the overarching requirement to achieve the upper limit salinity levels at Denman and Singleton.

A total of 1,000 credits are available for allocation through the scheme. Consequently, a holding of one credit entitles the owner to discharge 0.1 per cent of the total allowable discharge for the period.

The classification of low, high and flood flow periods is presented in Table 2.7.

HVO is located in the middle sector of the Hunter River. In the 2009/ 2010 period HVO held an allocation of 139 credits and operated discharge points under Environmental Protection Licence (EPL) 640 at Dam 9W (Parnells Dam), Dam 11N and K Dam (Lake James). If the discharge criteria were met, water was permitted to be released from the dams at rates of up to 130ML/day, 100ML/day and 120ML/day respectively, regardless of where it was generated.

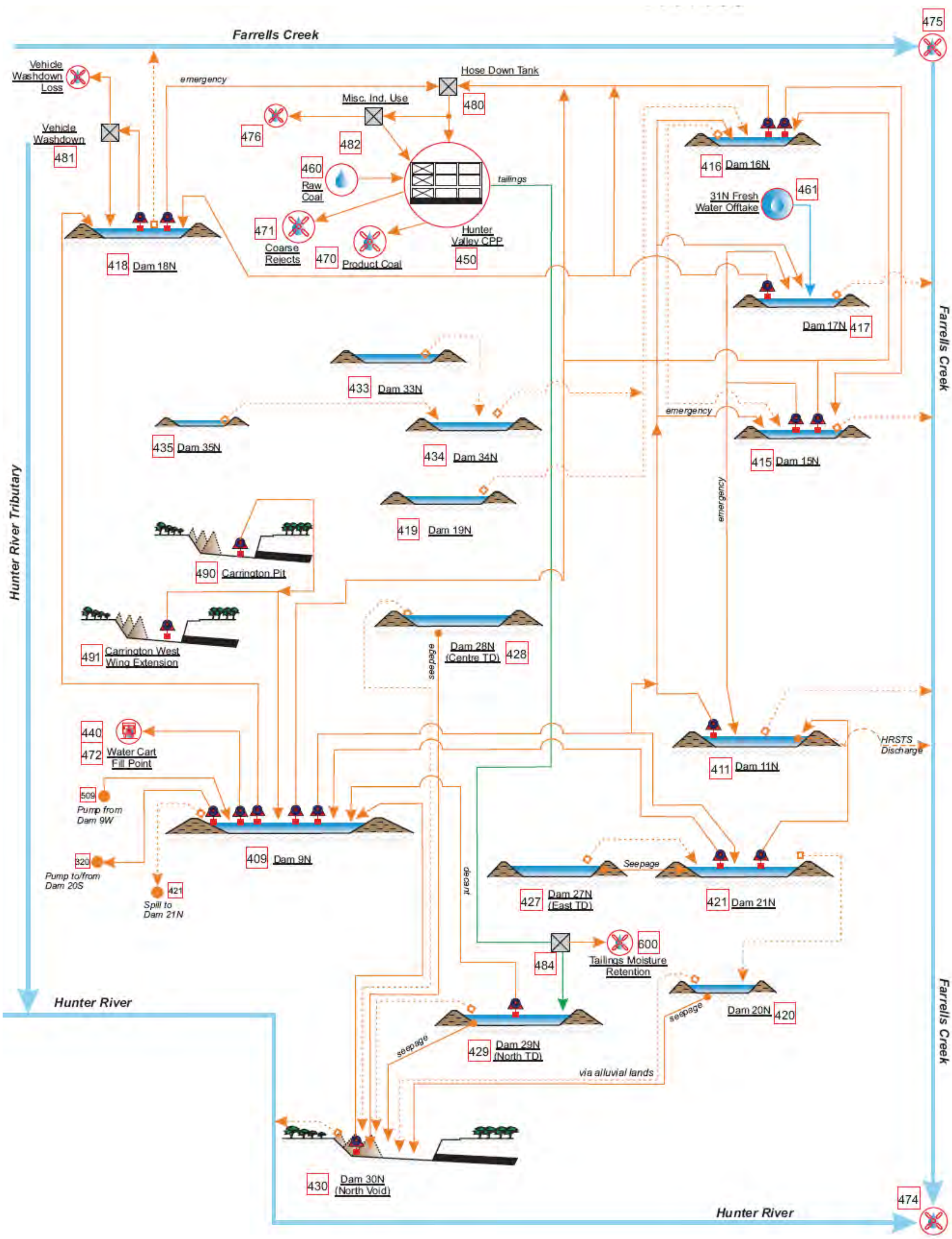

Figure 2.7 Minesite Water Management System Schematic

Table 2.7 Flow Discharge Categories for Each Sector of the Hunter River

Sector	Low flow range	High flow range	Flood flow range
Upper	Less than 1,000ML per day	1,000ML per day to 4,000ML per day (inclusive)	Exceeds 4,000ML per day
Middle	Less than 1,800ML per day	1,800ML per day to 6,000ML per day (inclusive)	Exceeds 6,000ML per day
Lower	Less than 2,000ML per day	2,000ML per day to 10,000ML per day (inclusive)	Exceeds 10,000ML per day

Protection of The Environment Operations (Hunter River Salinity Trading Scheme) Regulation 2002

If discharge of further excess water to the Hunter River system is required by either site, under the scheme, credits may be obtained on a day to day basis though trade between licensed users, or, for long term use, through public auction.

Table 2.8 shows a summary of the discharges from Dam 9W (EPA Point 4, Parnells Dam), Dam 11N (EPA Point 3) and K Dam (EPA Point 8, Lake James) under the HRSTS for 2007-2008.

Table 2.8 HRSTS Discharges 2007-2008

Discharge Year	Location	Number of Discharge Blocks	Credits Held	Allowable Discharge (tonnes)		Total Salt Load Discharged (tonnes)
				Total	At location	At location
2007	Dam 9W	6	126-211	13,767	2,166	447
	Dam 11N	1	159	2,330	370	4
	K Dam	-	-	-	-	-
2008	Dam 9W	14	65-397	30,224	5,898	1,152
	Dam 11N	5	20-139	25,730	2,220	251
	K Dam	20	11-303	36,931	4,905	602

3 POTENTIAL IMPACTS AND MITIGATION MEASURES

3.1 OVERVIEW

The proposal is expected to have a life of approximately 6 years (nominally 2012-2017). The potential impacts to surface water and water management during the life of the project are summarised below:

- Potential increase in flooding of adjoining properties along the Hunter River due to the proposed flood protection levees;
- Potential for Hunter River bank erosion to threaten the proposed groundwater barrier wall;
- Additional open cut pit water (including surface runoff and groundwater inflow) to be managed within the minesite water management system;
- Additional runoff from areas disturbed by mining (including overburden emplacement areas and rehabilitated areas);
- Potential change in runoff quality from disturbed catchments;
- Diversion of the Unnamed Tributary around the proposed extension area; and
- Post-mine extension water management impacts.

These impacts are discussed in the following sections.

3.2 HUNTER RIVER FLOODING

The proposal is potentially affected by regional flooding from the Hunter River to the south and local flooding from the Unnamed Tributary. Temporary levees are proposed to protect the proposed extension area from flooding. The levees would be constructed in two stages as shown in Figure 3.1 and Figure 3.2. The stage 1 levee would extend along the southern boundary and then northward adjacent to the Unnamed Tributary to join the existing spoil dump to the north of the proposed extension area. A drain and levee would also be constructed to the west of the pit adjacent to Lemington Road to divert local catchment runoff from the Unnamed Tributary around the pit to the north. These levees would protect the pit for the first three years of mine life as mining progresses from west to east for events up to and including the 100 year Average Recurrence Interval (ARI) event (plus 0.5m freeboard) from either the Hunter River or the Unnamed Tributary.

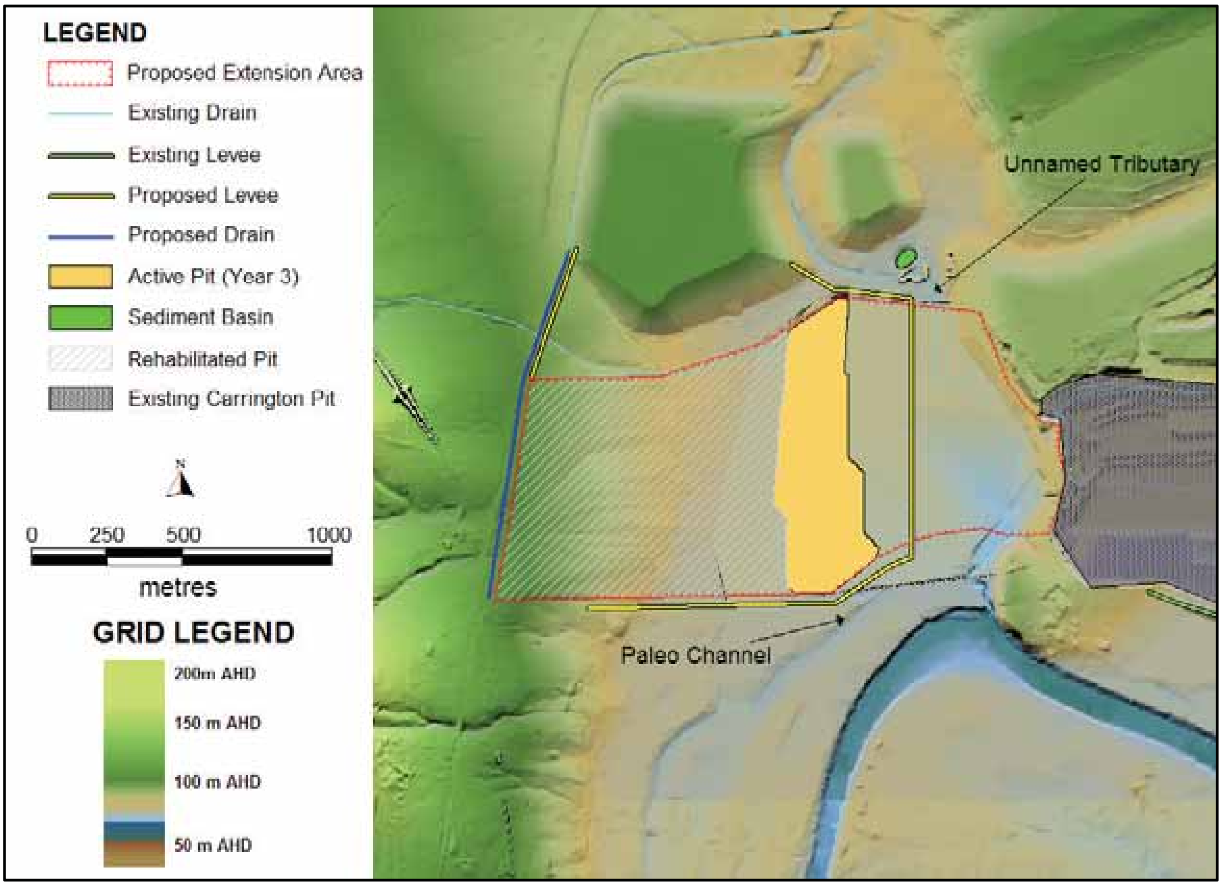

Figure 3.1 Stage 1 Levees and Drainage Channels

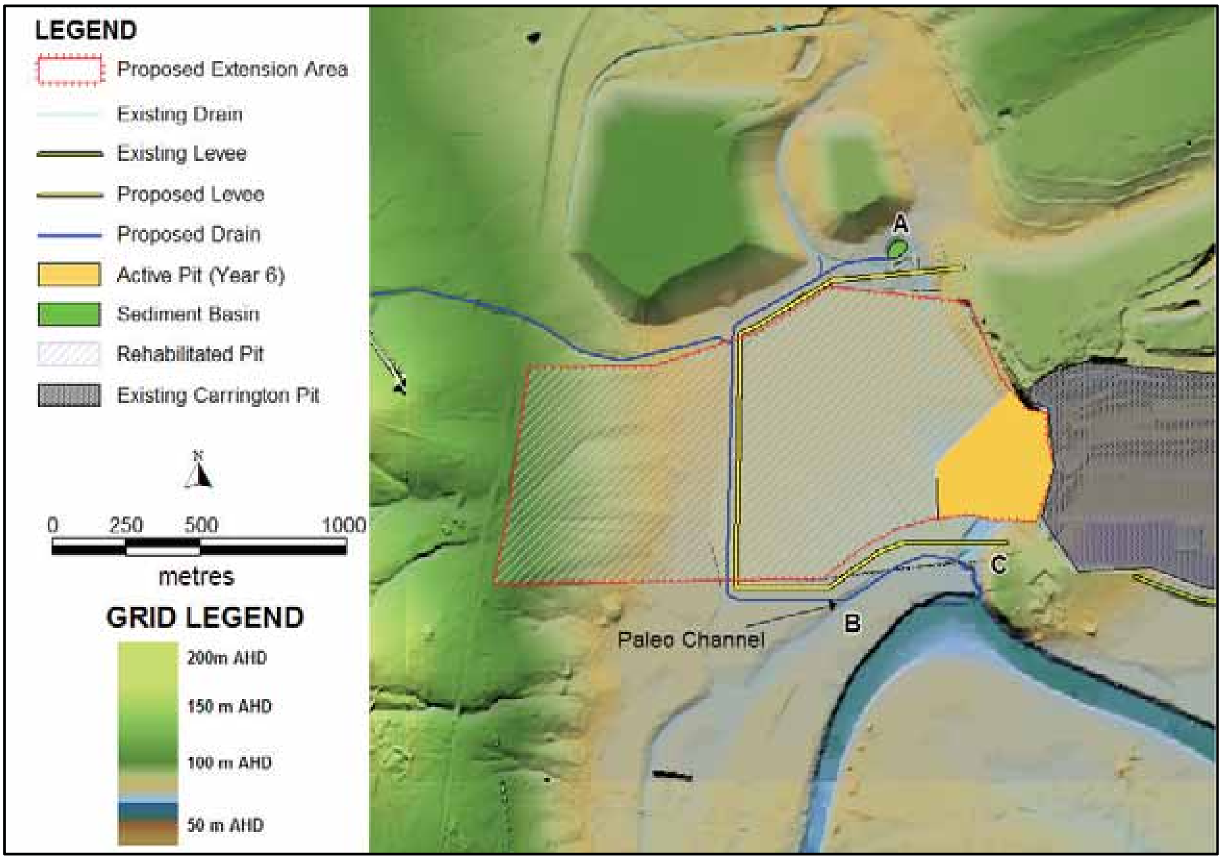

Figure 3.2 Stage 2 Levees and Drainage Channels

As mining progresses eastward, the pit would be progressively filled to the existing ground level and a new (stage 2) levee would be constructed across the fill around the western side of the pit. The levee adjacent to Lemington Road would be removed and the old drainage channel collecting local catchment runoff to the west would be reinstated. The Unnamed Tributary would be diverted to the west of the stage 2 levees across the filled pit. The diversion would then drain into the paleo-channel on the southern side of the levee back into the Unnamed Tributary before draining into the Hunter River. At the completion of mining, the levees would be removed and the existing Unnamed Tributary Channel would be reinstated, as shown in Figure 3.3. An assessment of the potential impact of the proposed levees on flood levels along the Hunter River is given in Section 5.

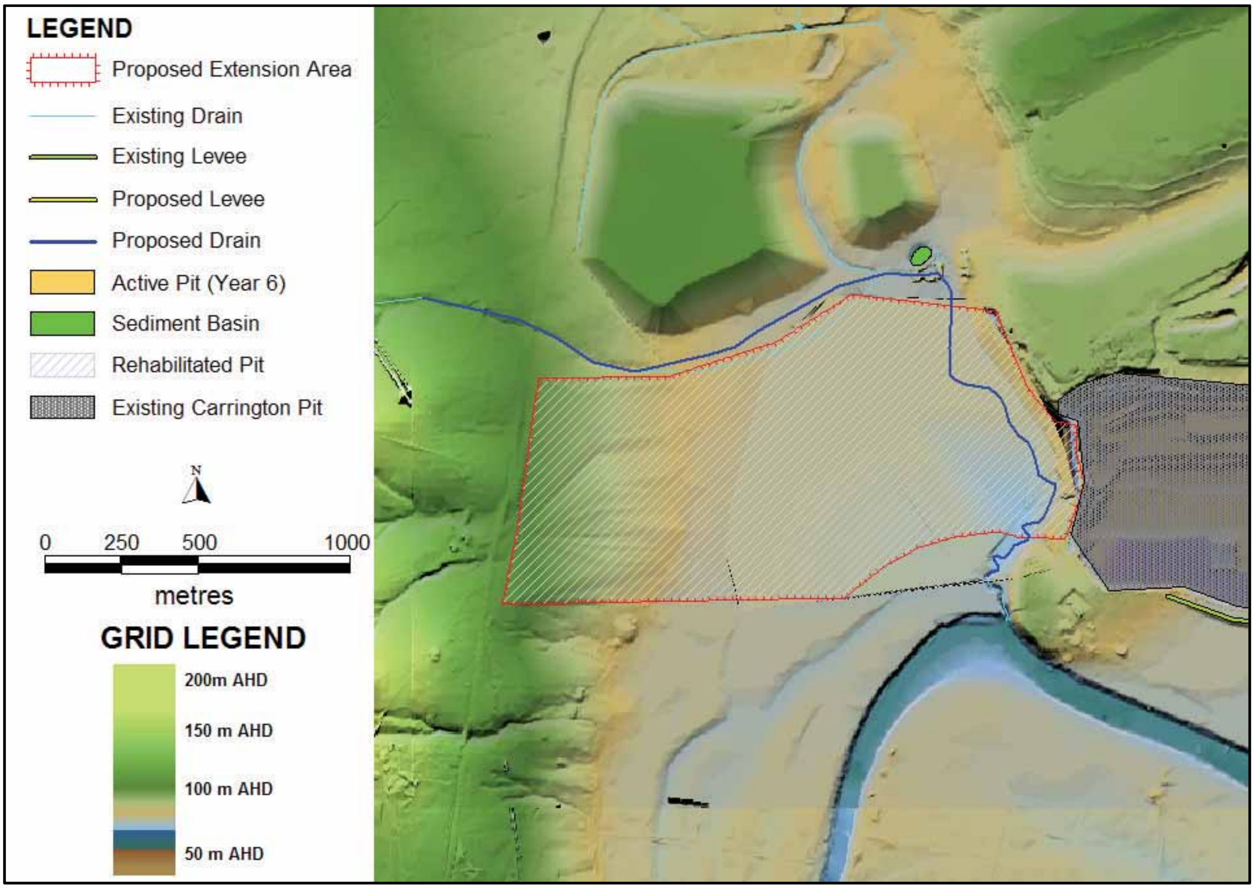

Figure 3.3 End of Mine Levees and Drainage Channels

3.3 HUNTER RIVER EROSION

There is a possibility that the proposed levees may impact on the erosion potential of the adjacent Hunter River channel. The Hunter River channel adjacent to the proposed extension area is located on an alluvial floodplain and is poorly aligned and therefore susceptible to erosion under existing conditions. If northward erosion of the Hunter River was to occur, it is possible that the proposed groundwater barrier wall may be at risk. To reduce the risk, the barrier wall would be located a minimum of 170m from the top of bank of the adjacent Hunter River, to the north of an existing paleo-channel. An assessment of the impact of the proposed levees on the erosion potential of the Hunter River is given in Section 5.6.

3.4 ADDITIONAL PIT WATER

Additional pit water would be generated by the collection of surface water runoff from areas draining to the open cut pit area, and groundwater inflow to the pits. Pit water can have elevated levels of salinity and may also contain elevated levels of suspended sediment.

The management of water in the proposed extension area would essentially be the same as for the existing operations. All water accumulated in the pit would be transferred via pit dewatering pumps to Dam 9N, where it would be re-used and recycled in the HVO North mine water management system. An assessment of the impact of the additional pit water on the mine site water balance is given in Section 4.

3.5 CHANGE IN SURFACE WATER RUNOFF VOLUME

The volume of surface runoff water entering the mine water management system is dependent on rainfall and the catchment areas of the open pits, active overburden emplacement areas, industrial areas and rehabilitation areas, which can vary considerably over the life of the proposal.

The expected removal of catchment due to mining and associated average annual runoff volume for the defined scenarios is presented in Table 3.1. The volume of surface water runoff from the various catchment areas on the minesite was estimated using the OPSIM model, described in Section 4 and long term rainfall data. For comparison, the average annual flow in the Hunter River at the closest gauging station has also been included.

Table 3.1 shows that the relative reduction in the Hunter River flows due to the proposal is small compared to the total flows in the Hunter River. It is proposed that the catchment removed due to mining would be largely reinstated to existing conditions at the end of the life of the mine.

Table 3.1 Catchment Diversion & Loss of Runoff

Scenario	Catchment Loss (ha)	Average Annual Catchment Runoff Reduction (ML/annum)	Average Annual Hunter River Volume (ML/annum)
Years 1 – 3	155.4	136	421,000
Years 4 - 6	90.4	79	

3.6 CHANGE IN RUNOFF WATER QUALITY

Land disturbance associated with mining has the potential to adversely affect the quality of surface runoff through increased sediment loads. In addition, runoff from active mining areas (pits, roads, coal stockpiles, etc.) and overburden emplacements may have increased salinity compared to natural runoff. The following measures will be implemented to minimise these potential impacts:

- Runoff from undisturbed catchments will be diverted away from disturbed areas using surface drains;
- Surface runoff from disturbed areas will be treated through sedimentation basins prior to discharge from the site. All new sediment dams and water management systems will be designed in accordance with relevant standards;
- Sedimentation basins will be used to treat surface runoff from rehabilitated areas until the quality of runoff is suitable for release;
- Saline water from mining related activities will be collected within the mine water management system. Discharges will be released in accordance with the HRSTS rules; and
- Sediment dams will be maintained or constructed as required and will be designed in accordance with relevant design standards (DECC 2008).

The proposed management measures will ensure no measurable adverse impacts on riparian and ecological values of watercourses on the site and downstream of the proposal.

3.7 UNNAMED TRIBUTARY DIVERSION

The proposed temporary diversion of the Unnamed Tributary required as part of the Stage 2 levees would be designed to be generally consistent with the existing approved Unnamed Tributary diversion channels constructed upstream. The proposed layout configuration of the diversion is given in Figure 3.4. Typical cross sections of the diversion are shown in Figure 3.5 and a longitudinal-section profile of the proposed diversion is given in Figure 3.6. The design criteria for the proposed diversion are as follows:

- A bed width of 5m;
- 1V:3H side slopes;
- A bed slope of 0.15% to the existing paleo-channel and a bed slope of 0.66% to the Unnamed Tributary;
- The soil profile below the channel will be reinstated with a suitable growing medium and the channel will be revegetated with grasses;
- The sub-grade of the diversion across the proposed filled in pit would be designed by a suitably qualified geotechnical engineer to minimise subsidence and cracking;
- The bed of the diversion at both upstream and downstream ends will match the existing unnamed tributary diversion bed elevation;
- The diversion will be aligned to the existing unnamed tributary diversion alignment at both upstream and downstream confluences to allow smooth transition of flow from the existing channel to the diversion; and
- The estimated cut volume of the diversion (assuming the pit is filled in to its existing level is approximately 110,000 m^3.

The diversion is some 50% longer than the existing Unnamed Tributary channel. Hence, the channel slope and therefore erosion potential is approximately half that of the existing channel. For this reason, no hard engineering erosion protection measures are proposed for the diversion. In addition, the bed slope of the diversion at the downstream confluence is approximately one sixth of the existing channel bed slope (0.6% compared to 4%). Hence, it is not expected that erosion protection measures will be required at the downstream confluence.

Figure 3.4 Unnamed Tributary Diversion Layout

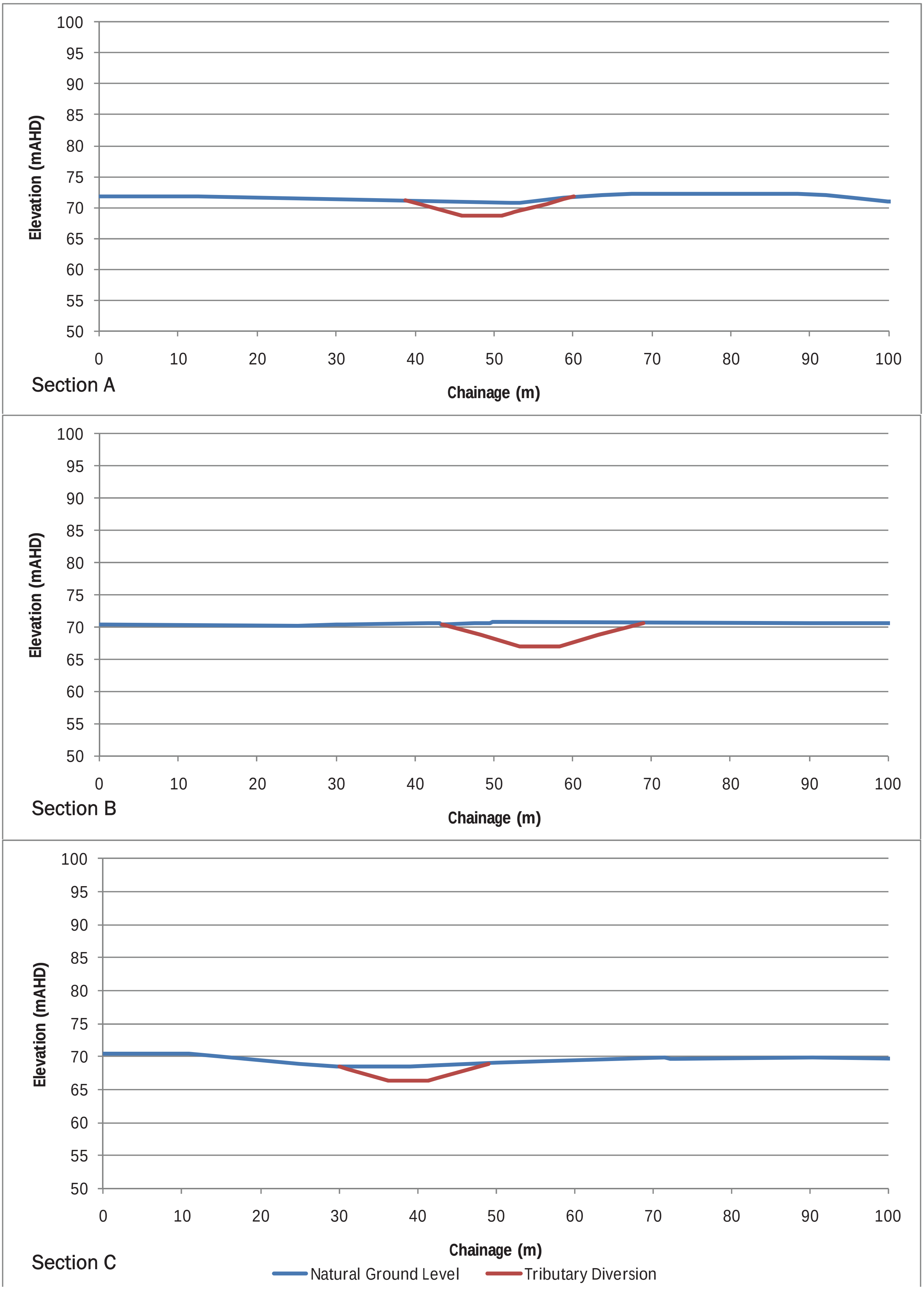

Figure 3.5 Unnamed Tributary Diversion Cross Sections

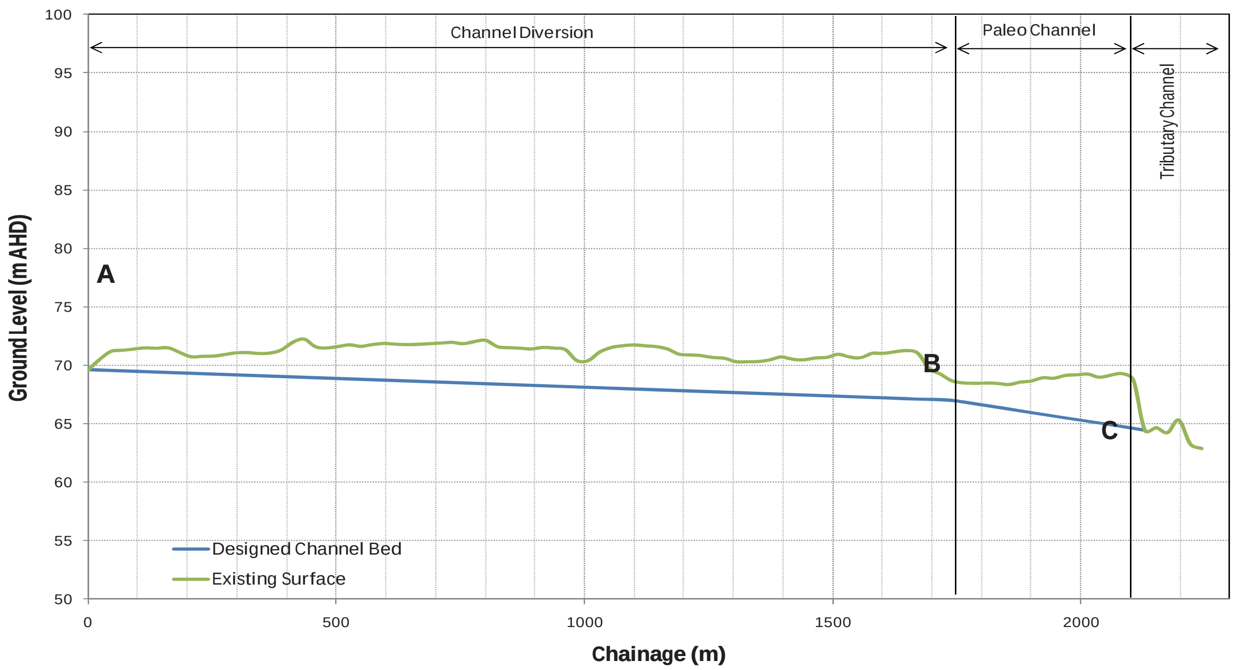

Figure 3.6 Unnamed Tributary Diversion Longitudinal Section Profile

At the end of mine life, the levees would be removed and the Unnamed Tributary channel would be reinstated to its original position, as shown in Figure 3.3. The end-of-mine Unnamed Tributary channel would be constructed to be a similar shape to existing conditions.

As identified in Section 2.2, and shown in Figure 2.2, the riparian zone of the existing ephemeral unnamed tributary lacks any significant riparian vegetation. It is of low aquatic significance, providing only poor quality to marginal habitat for aquatic species. Post-mining, the reinstated ephemeral Unnamed Tributary will be vegetated with appropriate species to reflect natural conditions along similar streams in the region. This accords with considerations set out in the Department of Water and Energy (2008) Guidelines for Controlled Activities – Riparian Corridors.

Detailed design plans for the temporary diversion and reinstatement of the Unnamed Tributary will be provided in a Management Plan to be developed in consultation with the NSW Office of Water and NSW Industry and Investment. The Management Plan would include details of:

- existing and proposed channel alignment, longitudinal section and cross-sections,
- proposed locations of cut and fill,
- sediment and erosion control measures to be implemented during construction,
- proposed revegetation of the channel bed, banks and riparian zone,
- a proposed monitoring regime to ensure ongoing stability and ecological health of the stream, which would include periodic inspection for erosion or deposition and a photographic record of key cross-section locations, supplemented by ground survey if instability is detected,
- contingency measures to be implemented to address any observed issues with establishment of the modified channel.

Section 5 and Appendix B presents the methodology and results of a flood study to assess the impact of the proposal on flood levels from both the Hunter River and the Unnamed Tributary.

3.8 POST MINING WATER MANAGEMENT

The final landform for the proposed Carrington Pit includes rehabilitated overburden emplacements and the evaporative sink. It is proposed that the extension area be rehabilitated to a combination of woodland, grazing land and potential cropping land in accordance with the HVO Mine Closure Plan, which would be developed with consideration of the Department of Primary Industries (DPI) “Synoptic Plan: Integrated Landscapes for Coal Mine Rehabilitation in the Hunter Valley of NSW (DMR, 1999)”.

The final void evaporative sink has been designed to facilitate evaporative losses at a rate which is greater than the accumulation of groundwater within the pit shell, rainfall runoff and infiltration through the rehabilitated final landform. It is understood that the proposed evaporative sink would need to be extended to accommodate the proposal. It is proposed that this void area be extended to between 85 to 100ha to accommodate the extended pit shell (Mackie 2010).

Rehabilitation at HVO is to be undertaken progressively and would generally follow the rate of mining. The proposed approach to rehabilitation within the proximity of the Carrington Pit gives consideration to, amongst other things, the pre-mining land capability class where practical. The Carrington Pit final void is proposed to function as an evaporative sink to manage groundwater post-mining. The final dimension and design of the evaporative sink would be prepared in consultation with the DoP.

4 WATER MANGEMENT SYSTEM ASSESSMENT

4.1 OVERVIEW

The potential impacts of the proposal on the HVO North surface water management system have been assessed using the OPSIM model. Details of the existing water management system at HVO North including the OPSIM model configuration is given in Appendix A. Details of the assessment methodology and assessment outcomes are discussed in the following sections.

4.2 METHODOLOGY

4.2.1 Potential Impacts

The potential impacts on the operation and performance of the HVO North mine water management system due to the proposal is dependent on a number of factors, including the following:

- Coal production;
- Open cut pit footprint;
- Rainfall runoff and evaporation;
- Changes in site demands;
- Water supplies;
- Controlled discharges (HRSTS).

The impact of these factors on the HVO North mine water management system has been assessed using the OPSIM operational simulation model. Background details of the HVO North OPSIM model are provided in Appendix A and summarised in the following sub-section.

4.3 OPSIM MODEL

HVO has developed a representative water balance model utilising the OPSIM Operational Simulation Program. The OPSIM operational simulation model was initially set up in 2007, and has since been regularly updated and calibrated when new data has been made available.

The HVO OPSIM model has been designed to simulate the operation of all major components of the water management system, including:

- Climatic variability – rainfall and evaporation;
- Catchment runoff and collection;

- Pit dewatering;
- Pump and gravity transfers;
- Water storage filling, spilling, evaporation and leakage;
- Industrial water extraction, usage and return;
- Regional groundwater inflows.

A schematic of the HVO North model is presented in Figure 2.7. The model comprises a collection of functional nodes, each representing a specific operational feature of the mine's water management system.

The current surface water impact assessment has utilised the most recent OPSIM model, which was updated in late 2009.

It should be noted that the proposal does not significantly alter the configuration of the water management system, including how the extended operations of the proposal would affect water supply and demand.

4.3.1 Assessment Scenarios

The surface water impact assessment for the proposal has been undertaken for the following scenarios:

- Base Case (Year 2009);
- Year 3 of the proposal (nominally 2014) – Total catchment & proposed extension area only; and
- Year 6 of the proposal (nominally 2017).

The progression of the proposal for each of these scenarios is provided in Figure 3.1 and Figure 3.2 and the changes in catchment area are given in Table 4.1. Year 3 and Year 6 are representative of the Stage 1 and Stage 2 levee configurations.

Table 4.1 HVO North Catchment Areas

Catchment Type	Catchment Area (ha)				
	2009 (Base Case)	2014 (Year 3)		2017 (Year 6)	
	Total	Total	Proposed Extension Area Only	Total	Proposed Extension Area Only
Natural/Undisturbed	93	93	-	93	-
Open Cut Pits	77	103	26	93	16
Cleared/Prestrip	2	2	-	2	-
Roads/Industrial/Hardstand	181	181	-	181	-
Spoil – Unrehab	95	224	129	169	74
Spoil – Rehab	641	641	-	641	-
Tailings Dam	109	109	-	109	-
Total	1,198	1,353	155	1,288	90

Table 4.1 shows the following:

- For the Year 3 design scenario, there is an increase in HVO North disturbed catchment area of 13% compared with the existing case, primarily associated with pit area and unrehabilitated spoil.
- For the Year 6 design scenario, there is an increase in HVO North disturbed catchment area of 8% compared with the existing case, primarily associated with pit area and unrehabilitated spoil.

Assessment of the impact of the proposal for each of the scenarios is discussed in Section 4.4.

4.3.2 Controlled Discharges (HRSTS)

The OPSIM model has been configured to include the simulation of controlled discharges of stored mine water inventories into the Hunter River in accordance with the requirements of the Hunter River Salinity Trading Scheme (HRSTS). The OPSIM model simulates the ability for controlled discharges from Dam 11N, at a maximum rate of 100ML/day if the discharge criteria are met. Note that the estimated HRSTS discharge opportunities were based on the 2009/2010 HVO credit allocation of 139 credits.

Discharge opportunities under the HRSTS were estimated by JP Environmental and the streamflow file was developed using streamflow data generated for the Hunter River, in the HRSTS Middle sector. The streamflow records generated by NSW Office of Water (NOW) were used for the period 1892 to 1992, whilst recorded data for the station were used from 1993 to 2007. A flow versus electrical conductivity relationship was established and used to estimate total allowable discharge (TAD's) for the HRSTS Middle Sector for high flows. Flood flows were allocated the maximum daily discharge rate allowed by the site discharge location.

As streamflow data was generated using local rainfall data from 1892, the timing of the TAD's are consistent with the rainfall runoff generated by OPSIM. Hence the HRSTS Scheme can be simulated by subtracting calculated allowable site TAD's (based on HVO credit holdings) from the relevant discharge storages. A conservative approach to estimating the discharge envelope was used in recognition that many of the EC values at the station are influenced by the operation of the HRSTS since 1993.

4.4 ASSESSMENT OUTCOMES

4.4.1 Overview

An assessment of the potential impacts of the proposal on the HVO North mine water management system has been undertaken using the HVO North OPSIM Model. Assessment of the potential impacts on the performance of the existing water management system has been undertaken against the following key performance indicators:

- Raw/mine water consumption;
- Minesite storage inventory;
- Pit Inventory;
- North Void Inventory;
- Storage discharges (quantity, frequency, duration); and
- Overall site water balance.

A schematic layout of the HVO North OPSIM model is presented in Figure 2.7. Operational guidelines and controls applied to the model are described in Appendix A.

It is important to note that investigation outcomes are dependent on the validity of the information on which the investigations were based. Although considerable care and attention has been paid to ensuring that base information is the best available, there is inherent variability with respect to some key site characteristics (eg catchment yield/rainfall runoff, pit groundwater inflows, tailings return rates). Nevertheless, investigation outcomes are considered to be fair and reasonable, given the current status of base information.

4.4.2 Site Raw Water Requirements

For the purposes of current investigations, the term *Site Raw Water Requirements* represents the amount of imported raw water via the current Hunter River Extraction licence that is required to sustain the nominated design production rate and associated operational demands at HVO North. Any shortfall in mine water is made up from imported raw water – that is, during dry periods imported raw water is used to ensure that all operational demands are met.

Site water requirements for each modelling scenario were assessed as follows:

- Extraction of raw water from the Hunter River was only required for the Base Case (Year 2009) modelling scenario.
- Raw water extraction from the Hunter River was not required for the Year 3 and Year 6 scenarios. This is primarily due to the lower production rate at HVCPP during the life of the project.
- The mine water system was sufficient to supply water demands for the Year 3 and Year 6 assessment scenarios.

4.4.3 Minesite Storage Inventory

An assessment of minesite storage inventory characteristics at HVO North has been undertaken for each modelling scenario. The following storages have been combined in the storage inventory assessment:

- Dam 9N
- Dam 11N
- Dam 15N
- Dam 16N
- Dam 17N
- Dam 18N
- Dam 19N
- Dam 20N
- Dam 21N

The combined full supply volume of the above storages is approximately 1,420ML. Figure 4.1 shows the combined storage inventory versus annual exceedance probability.

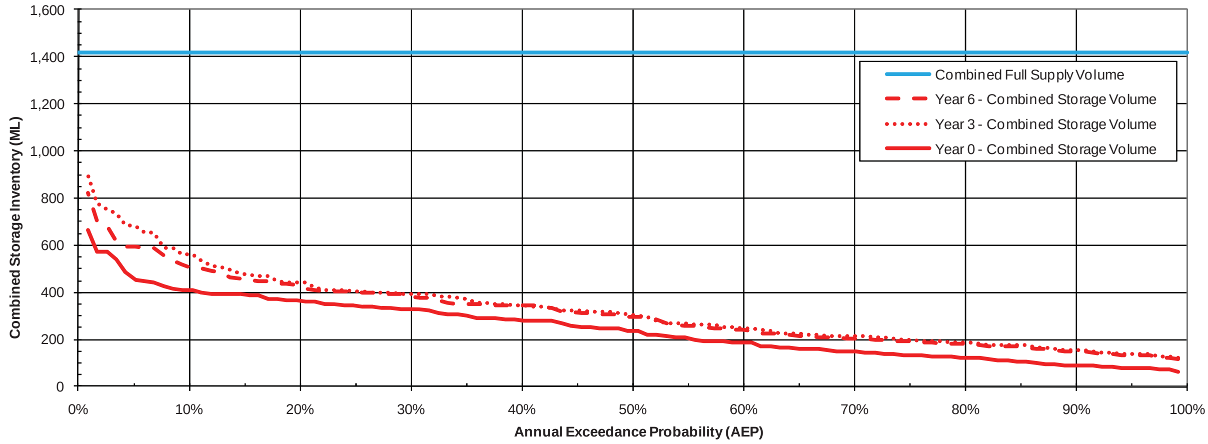

Figure 4.1 Minesite Storage Inventory – Annual Exceedance Probability (AEP)

A review of Figure 4.1 indicates the following:

- Under current conditions, the combined storage inventory does not exceed the available combined full supply volume (1,420ML) of the associated storages.
- For both the Year 3 and Year 6 scenarios, there is little increase in expected storage inventory.

The assessment indicates an approximate 15% increase (relative to the full supply volume) in the overall minesite inventory as a result of the proposal.

4.4.4 Pit Inventory

An assessment of pit inventory characteristics at HVO North has been undertaken for each modelling scenario. Note that the total Carrington Pit inventory have been assessed. Figure 4.2 shows the combined Carrington pit inventory versus annual exceedance probability.

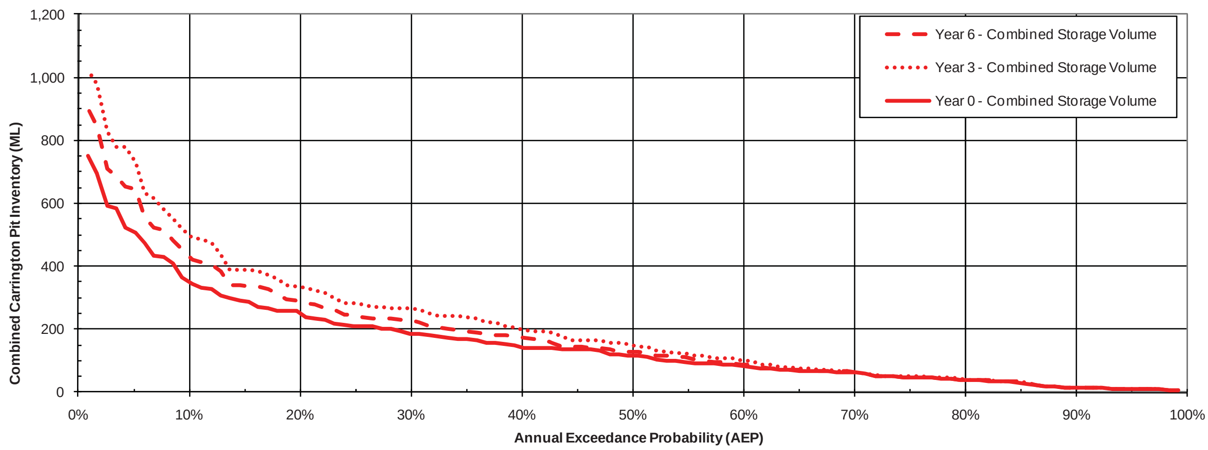

Figure 4.2 Carrington Pit Inventory – Annual Exceedance Probability (AEP)

A review of Figure 4.2 indicates that there is an increase in the risk of pit inundation as a result of the proposal. This is due to the increase in catchment area to the entire Carrington Pit area, and additional groundwater inflows associated with the proposed extension area.

For a 10% AEP, the modelled pit inundation for each scenario is as follows:

- Base Case (Year 0) - 340ML
- Year 3 - 490ML
- Year 6 - 430ML

However, these pit inundation volumes would be reduced if additional pit dewatering capacity is available at the Carrington pits for transfer to other minesite storages.

4.4.5 North Void Inventory

A forecast assessment of water accumulation in the North Void (Dam 30N) at HVO North has been undertaken for the period of the proposal (Years 2012-2017) to provide an indication of potentially available mine water reserves at HVO North.

This assessment has been based on a starting volume in the North Void of 16,250ML (current estimated inventory) and a full supply volume of 19,500ML. After reaching this volume, the North Void spills to the Hunter River. Additionally, modelling has conservatively assumed that water is extracted from the North Void only as required, and is not exported to other areas of the HVO minesite.

Figure 4.3 shows the forecast North Void inventory over a 6-year period.

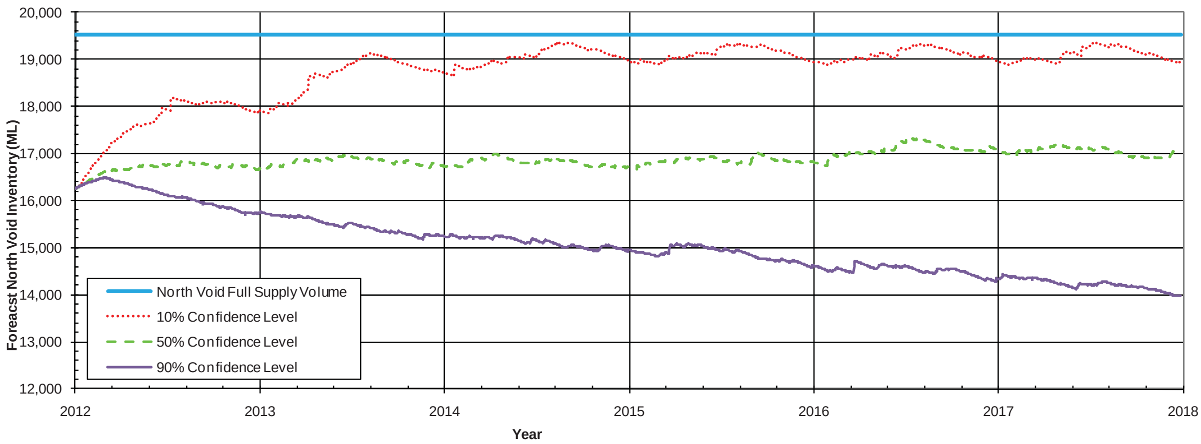

Figure 4.3 North Void Forecast Assessment

A review of Figure 4.3 indicates the following:

- There is a 10% chance that the North Void would increase in volume over the life of the project by 2,400ML or more.
- There is a 50% chance that the North Void inventory would remain steady over the life of the project.
- There is a 10% chance that the North Void would reduce in volume over the life of the project by more than 2,300ML.

4.4.6 Storage Discharges

For each modelling scenario, expected discharge characteristics at HVO North have been assessed on the basis of simulated spillway overflows from key site storages to receiving waters and are summarised in Table 4.2.

The assessment has only included storages which have the ability to spillway discharge into receiving water, as follows:

- Dam 11N
- Dam 15N
- Dam 16N
- Dam 17N
- Dam 18N

Table 4.2 indicates the proposal has the following impact on the overall site storage spill frequency:

- Increase in spill frequency from approximately a 1 in 10 to 1 in 5 year ARI.
- No increase in the average number of spills in a spill year.
- No increase in the average number of days per spill event.

Table 4.2 Estimated Site Spill Characteristics

Scenario	Risk of One or More Spillway Discharges – Annual Exceedance Probability (%)	Risk of One or More Spillway Discharges – Annual Exceedance Probability (1 in x)	Average No. Spills in Spill Year	Average No. Days Per Spill Event
Base Case (Year 2009)	9	11	1	3
Year 3	17	6	1	3
Year 6	17	6	1	3

4.4.7 HRSTS Assessment Outcomes

For each modelling scenario, expected HRSTS discharge characteristics at HVO North have been assessed on the basis of controlled discharges from Dam 11N, using the methodology detailed in Section 4.3.2.

Figure 4.4 shows the annual HRSTS discharge versus Annual Exceedance Probability. A review of Figure 4.4 indicates the following:

- There is a 50% chance that the annual HRSTS discharge volume would be around 1,100ML or greater.
- There is a 10% chance that the annual HRSTS discharge volume would be around 3,850ML or greater.

The HRSTS modelling results indicate, on average, 4.5 HRSTS discharge events per year.

Based on the calculated discharge opportunities and the current HVO credit allocation of 139 credits, modelled controlled discharges from HVO North should be in compliance with the HRSTS Scheme.

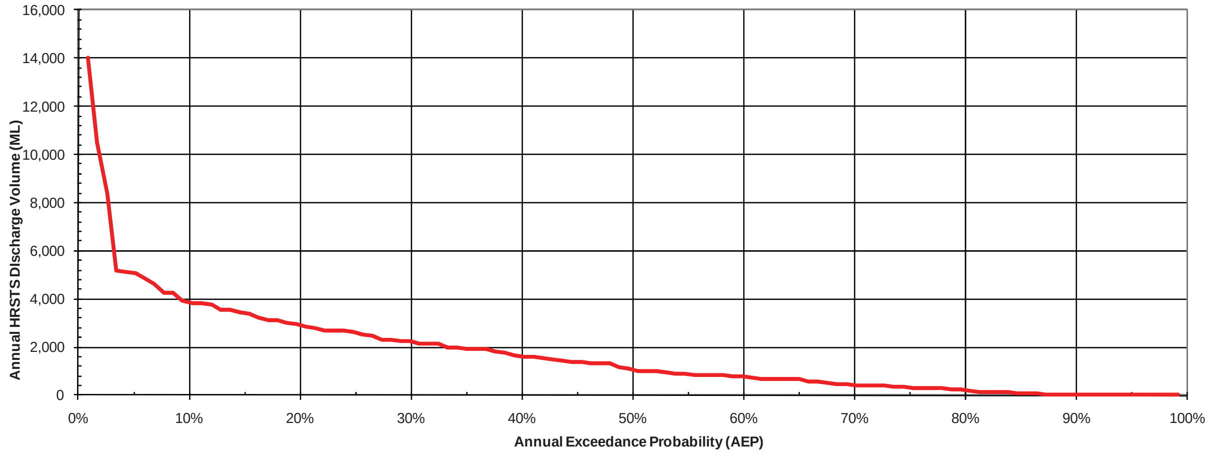

Figure 4.4 HRSTS Discharge Assessment

4.4.8 Overall Site Water Balance

A representative long-term water balance for each modelling scenario for HVO North is presented in Table 4.3. The data presented in the table has been derived from long-term averages estimated from the OPSIM 116 year simulation.

Table 4.3 Summary Average Annual Water Balance

Item	Base Case (Year 2009)		Year 3		Year 6	
	Inflow (kL/d)	Outflow (kL/d)	Inflow (kL/d)	Outflow (kL/d)	Inflow (kL/d)	Outflow (kL/d)
Climatic & Regional						
Rainfall Runoff	5,052	-	5,576	-	5,368	-
Evaporation	-	371	-	430	-	426
Groundwater Inflow	1,306	-	1,422	-	1,380	-
Imported						
Raw Coal Moisture	3,276	-	2,628	-	2,628	-
Hunter River Extraction	613	-	0	-	0	-
Losses						
Product Moisture Loss	-	3,014	-	2,417	-	2,417
Coarse Rejects Loss	-	1,489	-	1,195	-	1195
Tailings Moisture Retention	-	3,476	-	2,788	-	2,788
Vehicle Washdown Loss	-	63	-	63	-	63
HVCPP Misc. Ind Use Loss	-	131	-	253	-	253
Water Cart Loss	-	1,508	-	1,680	--	1,680
Site Releases/Spills						
HRSTS Discharges	-	128	-	302	-	287
Spills to Receiving Waters (in addition to HRSTS Discharges)	-	17	-	72	-	31
Change in Storage	13	63	12	438	12	248
Total	10,260	10,260	9,638	9,638	9,387	9,388

The long-term water balance rates provided above are the average of the 116 year operational simulation. It should be recognised that the following items are subject to climatic variability:

- Rainfall runoff.
- Evaporation.
- Imported water requirement.
- Site releases/spills.

Whilst it provides an indication of the long-term average rates for each of the items, application of the nominated rates for other purposes should only be undertaken with due consideration of the suitability of the nominated rate and any potential implications.

4.5 COMMENTARY

The assessment indicates that the proposal has the potential for an increased minesite water inventory, and an associated increase in spill frequency. Given the relatively small magnitude of these impacts, they could potentially be mitigated by implementing measures such as transferring mine water to other mining areas as required.

Although the assessment outcomes can be partially attributed to the additional groundwater inflows and catchment area associated with the proposal, the reduced production at HVCPP results in lower overall losses through the tailings management system, and hence a net increase in overall retained storage/pit inventory and frequency of discharge.

This assessment has been undertaken using the forward projected production rates for HVO North. Should overall production increase to the maximum allowable under the Mining Consent, the following impacts would be expected:

- Raw water consumption would increase;
- Overall minesite storage inventory (and associated site discharge characteristics) would decrease.

Note that detailed modelling of this scenario has not been undertaken as part of the current study scope.

4.6 MANAGEMENT AND MITIGATION

There are no substantial changes proposed to the HVO North water management system due to the proposal. Recommended management measures include the following:

- Continuation of surface and groundwater quality monitoring;
- Regular updates of the HVO water balance model to ensure currency with the current operational configuration of the mine water management system.

4.7 POST MINING WATER MANAGEMENT

4.7.1 Final Void Water Levels

Final void water levels have been modelled as part of the Carrington West Wing groundwater assessment. A summary of the findings is provided below:

- Long term open void water level is designed to stabilise at about 40mAHD after more than 50 years of recovery, with groundwater flow through spoils to the open void.
- This level is around 25m below a system "spill" elevation at the top of the barrier walls of 65mAHD and 20m below the median water level in the Hunter River.
- At this stabilised level the average net contribution to the pit from rainfall, runoff and infiltration are balanced by evaporative losses from the open water void.

Refer to the "Carrington West Wing Groundwater Assessment" report (Mackie 2010) for further details.

4.7.2 Long Term Salinity

The final void groundwater quality has also been modelled as part of the Carrington West Wing groundwater assessment, with outcomes summarised as follows:

- Long term void water quality is considered likely to exhibit the following:
- pH range from 7.5 to 9.5
- TDS range from 1000mg/L increasing to about 3000-4000mg/L in the long term.

Refer to the "Carrington West Wing Groundwater Assessment" report (Mackie 2010) for further details.

5 FLOOD IMPACT ASSESSMENT

5.1 GENERAL

The proposal is potentially susceptible to flooding from the Hunter River to the south and the Unnamed Tributary to the north. A detailed flood assessment was undertaken of both systems to estimate design flood levels adjacent to the mine and to determine the potential impacts associated with the proposed diversion and levees.

Design flood discharges for the Hunter River were estimated from an annual series flood frequency analysis of recorded flows. The XP-RAFTS rainfall runoff routing model was used to estimate design flood discharges for the Unnamed Tributary. The TUFLOW two-dimensional hydraulic model (WBM, 2008) was used to simulate the flow patterns of the Hunter River channel and floodplain adjacent to HVO North. Details of the methodology and results of the design discharge estimation and details of the development and calibration of the TUFLOW model are given in Appendix B.

5.2 MODEL SCENARIOS

Three TUFLOW models were prepared to represent the following development conditions:

- Existing conditions – including the existing approved levees;
- Stage 1 Operational Phase levees – including the existing approved levee and Stage 1 levees shown in Figure 3.1.
- Stage 2 Operational Phase levees – including the existing approved levee and the Stage 2 levee and diversion shown in Figure 3.2.

The existing, Stage 1 and Stage 2 models were used to determine design flood levels, depths, extents, velocities on the floodplain adjacent to the proposed extension area for the 2, 5, 10, 20, 50 and 100 year ARI design floods and the impacts of the proposed levees on adjoining properties.

At the conclusion of mining, the ground levels across the proposed extension area will be returned to existing levels and the levees would be removed. Therefore the existing conditions model would represent the 'End of Mine' scenario. As a result, there would be no flood impacts resulting from the proposal at the end of mine life.

5.3 EXISTING CONDITIONS MODEL RESULTS

5.3.1 Flood Extents and Depths

Figure 5.1 and Figure 5.2 show the 10 year and 100 year ARI design flood depths and extents for the Hunter River and the Unnamed Tributary adjacent to HVO North for existing (and end of mine) conditions. Peak flood levels at key reporting locations within the model area (shown in Figure 5.1) for the 2, 5, 10, 20, 50 and 100 year ARI design flood are given in Table 5.1. The following is of note:

- The 2 year ARI Hunter River design flood is generally confined to the main channel. The Hunter River flood flows exceed the capacity of the channel and inundate the floodplain in the vicinity of the proposed extension area for the 5 year ARI design event.
- The Hunter River dominates flood levels across the proposed extension area for floods greater than and equal to the 10 year ARI event. Local catchment flows from the Unnamed Tributary dominate for the more frequent floods.
- The 100 year ARI design flood levels across the proposed extension area are about 75m AHD. Ground levels across the proposed extension area range from 70m AHD to 74m AHD.

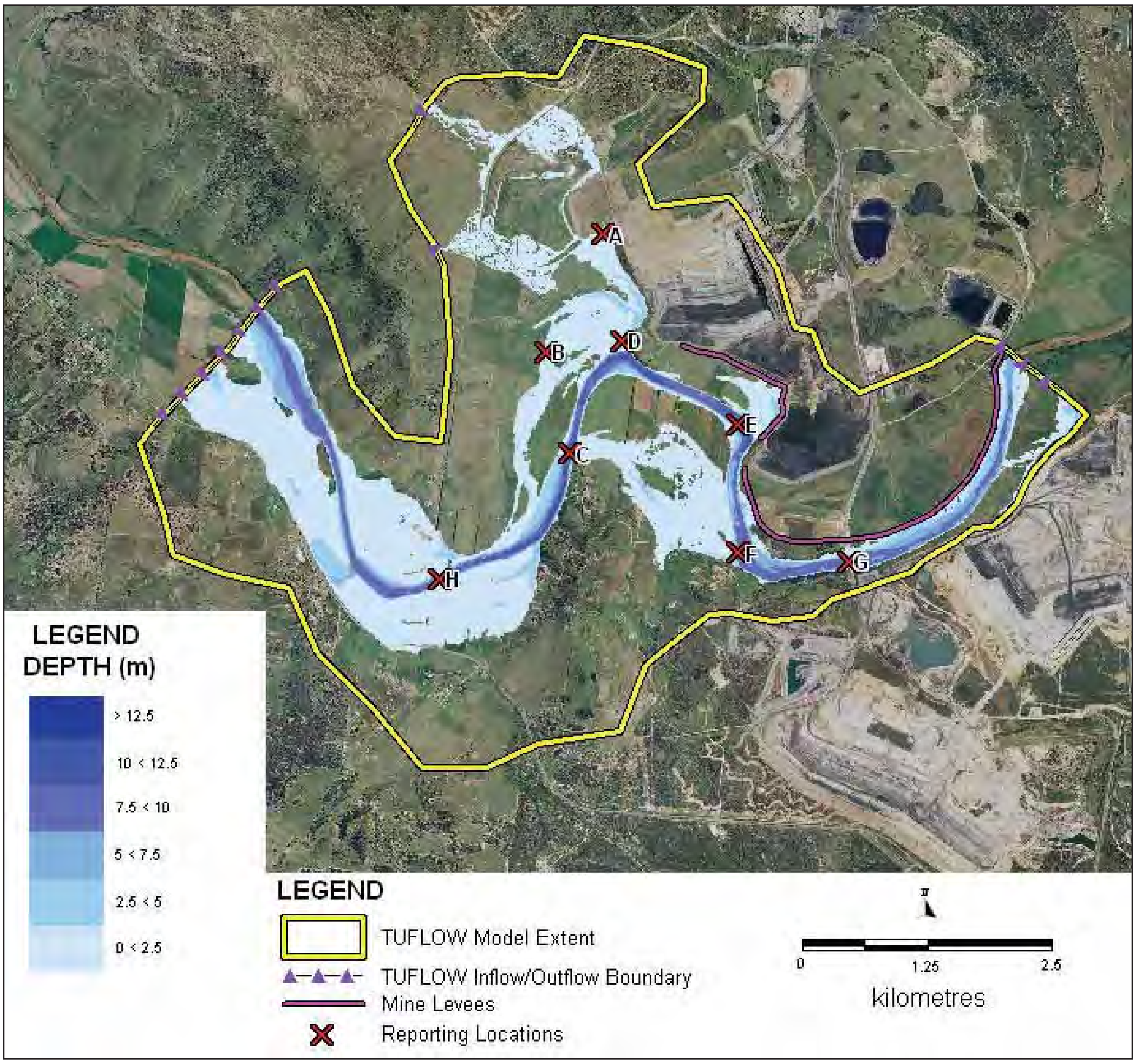

Figure 5.1 Existing Case and End of Mine Q10 Flood Depths

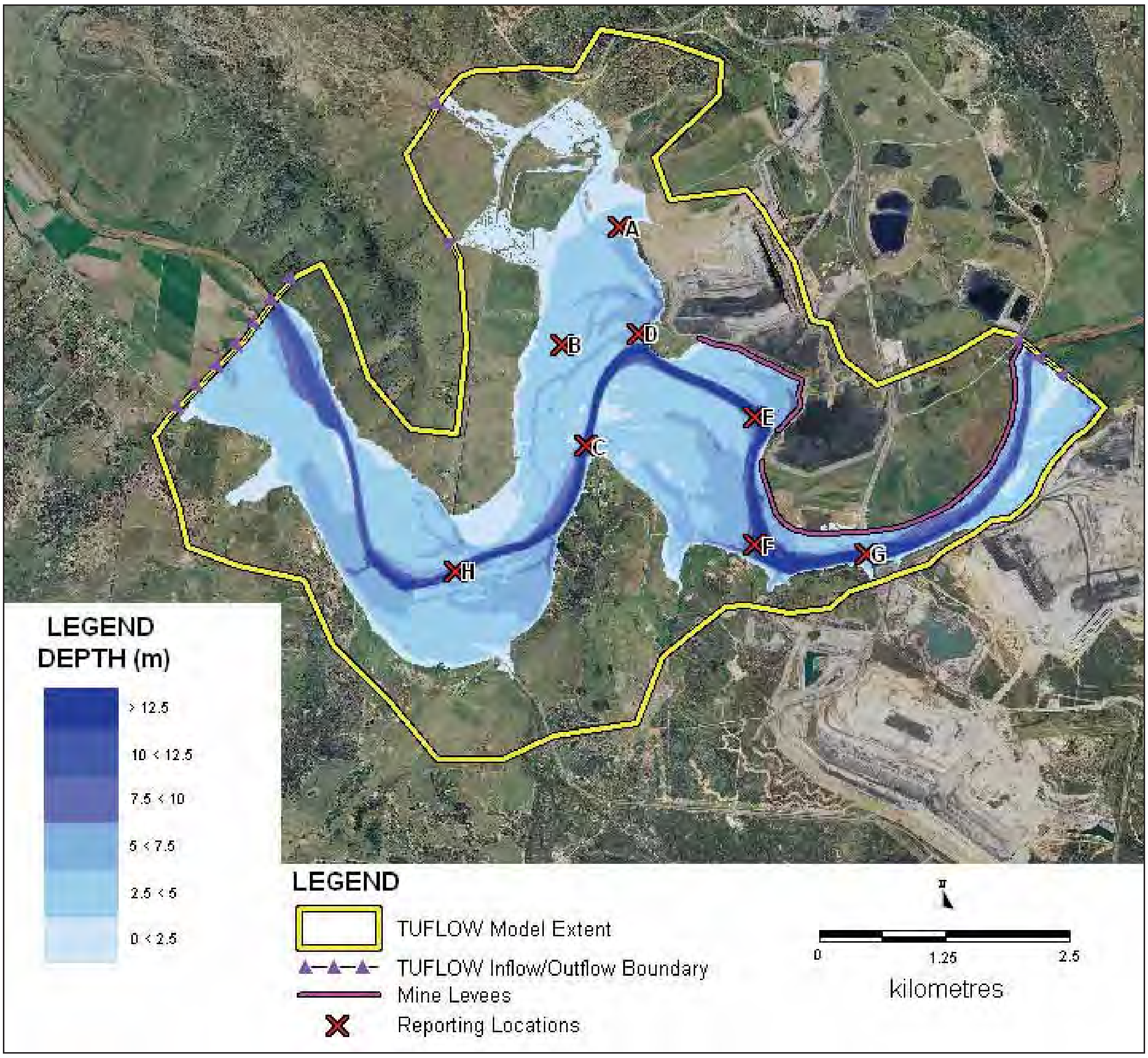

Figure 5.2 Existing Conditions and End of Mine Q100 Flood Depths

Table 5.1 Existing Conditions Design Flood Levels, 2, 5, 10, 20, 50 and 100 year ARI

Reporting Location	Design Flood Level (m AHD)					
	2 Year	5 Year	10 Year	20 Year	50 Year	100 Year
A	69.68	69.82	70.83	72.18	73.62	75.02
B	-	-	70.92	72.22	73.64	75.02
C	65.87	69.43	71.73	72.91	74.00	75.14
D	65.87	68.55	70.83	72.16	73.58	74.98
E	64.82	67.60	69.70	71.13	72.89	74.50
F	62.64	65.65	68.02	69.98	72.21	73.93
G	62.00	64.64	66.78	68.49	70.38	71.87
H	67.73	71.06	73.12	74.40	75.86	77.00

5.3.2 Flood Velocities

Figure 5.3 and Figure 5.4 show the 10 year and 100 year ARI design flood velocities respectively for existing conditions. Flood velocities across the proposed extension area are generally below 0.2m/s at the peak of the Hunter River flood, which suggests that the area is located in a backwater of the Hunter River. Flood velocities are generally below about 1m/s across the proposed extension area at the peak of the Unnamed Tributary flows but are up to 2m/s along the Unnamed Tributary to the south of the proposed extension area as it drains into the Hunter River.

The 100 year ARI flood velocities along the Hunter River channel adjacent to the proposed extension area vary from 1.4m/s at the northern most corner of the meander (location D) to 2.2m/s immediately to the east. It appears that the high ridge separating the Hunter River from the existing Carrington Pit (see Figure 5.3) causes a minor constriction in the flood flows effectively creating a zone of low velocity immediately upstream on the bend in the river.

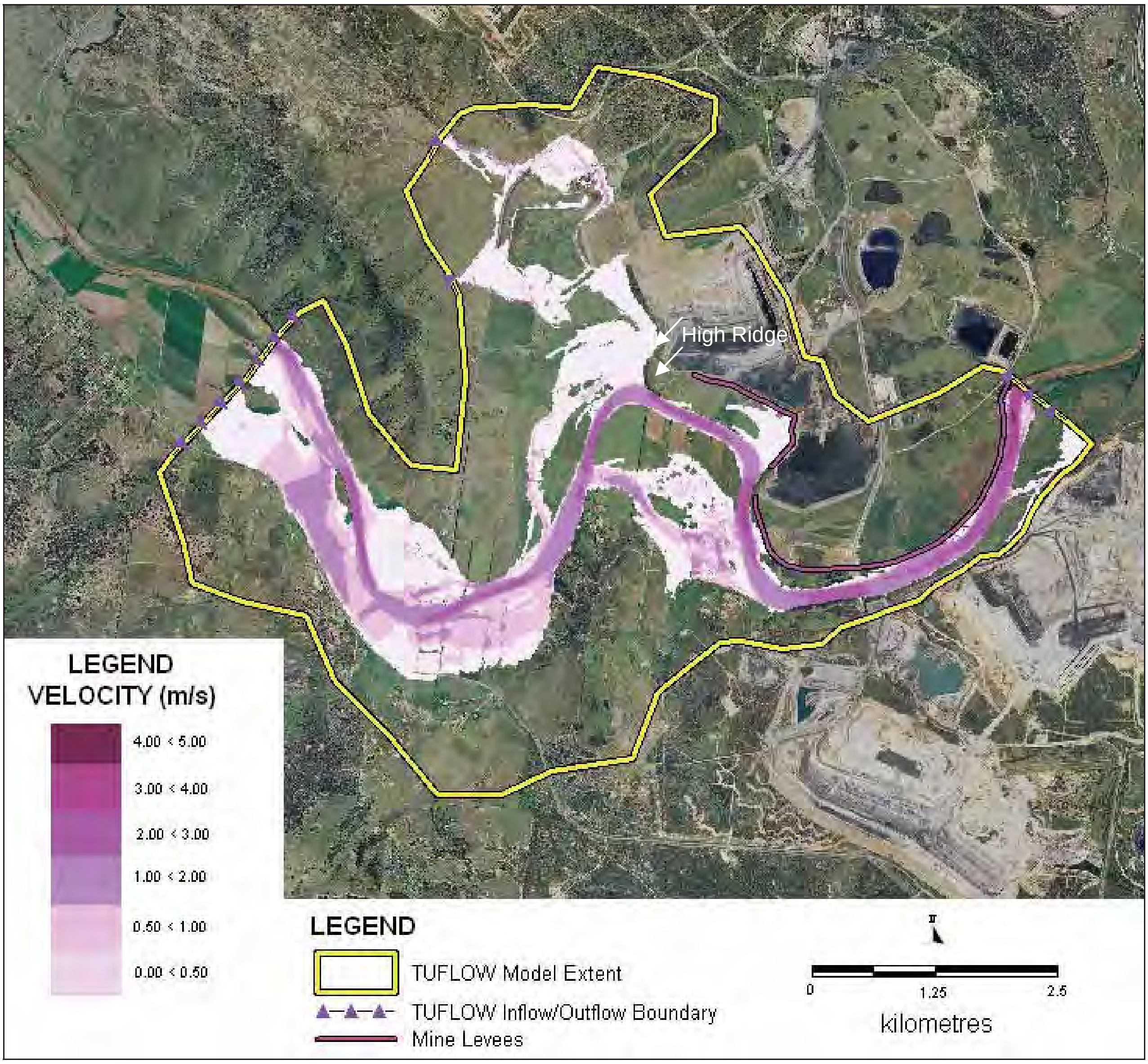

Figure 5.3 Existing Case and End of Mine Q10 Flood Velocities

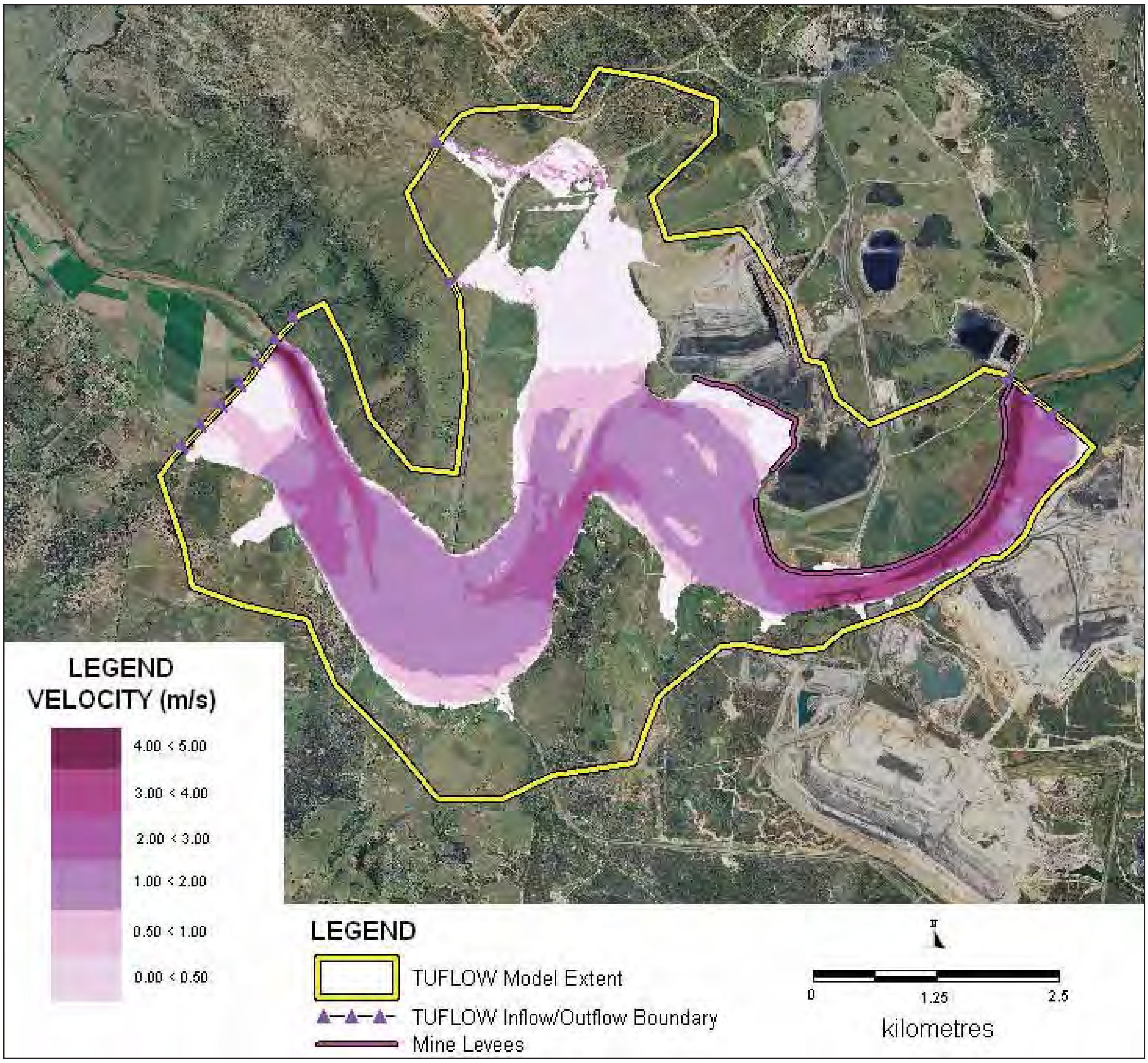

Figure 5.4 Existing Case and End of Mine Q100 Flood Velocities

5.4 STAGE 1 LEVEES MODEL RESULTS

5.4.1 Flood Depths and Extents

Figure 5.5 and Figure 5.6 show the design flood depths and extents for the 10 year and 100 year ARI design floods for the Hunter River and the Unnamed Tributary in the vicinity of HVO North and the proposed extension area with the Stage 1 levees in place. Peak flood levels at key reporting locations within the model area for the 2, 5, 10, 20, 50 and 100 year ARI design flood are given in Table 5.2.

- The stage 1 flood levees effectively prevent flooding of the proposed extension area for events up to the 100 year ARI event.
- The 100 year ARI flood levels along the proposed levees are within 0.15m of existing conditions. In fact, flood levels to the north of the pit are marginally lower than existing conditions.

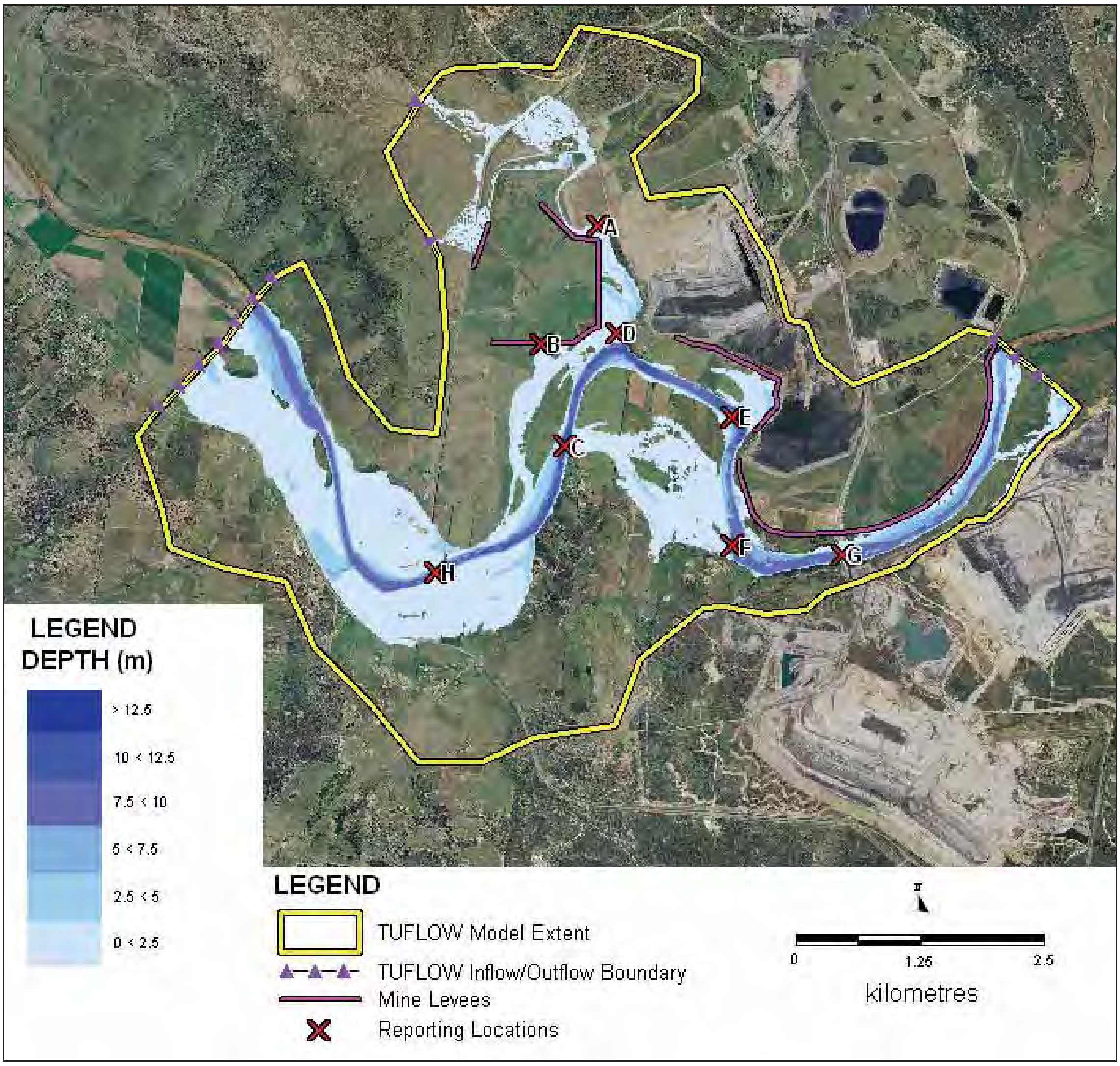

Figure 5.5 Stage 1 Levees Q10 Flood Depths

Table 5.2 Stage 1 Conditions Design Flood Levels, 2, 5, 10, 20, 50 and 100 year ARI

Reporting Location	Design Flood Level (m AHD)					
	2 Year	5 Year	10 Year	20 Year	50 Year	100 Year
A	69.64	69.81	70.83	72.15	73.58	74.99
B	-	-	71.21	72.40	73.78	75.12
C	65.87	69.43	71.74	72.93	74.04	75.19
D	65.79	68.55	70.83	72.15	73.57	74.99
E	64.82	67.60	69.71	71.13	72.89	74.51
F	62.64	65.65	68.02	69.99	72.22	73.94
G	62.00	64.64	66.78	68.50	70.39	71.87
H	67.73	71.06	73.12	74.41	75.87	77.03

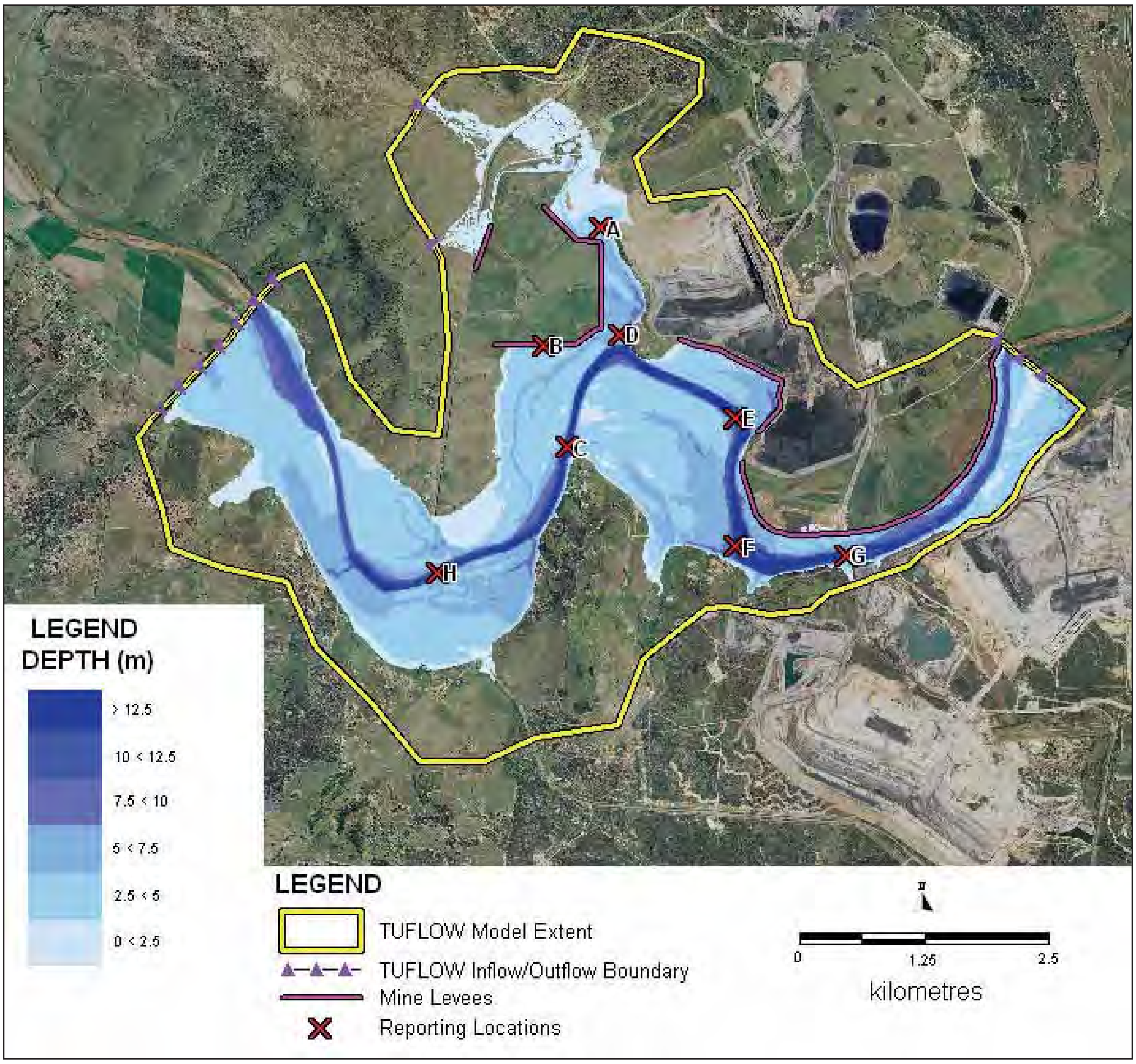

Figure 5.6 Stage 1 Levees Q100 Flood Depths

5.4.2 Flood Velocities

Figure 5.7 and Figure 5.8 show the 10 year and 100 year ARI design flood velocities respectively with the Stage 1 levees in place. Flood velocities adjacent to the levees at the peak of the 100 year ARI event are generally below 0.2m/s. When the Unnamed Tributary is in flood, the flood velocities adjacent to the levees are similar to existing conditions at about 0.5 m/s.

Flood velocities along the Hunter River channel generally remain unchanged from existing conditions. At the bend in the river near location D, 100 year ARI flood velocities increase by 0.1m/s to 1.5m/s. Both upstream and downstream of the bend, the flood velocities remain unchanged from existing conditions. The 10 year ARI flood velocities are unchanged from existing conditions.

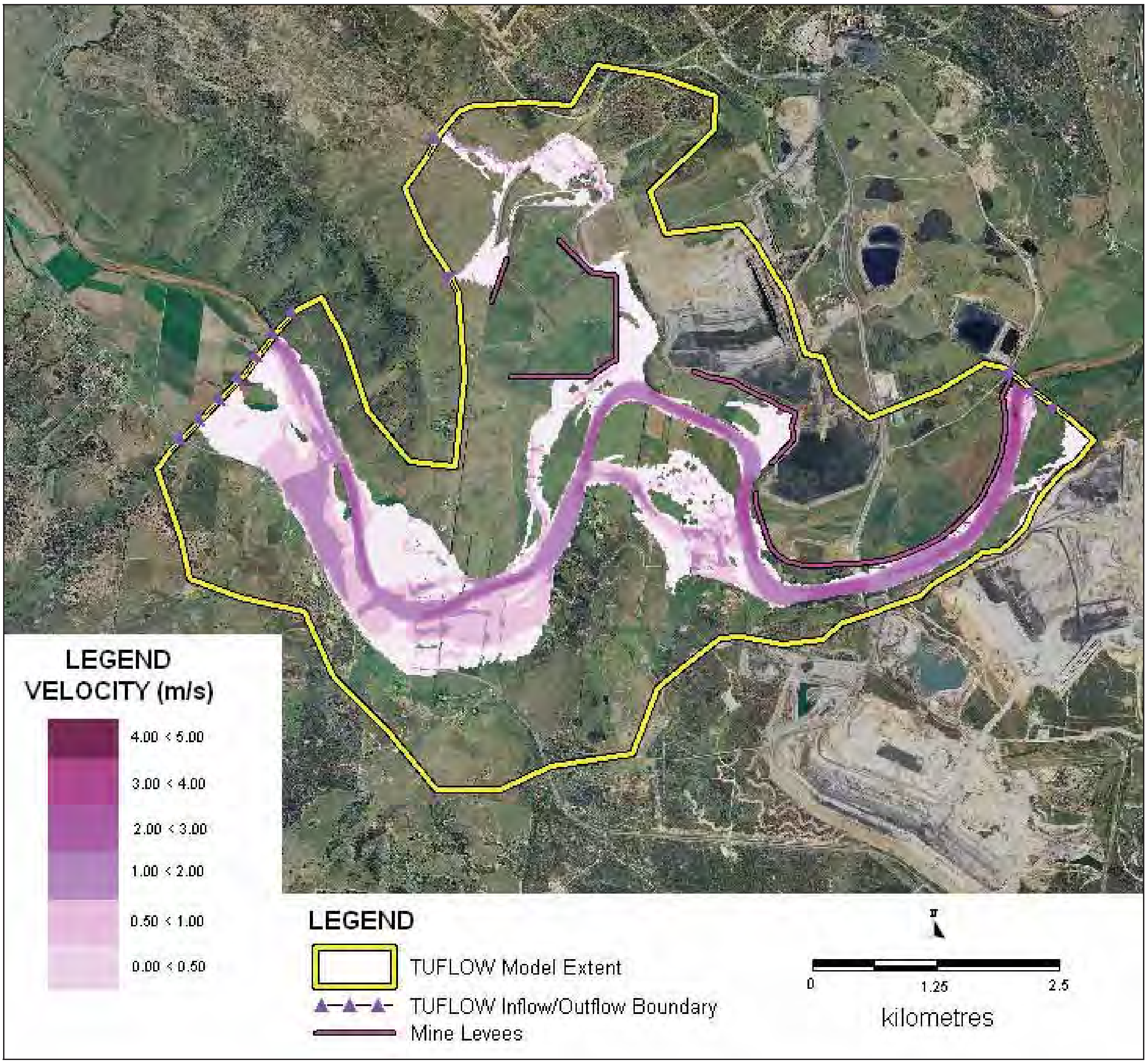

Figure 5.7 Stage 1 Levees Q10 Flood Velocities

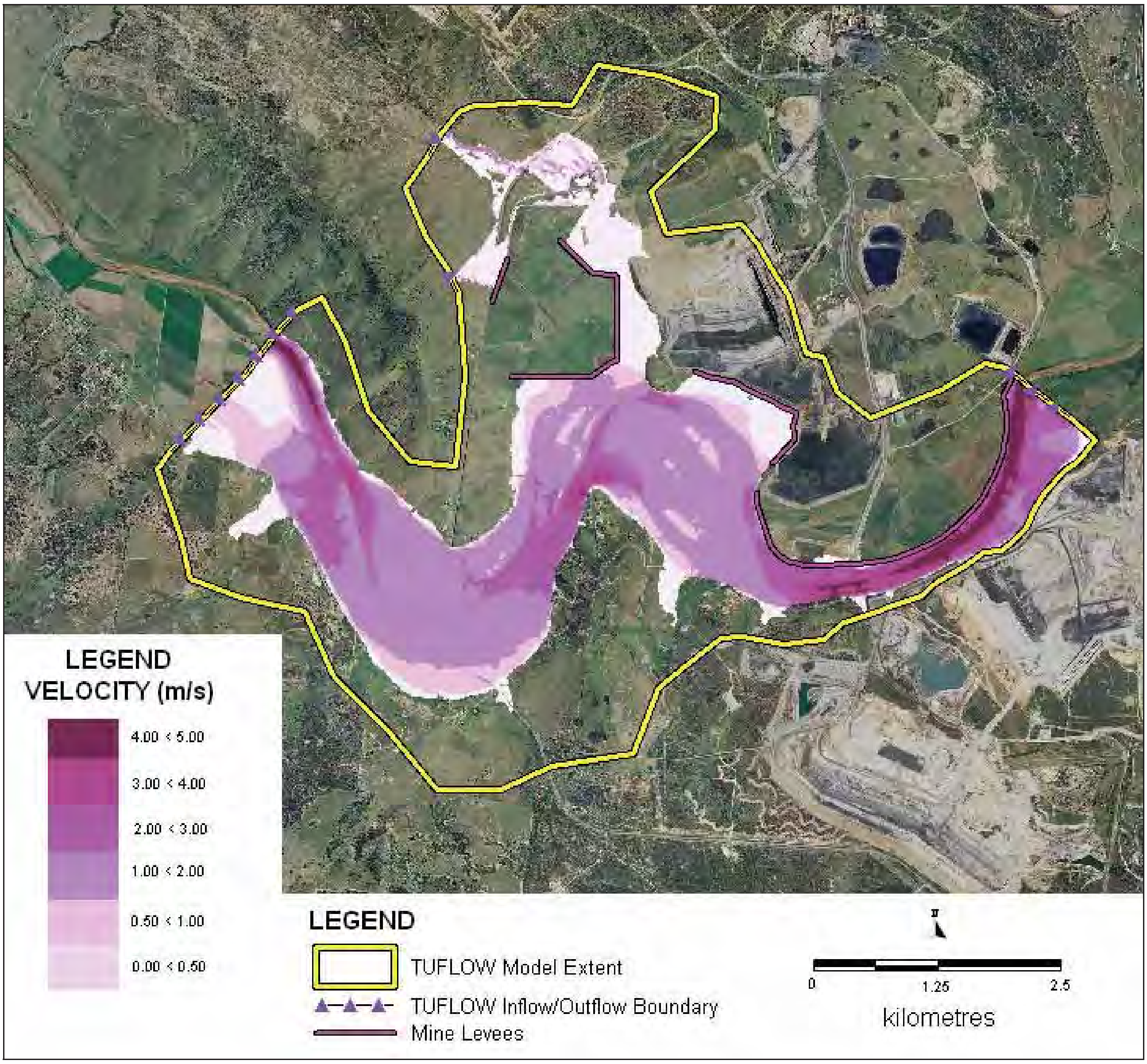

Figure 5.8 Stage 1 Levees Q100 Flood Velocities

5.4.3 Flood Level Impact

Figure 5.9 and Figure 5.10 show the 10 year and 100 year ARI flood level impacts for the Stage 1 Levees when compared to the existing case.

- The extent of the increased flood levels is generally confined to the two parcels on Hunter River floodplain immediately to the south of the Stage 1 levees.
- The flood depths in this reach are generally of the order of 5m to 6m and therefore the 0.05m to 0.15m increase in these zones is not significant.
- Elevated flood levels are expected to remain for periods of 12 hours to 48 hours, depending upon the duration and severity of the flood event.
- There are no buildings located within the zone of impact of the proposed levees on these two parcels.
- Upstream and downstream flood levels are unaffected.

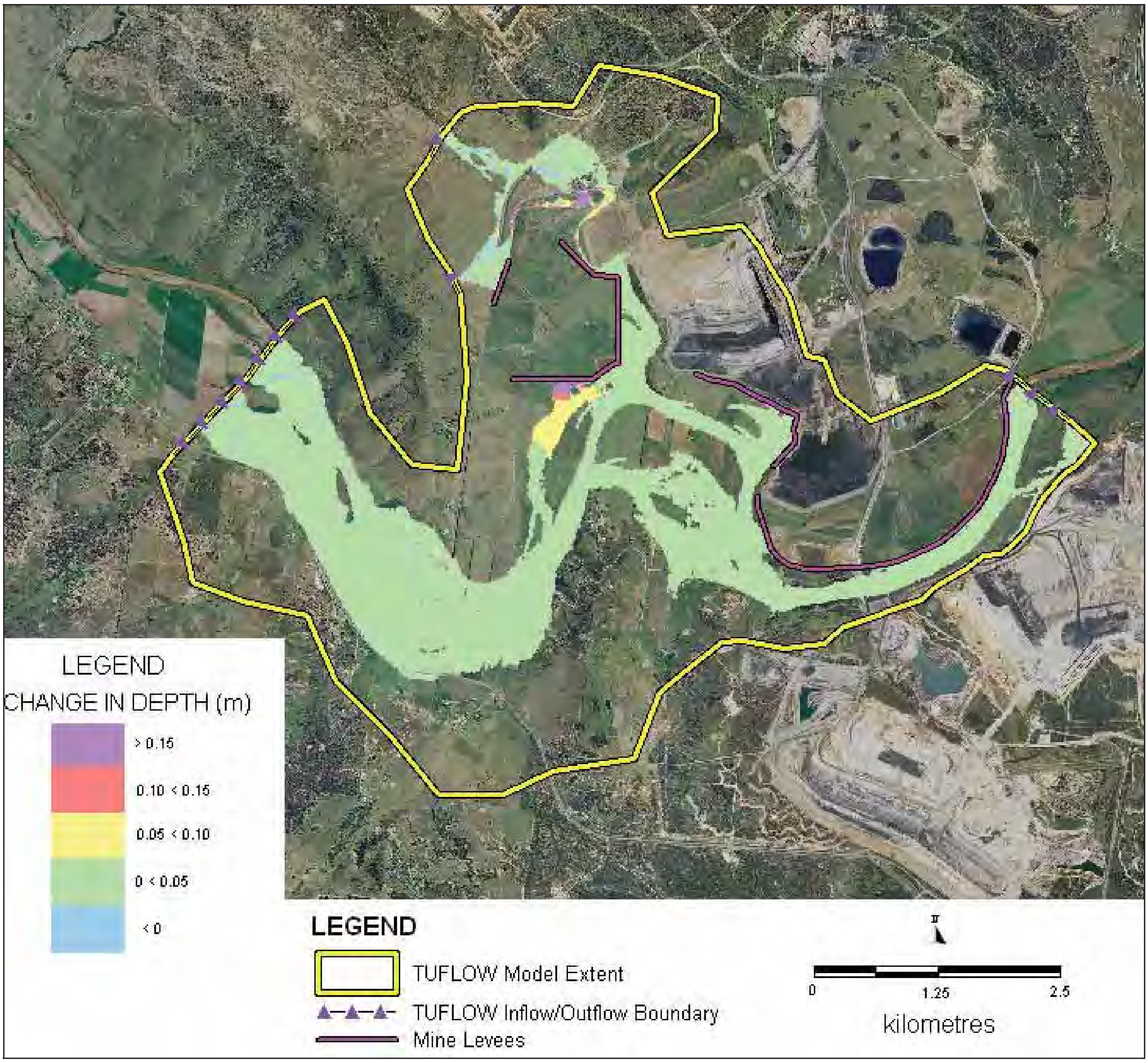

Figure 5.9 Stage 1 Levees Q10 Flood Level Impacts (compared to existing case)

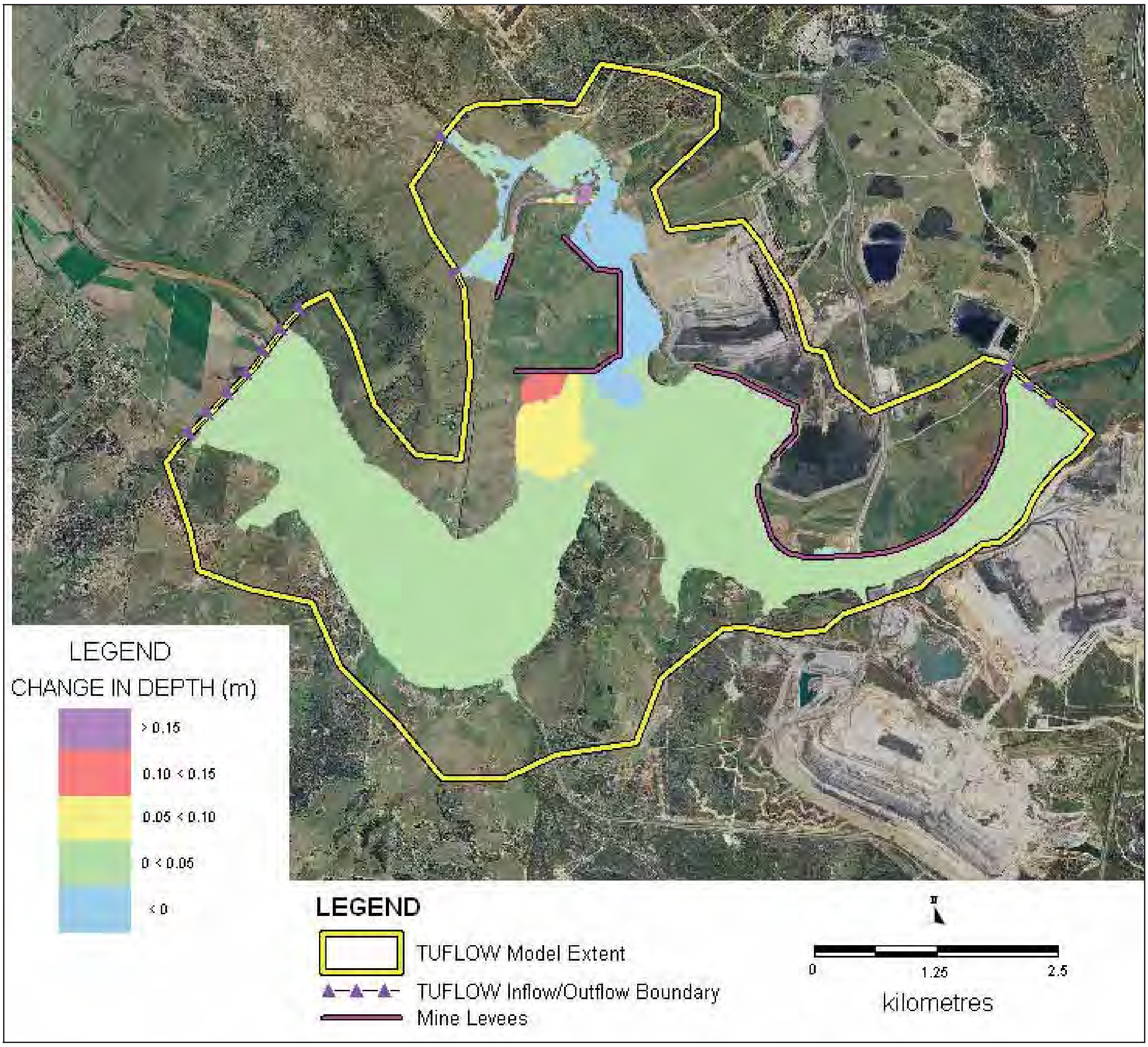

Figure 5.10 Stage 1 Levees Q100 Flood Level Impacts (compared to existing case)

5.5 STAGE 2 LEVEE MODEL RESULTS

5.5.1 Flood Depths and Extents

Figure 5.11 and Figure 5.12 show the design flood depths and extents for the 10 year and 100 year ARI design floods for the Hunter River and the Unnamed Tributary in the vicinity of HVO North and the proposed extension area with the Stage 2 levee and Unnamed Tributary diversion in place. Peak flood levels at key reporting locations within the model area for the 2, 5, 10, 20, 50 and 100 year ARI design flood are given in Table 5.3. The following is of note:

- Runoff from the Unnamed Tributary catchment is effectively conveyed around the levees by the proposed diversion. The proposed diversion conveys the 10 year ARI flow within bank.
- It is likely that the finished levels of the overbank area in the vicinity of the proposed diversion channel would be lowered to reduce the in-bank capacity of the channel to the

recommended 2m depth in accordance with the recommended channel design given in Section 3.7. This will be determined during the detailed design of the filled in pit. For the purposes of this report, the finished ground levels are assumed to be the same as existing conditions.

- At location A to the north of the proposed extension area, 10 year ARI design levels are raised by some 0.6m and 100 year ARI levels are raised by 0.14m.

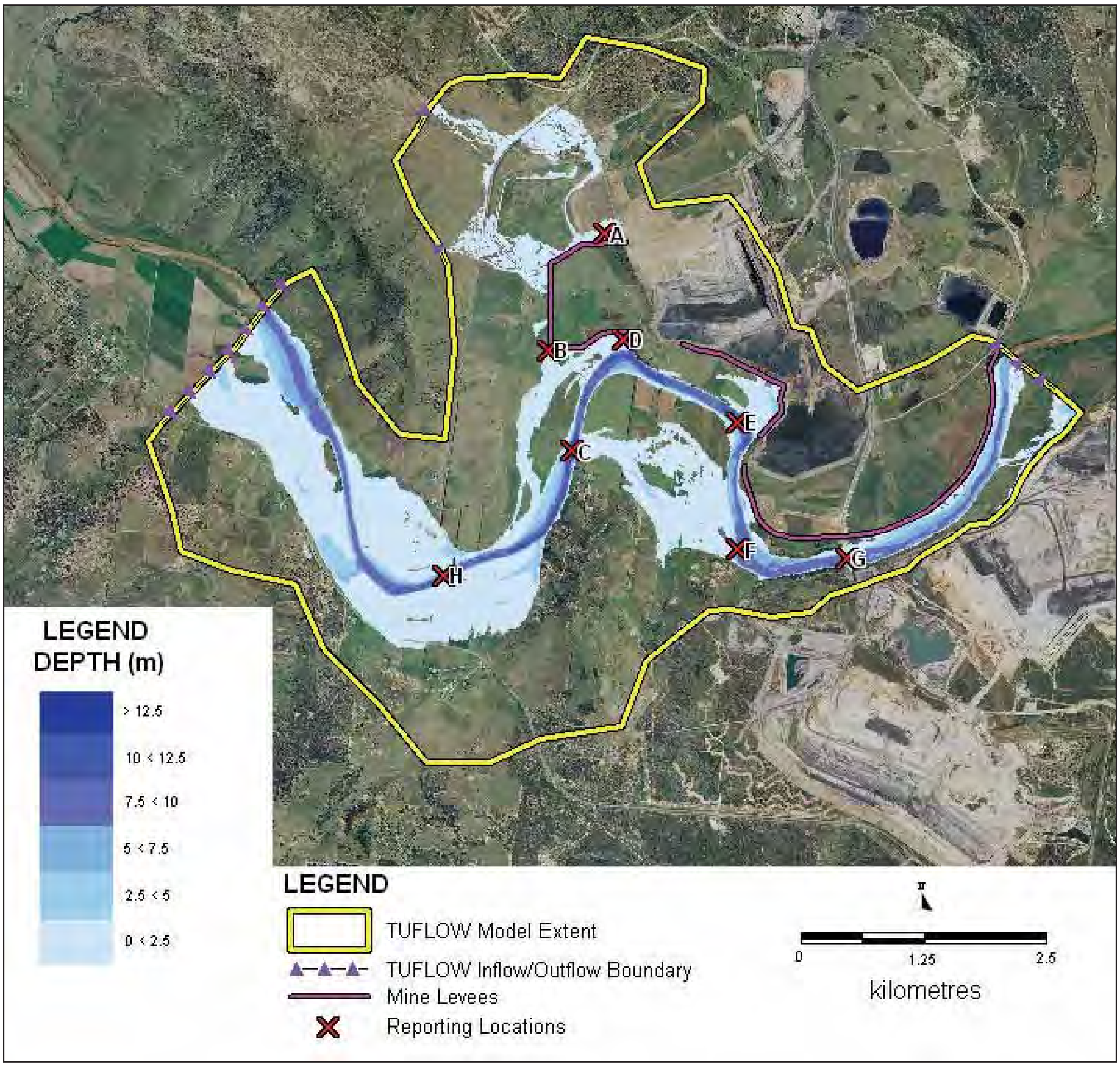

Figure 5.11 Stage 2 Levees and Channel Q10 Flood Depths

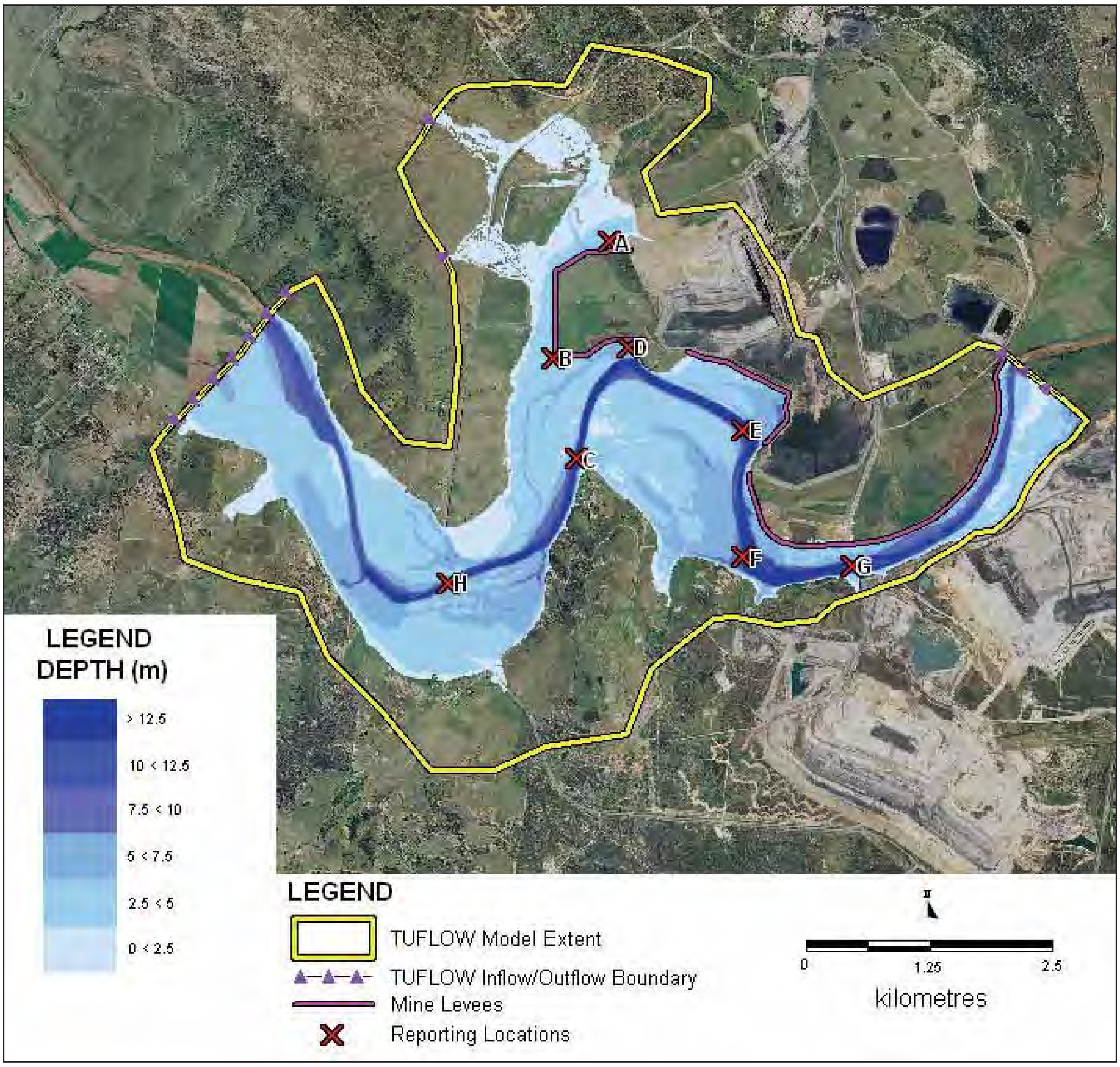

Figure 5.12 Stage 2 Levees and Channel Q10 Flood Depths

Table 5.3 Stage 2 Conditions Design Flood Levels, 2, 5, 10, 20, 50 and 100 year ARI

Reporting Location	Design Flood Level (m AHD					
	2 Year	5 Year	10 Year	20 Year	50 Year	100 Year
A	69.40	71.10	71.44	72.39	73.80	75.16
B	69.91	70.26	71.09	72.38	73.77	75.12
C	65.87	69.43	71.74	72.93	74.04	75.19
D	66.17	68.55	70.83	72.15	73.58	74.99
E	64.82	67.60	69.71	71.13	72.89	74.51
F	62.64	65.65	68.02	69.98	72.22	73.94
G	62.00	64.64	66.79	68.50	70.39	71.87
H	67.73	71.06	73.13	84.41	75.87	77.02

5.5.2 Flood Velocities

Figure 5.13 and Figure 5.14 show the design flood velocities for the 10 year and 100 year ARI design floods for the Hunter River and the Unnamed Tributary in the vicinity of HVO North and the proposed extension area with the Stage 2 levee and Unnamed Tributary diversion in place. The 100 year ARI flood velocities along the diversion (without the Hunter River being in flood) are about 0.9m/s. Flood velocities along the Hunter River channel are unchanged for the 10 year ARI event and 0.1m/s greater near Location D for the 100 year ARI event. 100 year ARI flood velocities are unchanged from existing conditions both upstream and downstream of Location D.

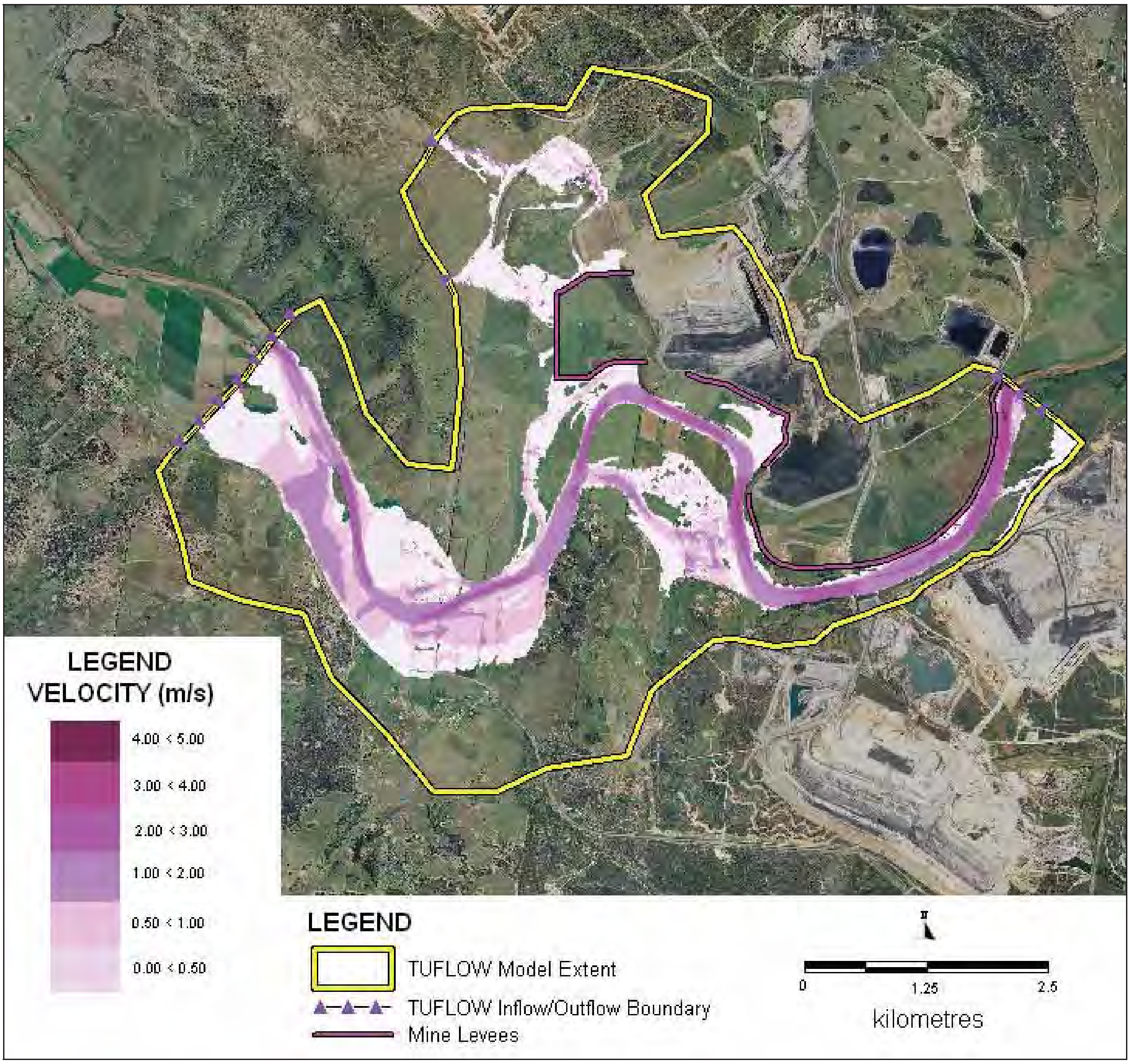

Figure 5.13 Stage 2 Levees and Channel Q10 Flood Depths

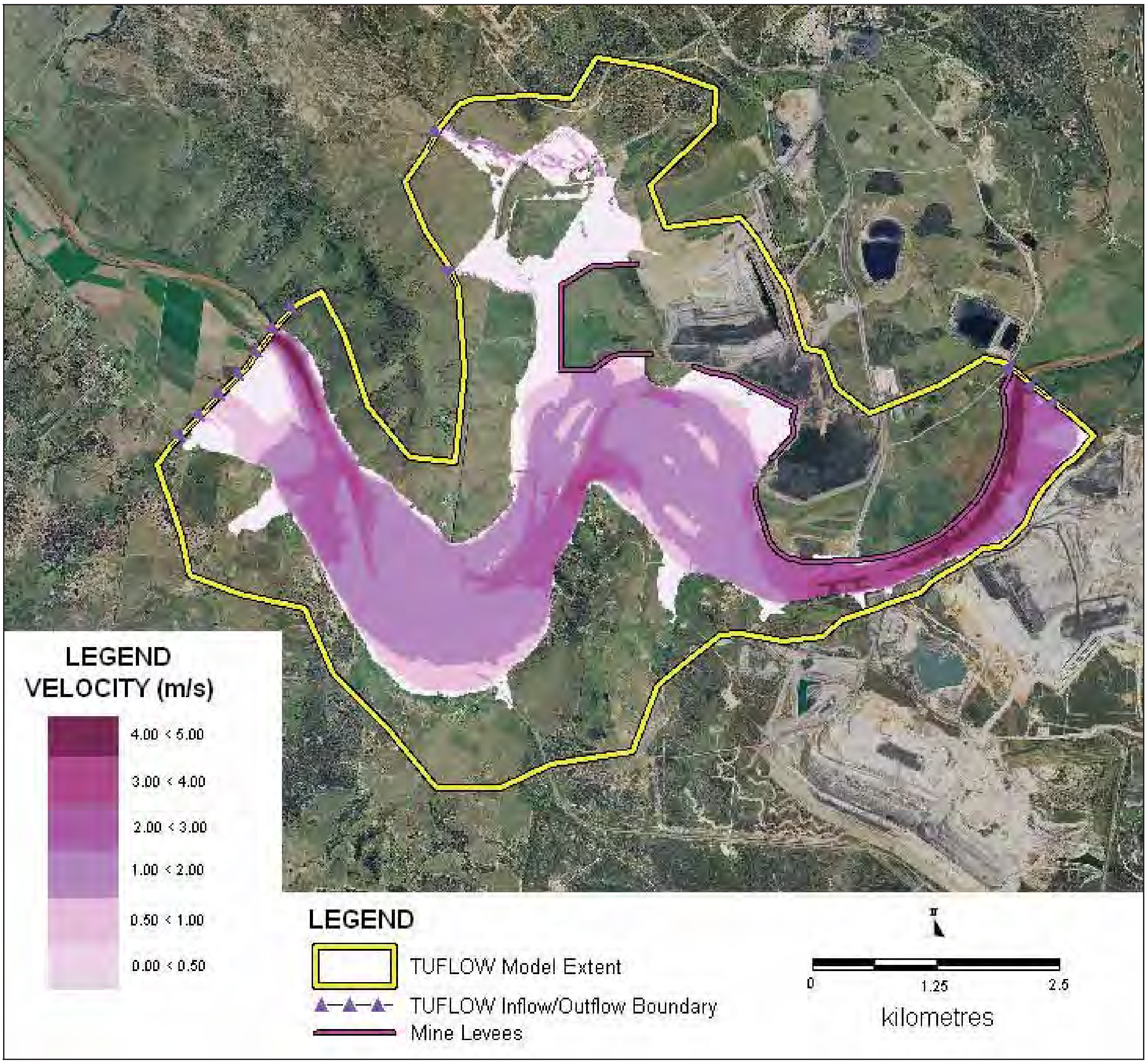

Figure 5.14 Stage 2 Levees and Channel Q100 Flood Depths

5.5.3 Flood Impacts

Figure 5.15 and Figure 5.16 show the flood level impacts associated with the Stage 2 levee and diversion drain for the 10 year and 100 year ARI design floods compared to the existing conditions.

- There is negligible impact on flood levels along the Hunter River main channel for the 10 year ARI design flood and a minor impact on the floodplain immediately adjacent to the south-western corner of the proposed levee.
- The extent of the flood impact for the 100 year ARI design flood is again confined to the two parcels on Hunter River floodplain immediately to the south of the proposed levee. The 100 year ARI flood levels along the diversion drain are up to 0.14m higher than existing conditions.
- The increase in flood depth is insignificant when compared to the overall flood depths in this region of 5 to 6m.

- There are no buildings located within the zone of impact of the proposed levees on these two parcels.
- It is expected that elevated flood levels would remain in these areas for 12 hours to 48 hours, depending upon the duration and severity of the flood event.

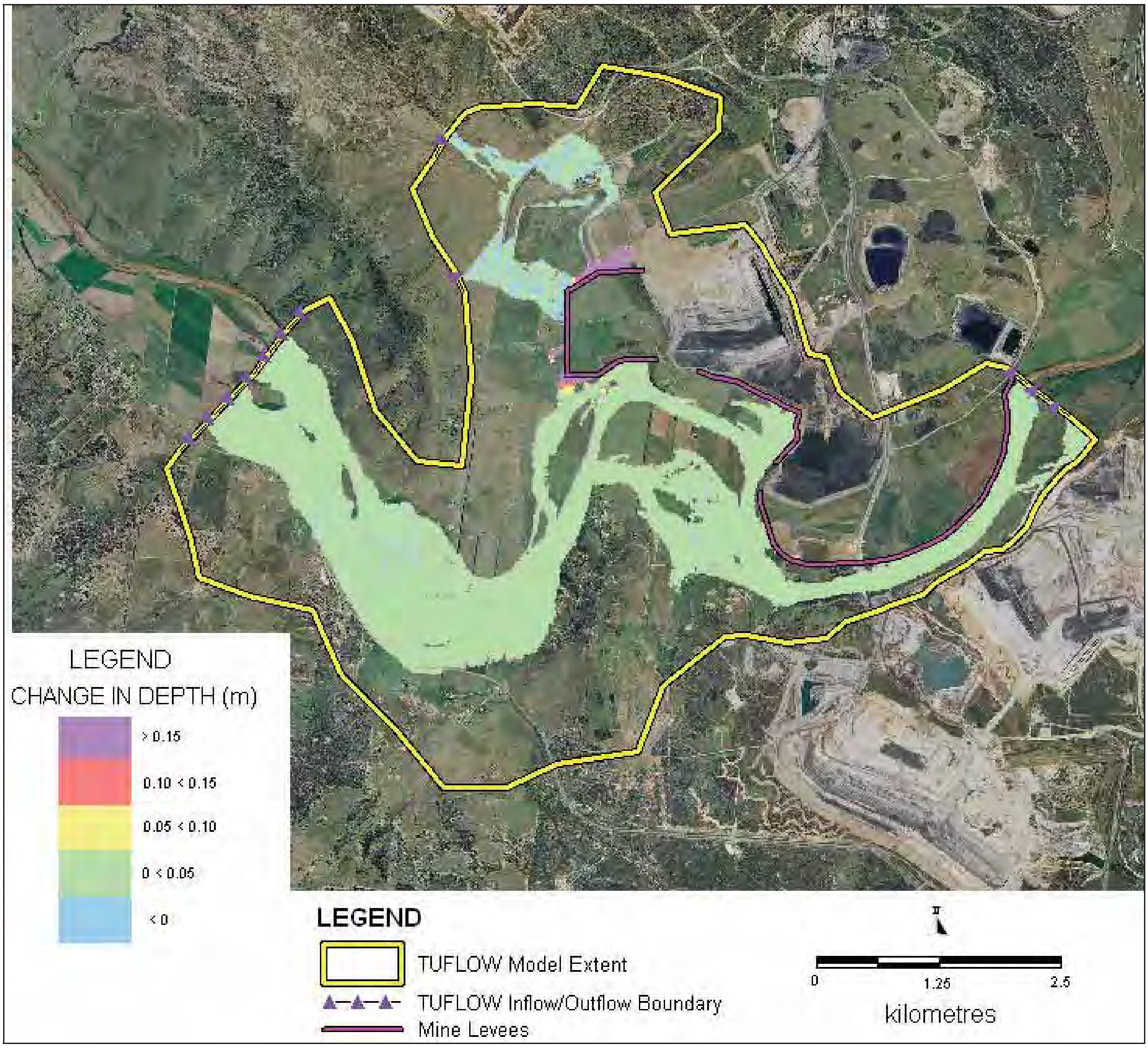

Figure 5.15 Stage 2 Levees Q10 Flood Level Impacts (compared to existing case)

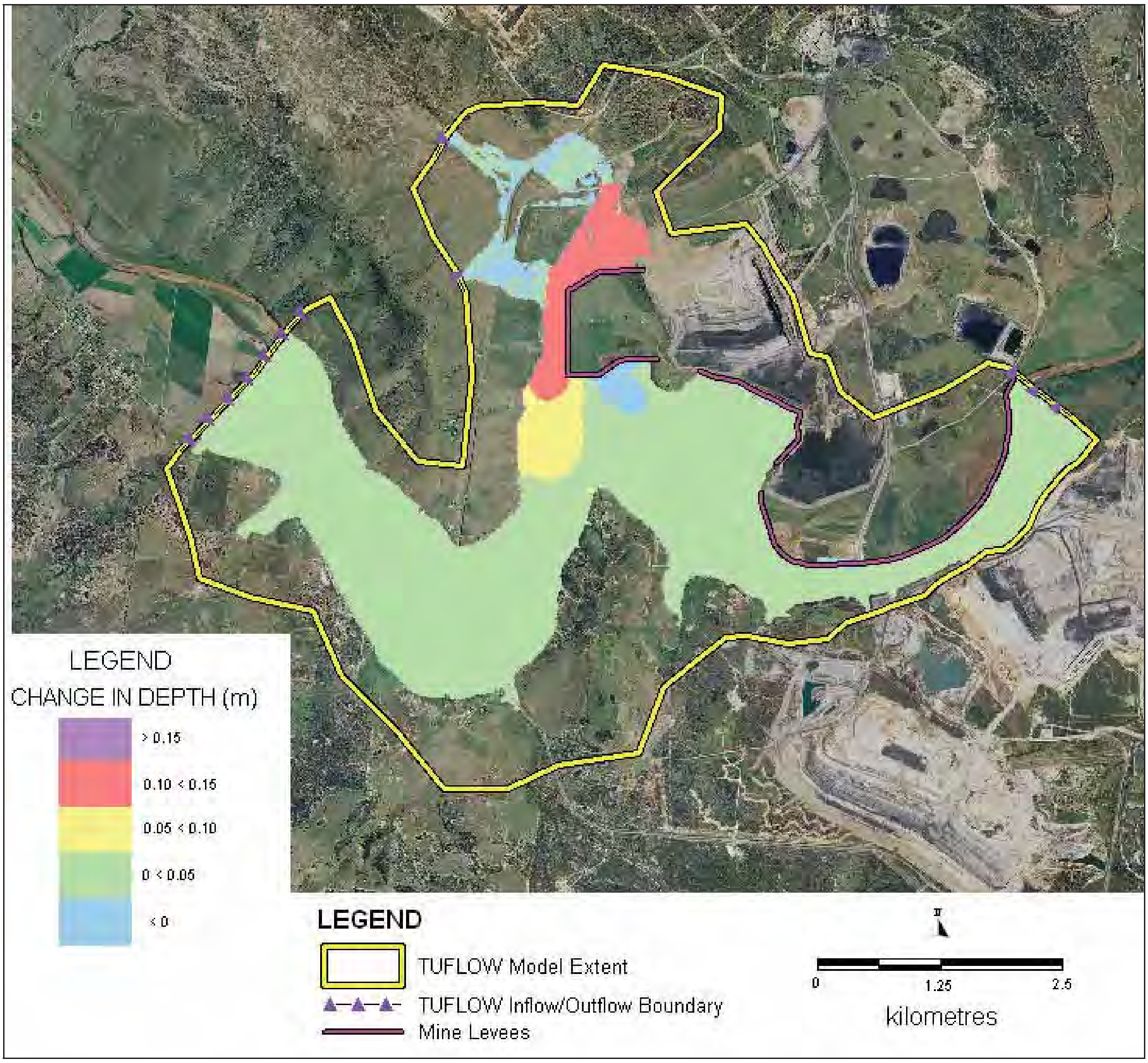

Figure 5.16 Stage 2 Levees Q100 Flood Level Impacts (to existing case)

5.6 HUNTER RIVER EROSION POTENTIAL

5.6.1 General

The hydraulic modelling shows that flood levels and flood velocities along the Hunter River channel are virtually unchanged by the proposal for events up to and including the 100 year ARI event. On this basis, there would be no increase in erosion potential of the Hunter River channel as a result of the proposal. However, the Hunter River channel adjacent to the proposed extension area is located on an alluvial floodplain and is poorly aligned and is therefore susceptible to erosion under existing conditions. This is the case with or without the proposal. The hydraulic model has been used to determine the bed shear stress along the river channel for the 2 year ARI and 100 year ARI design events to determine the potential changes in the Hunter River channel over time. The change in bed shear is better than stream velocity in predicting erosion potential, which is typically associated with a combination of the force of gravity and stream velocity. Historical aerial photographs have been obtained of the area to determine the changes that have occurred to the channel over time in an attempt to support the findings of the hydraulic model.

5.6.2 Bed Shear stress Analysis

Figure 5.17 and Figure 5.18 show the estimated bed shear stress along the Hunter River for the 2 year ARI and 100 year ARI design events for the Stage 2 levee conditions. As stated previously, there would be no discernable difference in flood depth and velocity and hence bed shear between existing conditions and the two levee scenarios. Accordingly, only the Stage 2 levee scenario is shown.

For the 2 year ARI event, bed shear is relatively consistent along the channel at about 20 to 25 N/m^2 except for adjacent to the alluvial lands about 2km downstream of the Unnamed Tributary confluence where it is some 5 times higher. This appears to be a natural phenomenon. The bed shear is lower at the Unnamed Tributary confluence adjacent to the proposed extension area at about 10 N/m^2. The hydraulic modelling suggests that the high ridge separating the Unnamed Tributary confluence and the existing Carrington Pit (see Figure 5.3) forms a minor constriction causing lower flood velocities and hence lower bed shear at this location.

For the 100 year ARI event, similar bed shear is experienced at the Unnamed Tributary confluence whereas bed shear across the inside bend across the gravel bar is four times higher at up to 40 N/m^2 as shown in Figure 5.19. Bed shear is also much higher upstream of the Unnamed Tributary confluence where flood flows break out of the channel and head eastward across the southern floodplain. These break-out flows have the effect of reducing bed shear of the Hunter River adjacent to the project area. The hydraulic modelling suggests that the Hunter River bank adjacent to the project area is less susceptible to erosion than other locations along the river within the study area.

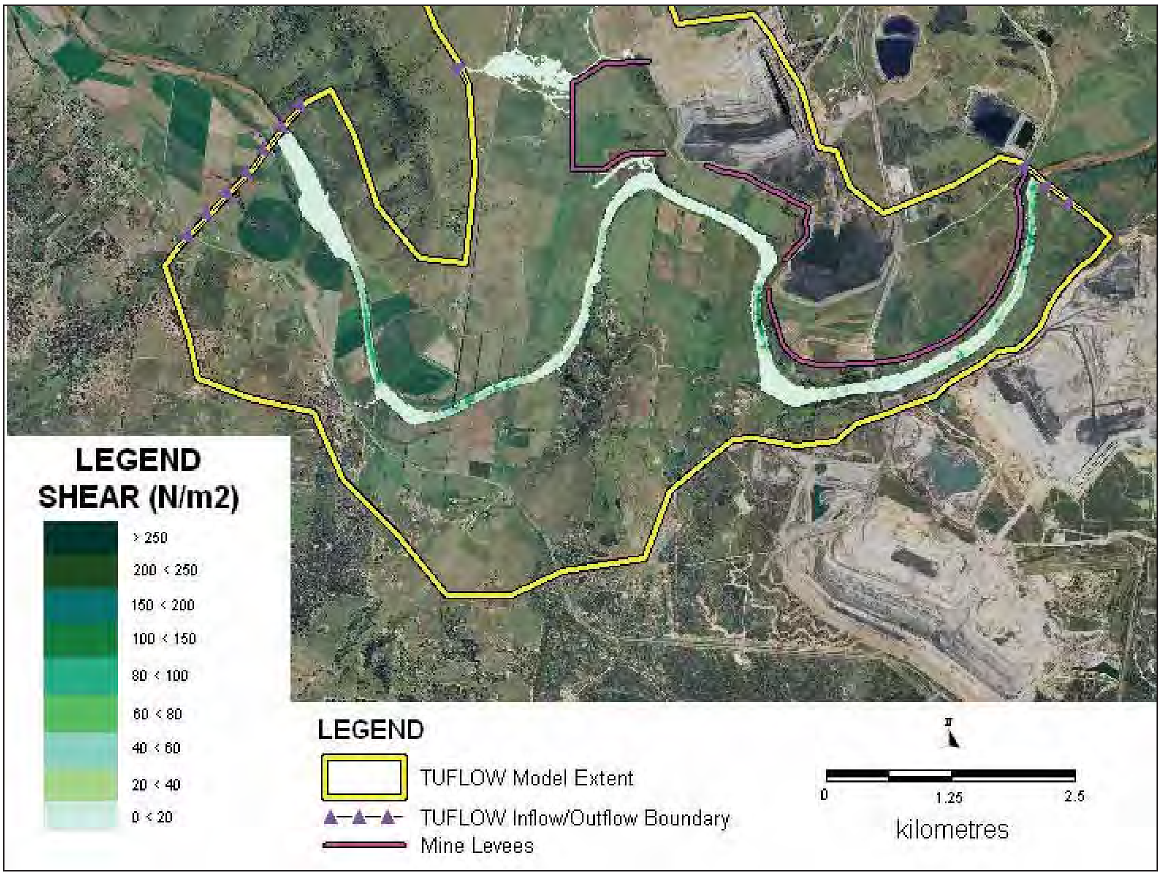

Figure 5.17 Hunter River Bed Shear, 2 Year ARI Flood

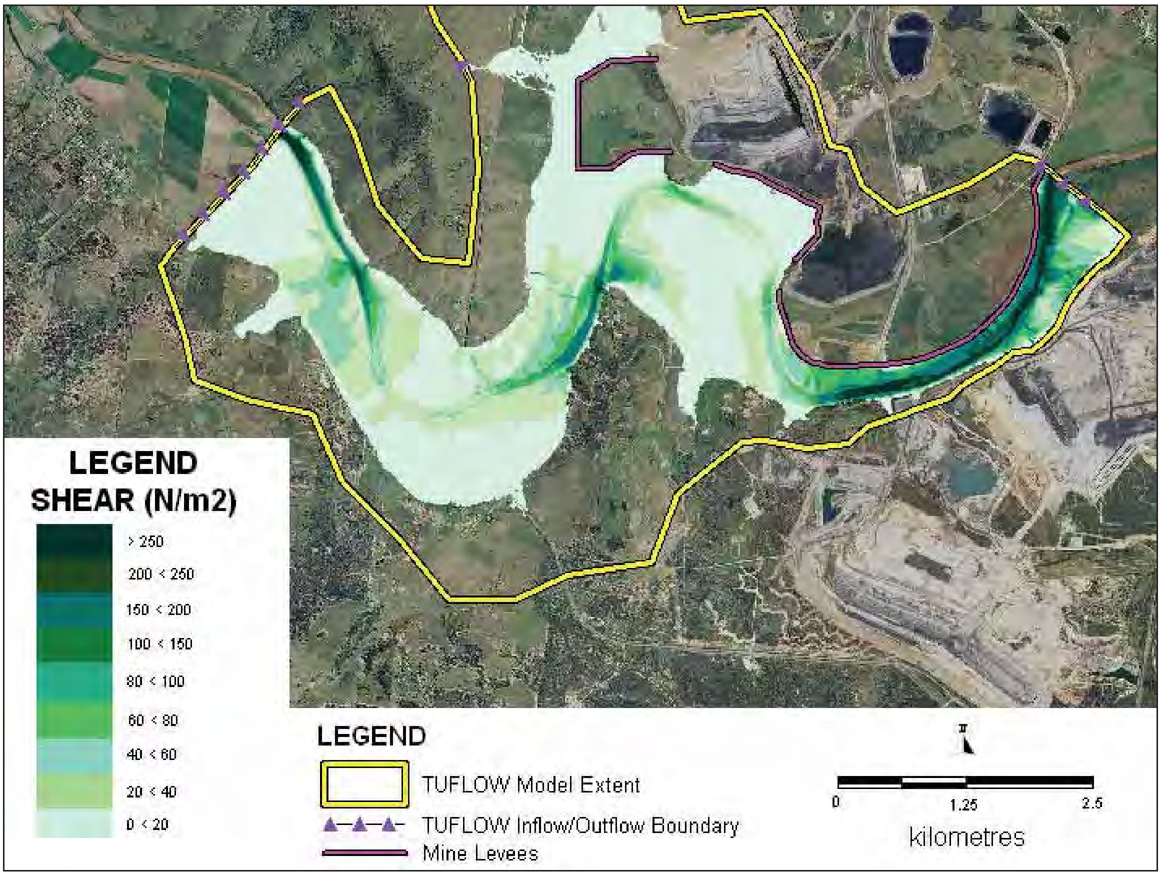

Figure 5.18 Hunter River Bed Shear, 100 Year ARI Flood

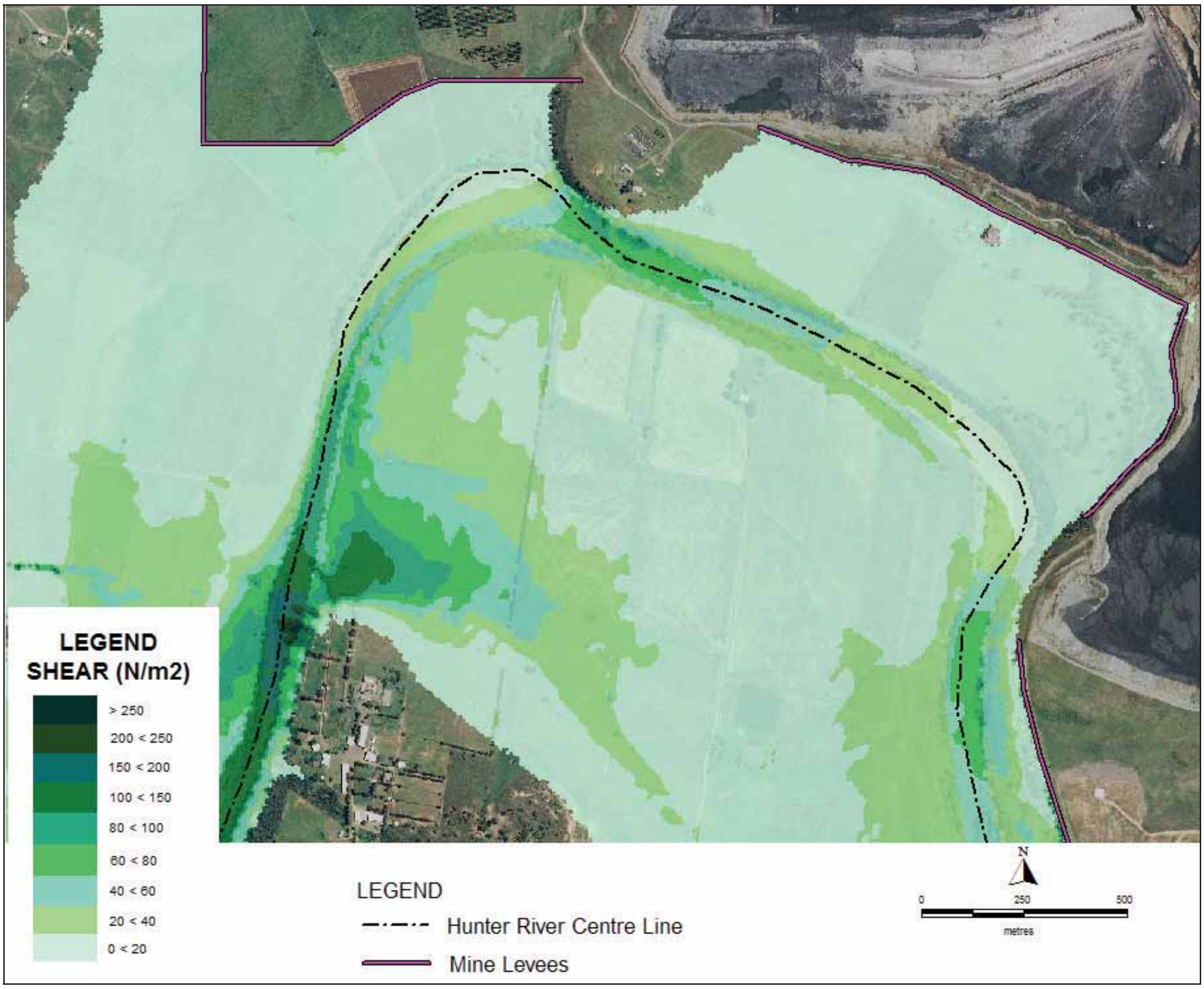

Figure 5.19 Hunter River Bed Shear , 100 Year ARI Flood

5.6.3 Historical River Changes

Figure 5.20 shows an ortho-rectified aerial photograph of the Hunter River floodplain at the proposed extension area as it was in about 1963. The top of bank of the Hunter River as derived from this photograph is also shown, as well as the top of bank as it is in 2009. Whilst there is some uncertainty in determining the top of bank from this photograph, the analysis shows that the top of bank adjacent to the Unnamed Tributary confluence may have moved some 10 to 15m over this 46 year period. Upstream and downstream of the confluence, the top of bank has moved about 5 to 10m. This somewhat conflicts with the hydraulic model results, which indicate lower velocities and bed shear at this location for both the smaller and larger flood events. It is possible that the large gravel bar that has built up on the inside bend of the river at this location has a localised effect that increases erosion during the smaller floods. The build-up of vegetation on the gravel bar may also cause water to be diverted onto this bank.

Figure 5.20 Hunter River at HVO North, 1963 to 1967

5.6.4 Long-term Erosion Potential

The long term rate of erosion of the Hunter River adjacent to the project area is difficult to predict with certainty. The hydraulic modelling suggests that the river bank at this location is not particularly susceptible to erosion during small or large floods. The hydraulic modelling also suggests that there is a higher probability that the river could cut off this meander and create a new channel across the southern floodplain, rather than erode northward. Notwithstanding this, the historical photo suggests that some localised erosion has occurred at this location most likely due to the gravel bar build-up on the inside bend.

Assuming the current rate of erosion of 10 to 15m over 46 years, as was estimated from the aerial photographs, it would take between 521 to 782 years for the Hunter River to reach the groundwater barrier wall. However, if this occurred, the alignment of the Hunter River at this location would be such that the meander radius would be about 200m, approximately one third of the meander radius of the channel in this reach because the hard ridge immediately downstream would erode at a much slower rate. With such a poor alignment, the channel would almost certainly cut across the adjacent gravel bar and create a new channel in a similar location to the existing channel. The hydraulic model results, shown in Figure 5.19, support this view. In other words, the risk that the Hunter River could continue to erode northward to reach the groundwater cut off wall is considered extremely low to unlikely.

6 SUMMARY OF FINDINGS

6.1 HUNTER RIVER FLOOD IMPACT

The hydrologic and hydraulic modelling of the Hunter River and its floodplain in the vicinity of the proposed extension area has found the following:

- The 2 year ARI Hunter River design flood is generally confined to the main channel. The Hunter River flood flows exceed the capacity of the channel and inundate the floodplain in the vicinity of the proposed extension area for the 5 year ARI design event.
- The Hunter River dominates flood levels across the proposed extension area for floods greater than and equal to the 10 year ARI event. Local catchment flows from the Unnamed Tributary dominate for the more frequent floods.
- The 100 year ARI design flood levels across the proposed extension area are about 75m AHD. Ground levels across the proposed extension area range from 70m AHD to 74m AHD.
- The 100 year ARI flood velocities along the Hunter River channel adjacent to the proposed extension area vary from 1.4m/s at the northern most corner of the meander (location D) to 2.2m/s immediately to the east. It appears that the high ridge separating the Hunter River from the existing Carrington Pit causes a minor constriction in the flood flows effectively creating a zone of low velocity immediately upstream on the bend in the river.
- The Stage 1 and Stage 2 flood levees effectively prevent flooding of the proposed extension area for events up to the 100 year ARI event.
- The 100 year ARI flood levels along the proposed levees are within 0.15m of existing conditions.
- Flood velocities along the Hunter River channel generally remain unchanged from existing conditions as a result of the proposal.
- There is negligible impact on flood levels along the Hunter River main channel for the 10 year ARI design flood and a minor impact on the floodplain immediately adjacent to the south-western corner of the proposed levee.
- The extent of the flood impact for the 100 year ARI design flood is confined to the two parcels on Hunter River floodplain immediately to the south of the proposed levee. The 100 year ARI flood levels along the proposed diversion drain are up to 0.14m higher than existing conditions.
- The increase in flood depth is insignificant when compared to the overall flood depths in this region of 5 to 6m.
- There are no buildings located within the zone of impact of the proposed levees on these two parcels.
- It is expected that elevated flood levels would remain in these areas for 12 hours to 48 hours, depending upon the duration and severity of the flood event.

- Upstream and downstream flood levels are unaffected.

6.2 HUNTER RIVER BANK EROSION

Given the minor changes in flood levels and flood velocities associated with the proposed levees, there would be no increase in erosion potential of the Hunter River channel as a result of the proposal. However, the Hunter River channel adjacent to the proposed extension area is located on an alluvial floodplain and is poorly aligned and is therefore susceptible to erosion under existing conditions.

Based on an assessment of historical river alignments from aerial photography, and assuming the average rate of channel movement over this period were to continue, it would take between 521 to 782 years for the Hunter River to reach the groundwater barrier wall. However, if this occurred, the alignment of the Hunter River at this location would be so poor, the channel would almost certainly cut across the gravel bar and create a new channel in a similar location to the existing channel. In other words, the risk that the Hunter River could continue to erode northward to reach the groundwater cut off wall is extremely low.

6.3 WATER MANAGEMENT SYSTEM IMPACT

The impact of the additional pit water on the mine site water management system is summarised as follows:

- Raw water consumption is expected to decrease due to the reduction in production at HVCPP based on the production forecasts at the time of preparing this report, which reduces overall water consumption at HVO North (refer to Section 4.4.2).
- The overall mine water inventory and risk of pit inundation is expected to slightly increase due to the additional groundwater inflow and catchment area reporting to the pit extension (refer to Sections 4.4.3 & 4.4.4). However, sufficient capacity is available within HVO North to accommodation the potential increase in inventory.
- Long-term modelling indicates an increase in the annual exceedance probability of site spillway discharge from 9% to 17% in any one year (refer to Section 4.4.6). This impact could potentially be mitigated by transferring excess mine water to other mining areas within Hunter Valley Operations.

Based on the above assessment outcomes, it is expected that the proposal would have little impact on the existing HVO North water management system. Any discharges can be managed within the HRSTS rules. There are no substantial changes proposed to the HVO North water management system to accommodate the proposal. It is recommended that surface and groundwater monitoring be reviewed regularly, and existing water management tools be updated as appropriate to ensure currency with the operational configuration of the mine water management system.

This assessment has been undertaken using the forward projected production rates for HVO North. Should overall production increase to the maximum allowable under the Mining Consent, the following impacts would be expected:

- Raw water consumption would increase;
- Overall minesite storage inventory (and associated site discharge characteristics) would decrease.

Note that detailed modelling of this scenario has not been undertaken as part of the current study scope.

6.4 CHANGE IN SURFACE WATER RUNOFF VOLUME

The relative reduction in the Hunter River flows due to the proposal is small compared to the total flows in the Hunter River. It is proposed that the catchment removed due to mining would be largely reinstated to existing conditions at the end of the life of the mine.

6.5 CHANGE IN RUNOFF WATER QUALITY

The proposed management measures will ensure no measurable adverse impacts on riparian and ecological values of watercourses on the site and downstream of the proposal. It is expected that there would be little impact on runoff water quality to the Hunter River due to the proposed diversions and levees associated with the proposal. Also, it is proposed that all areas are to be returned to a rehabilitated catchment after mining. Any releases will be made in accordance with the HRSTS rules.

6.6 UNNAMED TRIBUTARY DIVERSION

Runoff from the Unnamed Tributary catchment is effectively conveyed around the proposed extension area by the proposed levees and diversion channel.

The proposed diversion effectively conveys the 10 year ARI channel within bank. It is likely that the finished levels of the overbank area in the vicinity of the proposed diversion channel would be lowered to reduce the in-bank capacity of the channel to the recommended 2m depth in accordance with the recommended channel design principles. This will be determined during the detailed design of the filled in pit. For the purposes of this assessment, the finished ground levels are assumed to be the same as existing conditions.

Post-mining, the ephemeral Unnamed Tributary will be reinstated to its original location. It will be constructed to be a similar shape to existing conditions and vegetated with appropriate species to reflect natural conditions along similar streams in the region. This accords with considerations set out in the Department of Water and Energy (2008) Guidelines for Controlled Activities – Riparian Corridors.

6.7 POST MINING WATER MANAGEMENT

The final void evaporative sink has been designed to facilitate evaporative losses at a rate which is greater than the accumulation of groundwater within the pit shell, rainfall runoff and infiltration through the rehabilitated final landform. It is understood that the proposed evaporative sink would need to be extended to accommodate the proposal. It is proposed that this void area be extended to between 85 to 100ha to accommodate the extended pit shell (Mackie 2010).

Rehabilitation at HVO is to be undertaken progressively and would generally follow the rate of mining. The proposed approach to rehabilitation within the proximity of the Carrington Pit gives consideration to, amongst other things, the pre-mining land capability class where practical. The Carrington Pit final void is proposed to function as an evaporative sink to manage groundwater post-mining. The final dimension and design of the evaporative sink would be prepared in consultation with the DoP.

7 REFERENCES

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APPENDIX A

HVO NORTH -
MINE WATER MANAGEMENT SYSTEM

A.1 OVERVIEW

The following sections provide detailed information relating to the HVO North mine water management system, including changes due to the proposal.

A.2 PROJECT DATA

A.2.1 Coal Production

There are currently two plants at HVO North, Hunter Valley Coal Preparation Plant (HVCPP) and Howick Coal Preparation Plant (HCPP). Generally, the majority of coal processing at HVO North occurs at HVCPP.

Current and forecast annual coal production data at HVO North for the life of the project is provided in Table A.1.

Table A.1 HVO North –Coal Production Data (Wet tonnes)

Case	ROM Feed (Mt)	Coarse Rejects (Mt)	Fine Tailings (Mt)	Product (Mt)
2009 (Base Case)	15.0	3.0	4.5	10.2
2012 – 2017 (Life of Mine)	14.0	2.8	4.2	9.5

Review of Table A.1 shows around a 7% reduction in total ROM tonnage during the life of the proposal compared with current tonnages.

A.2.2 Site Water Demands

Key water demands at HVO North are associated with the HVCPP process makeup water, and haul road dust suppression. The impact on these demands due to the proposal is discussed in the following sub-sections.

(i) CPP Makeup Water

Water is required at the HVCPP for coal processing, washdown and other associated uses. The volume of water required for CPP makeup is generally related to the annual coal production tonnages. Based on this forecast production information, the current and forecast combined HVCPP and HCPP makeup water volumes required are provided in Table A.2.

A review of Table A.2 shows a reduced overall process water makeup of around 670kL/day or 6.5% of the 2009 design process makeup estimates.

Table A.2 Design Plant Operational Parameters – Combined HVCPP & HCPP

Scenario	Design Raw Feed	HVCPP Water Balance (kL/day)				
		Raw Coal	Product	Coarse Rejects	Tailings	Process Makeup
	(Mtpa)	(a)	(b)	(c)	(d)	(e) = (b + c + d - a)
2009 (Base Case)	15.0	3,276	3,015	1,491	9,153	10,383
2012 – 2017 (Life of Mine)	14.0	3,068	2,822	1,395	8,565	9,714

(ii) Haul Road Dust Suppression Water

Water is required for suppression of dust on haul roads and coal stockpiles. For 2009, haul road dust suppression usage was recorded as 613ML/annum.

Based on the overall active pit footprint at HVO North during the life of the proposal, it is expected that haul road dust suppression would not significantly increase. Therefore a dust suppression demand of 613ML/annum for HVO North has been adopted for the proposal water balance for all scenarios.

A.2.3 Site Water Supply

Water is supplied to HVO North through a number of sources, including:

- Hunter River water extraction;
- Surface water runoff from disturbed and undisturbed areas; and
- Groundwater inflow.

The impact of the proposal on these water sources is discussed in the following sub-sections.

(iii) Hunter River Water Extractions

HVO maintains a Water Licence permitting the extraction of up to 2,675ML/annum of fresh water from the Hunter River (via Dam 17N). It is not expected that this arrangement would change during the life of the proposal.

(iv) Surface Water Runoff Volume

The volume of surface runoff water entering the mine water management system is dependent on rainfall and the catchment areas of the open pits, active overburden emplacement areas, industrial areas and rehabilitation areas, which can vary considerably over the life of the proposal.

Estimates of the different types of catchment area which contribute to the mine water system have been undertaken, and previously established rainfall runoff parameters have been applied to these areas. The area of each catchment type are summarised in Table 4.1 for the following development scenarios:

- Base Case (Year 2009);
- Year 3 of the proposal (nominally 2014);
- Year 6 of the proposal (nominally 2017).

Table A.3 HVO North Catchment Areas

Catchment Type	Catchment Area (ha)		
	2009 (Base Case)	2014 (Year 3)	2017 (Year 6)
Natural/Undisturbed	93.0	93.0	93.0
Open Cut Pits	77.1	103.5	92.7
Cleared/Prestrip	2.0	2.0	2.0
Roads/Industrial/Hardstand	181.4	181.4	181.4
Spoil – Unrehab	94.6	223.8	169.4
Spoil – Rehab	640.7	640.7	640.7
Tailings Dam	109.0	109.0	109.0
Total	1,198	1,353	1,288

(v) Groundwater Inflows

In addition to surface water runoff, water also enters the mine water management system due to groundwater inflow to the open cut pits from the coal seam aquifers. Of interest to this assessment is the groundwater inflow to the proposal.

Groundwater inflow estimates to the proposal have been sourced from recent groundwater investigations (Mackie, 2010). Predicted groundwater inflows to the proposal for the defined modelling scenarios are presented in Table 4.5.

Table A.4 Predicted Groundwater Inflow Volumes

Year	Predicted Groundwater Inflow (kL/day)
2014 (Year 3)	116
2017 (Year 6)	73

A.3 EXISTING WATER MANAGEMENT SYSTEM

A.3.1 Overview

The existing HVO North mine water management system is operated in accordance with the current HVO Water Management Plan, last updated in September 2009. The key objectives of the Water Management Plan are as follows:

- Diversion of clean surface water runoff away from areas disturbed by mining activities;
- Collection of surface water runoff from areas disturbed by mining activities to control suspended sediment prior to runoff from site or re-use via the mine water management system;
- Transfer of open cut pit water to storage dams for re-use in the mine water management system;
- Maximise the re-use and recycling of stored water on site, especially for use as the process supply to the CPP's and other related activities;
- Use stored water for dust suppression on haul roads, trafficable areas and stockpiles;

- Minimise extraction of water from the Hunter River during dry and drought periods; and
- Minimise offsite discharge under the Hunter River Salinity Trading Scheme (HRSTS) during wet periods.

A schematic of the HVO North mine water management system is provided in Figure 3.1 in the main body of the report.

A.3.2 Water Supply and Demands

The water management system at HVO is highly dependent on the prevailing climatic conditions. This means the mine can operate as either a water deficit or water surplus site, depending on the seasonal rainfall conditions.

(vi) Minesite Water Sources

The sources of mine water supply at HVO North are as follows:

- Open Cut pit water (from both surface and groundwater inflow);
- Active overburden emplacement area runoff;
- Industrial area surface water runoff;
- Production bore supply;
- Rehabilitated area runoff; and
- Dam catchments.

The water generated from these sources is transferred to mine water storage dams for re-use in the mine water management system.

(vii) Raw Water Supply

HVO maintains a Water Licence permitting the extraction of up to 2,675ML/annum of fresh water from the Hunter River. This is usually only required when site demands cannot be met by the mine water stored on site.

(viii) Site Water Demands

Site water demands at HVO North are summarised as follows:

- Make-up water for the Coal Preparation Plants (CPP's);
- Dust suppression;
- Industrial use, including workshop and washdown facilities;
- Fire fighting; and

Water requirements for CPP and associated mining activities are met from the following sources, in order of priority:

- Water stored in mine water storages which is harvested from mining operations,
- Freshwater extraction from the Hunter River.

A.3.3 Hunter River Salinity Trading Scheme

The HRSTS operates under the "Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Regulation 2002".

Under this scheme, credit holders are permitted to discharge saline water to the Hunter River on a managed basis. The aim is to maintain river salinity levels below 600 electrical conductivity (EC) unit at Denman and 900 EC at Singleton.

Management of the scheme is achieved through the following:

- Discharge scheduling that allows discharge only at times when the river flow and salinity level are such that salt can be discharge without breaching the salinity targets; and
- Sharing the allowable discharge according to licensed holdings of tradeable salinity credits.

The discharge point at HVO North is located at Dam 11N, which is permitted to release up to 100ML/day if the discharge criteria are met.

A.3.4 Mine Water Storages

Surface water at HVO North is managed through a series of dams used for water storage or sedimentation. Many of the dams are interconnected by a pump/pipe network which facilitates the movement of water around the site. A summary of the main water storages, their capacities, surface areas and current water volumes is provided in Table A.5.

Table A.5 HVO North - Summary Storage Details

Storage Name	Full Supply Volume (ML)	Full Supply Surface Area (ha)	Current Estimated Volume (Dec-2009)
Dam 9N	66	1.5	56
Dam 11N	86	2.0	61
Dam 15N	80	2.5	11
Dam 16N	52	1.5	34
Dam 17N	36	1.2	17
Dam 18N	27	1.1	1
Dam 19N	10	0.5	-
Dam 20N	151	11.0	0
Dam 21N	909	8.4	392
Dam 27N	200	2.0	-
Dam 28N	200	2.2	-
Dam 29N	100	8.1	-
Dam 30N	19,526	-	16,257
Dam 33N	18	0.5	-
Dam 34N	18	0.5	-
Dam 35N	18	0.5	-
Carrington Pit	19,900	84.3	-

A.3.5 Operational Guidelines

Representative operational guidelines for OPSIM modelling have been developed for the HVO North water management system based on review of available site operating protocol and discussions with HVO operational personnel. Refer to Table A.6 for the HVO operational guidelines.

Table A.6 HVO North OPSIM - Operational Guidelines

Item	Operational Description	Operating Rules
1 1.1	External Supply to Mine HVCPP River Pumps	❑ Raw water supply to HVO North operations. ❑ Licensed HVO Allocation – 2,665ML/year. ❑ Licensed Lemington Allocation – 1,500ML/year. ❑ Pumped from Hunter River pump station at 90L/s. ❑ Supply to Dam 17N as required. ❑ N.B. – Pumps are not currently operational due to silting issues, however would be reinstated when there is sufficient flow in Hunter River. Also, pumping not currently required due to surplus water in-pit.
2 2.1	Supply to Demands HV CPP – Raw Water	❑ HV CPP raw water demand is supplied from HVCPP River Pumps via Dam 17N.
2.2	HV CPP – Mine Water	❑ HV CPP mine water demand of 10,375kL/day is supplied from the following locations, in order of preference: ➢ Dam 17N ➢ Dam 16N ➢ Dam 9N ➢ Dam 15N ➢ Dam 18N (emergency supply)
2.3	Miscellaneous Industrial Use (ie. washdown, etc)	❑ Nominal demand of 450kL/day adopted, supplied from the following location: ➢ Hose Down Tank ❑ 25% loss assumed.
2.4	Vehicle Washdown	❑ Nominal demand of 250kL/day adopted, supplied from the following location: ➢ Dam 18N ❑ 25% loss assumed.
2.5	Haul Road Water	❑ Total demand of 1,680kL/day nominally supplied from the following location: ➢ Dam 9N. ❑ 100% loss assumed.
3 3.1	Transfer of Mine Waters Carrington Pit	❑ Continuous pumping from pit dewatering pumps at a nominal maximum rate of 100L/s per unit, or 200L/s total (i.e. 2 units). ❑ Pit dewatering directed to Dam 9N.
3.2	Carrington West Wing Pit	❑ Continuous pumping from pit dewatering pumps at a nominal maximum rate of 100L/s per unit, or 200L/s total (i.e. 2 units). ❑ Pit dewatering directed to Dam 9N.

Table A6 – HVO North OPSIM - Operational Guidelines (con't)

Item	Operational Description	Operating Rules
4	Operation of Key Storages	
4.1	Dam 9N	❑ Mine water collection and transfer storage: ❑ Receives inflows from the following locations: ➢ Pumped dewatering from Carrington Pit. ➢ Pumped dewatering from North Void. ➢ Decant water from Dam 29N (North Pit Void Tailings Dam). ➢ Pumped transfer from Dam 21N. ➢ Pumped transfers from Dam 9W (HVO West – Parnells Dam) – note this transfer is not currently used. ➢ Pumped transfer from Dam 20S (HVO South – Riverview East Void) ❑ Supplies to the following locations: ➢ Pumped transfer to Dam 17N (priority). ➢ Pumped transfer to Dam 16N ➢ Pumped transfer to Dam 18N ➢ Pumped transfer to Dam HVCPP ➢ ☐umped transfer to Dam 15N ➢ Pumped transfer to Dam 21N. ➢ Haul Road Water. ➢ Pumped transfer to Dam 20S (HVO South – Riverview East Void). ❑ Storage overflows to Dam 21N.
4.2	Dam 11N	❑ Mine water collection and transfer storage: ❑ Receives inflows from the following locations: ➢ Pumped transfer from Dam 21N. ➢ Pumped transfer from Dam 15N (emergency). ❑ Supplies to the following locations: ➢ Pumped transfer to Dam 17N. ❑ Licensed HRSTS discharge point, with a maximum daily discharge of 100ML/day. ❑ Storage overflows to Farrells Creek
4.3	Dam 15N	❑ Mine water collection and transfer storage: ❑ Receives inflows from the following locations: ➢ Overflows from Dam 16N. ➢ Pumped transfers from Dam 9N. ➢ Pumped transfers from Dam 16N (if required). ❑ Supplies to the following locations: ➢ Dam 17 (priority makeup). ➢ Dam 16 ➢ Dam 11N (emergency only) ❑ Storage to be operated in a drawn down condition to provide adequate storm runoff buffer. ❑ Storage overflows to Farrells Creek.

Table A6 – HVO North OPSIM - Operational Guidelines (con't)

Item	Operational Description	Operating Rules
4.4	Dam 16N	❑ Mine water collection and transfer storage: ❑ Receives inflows from the following locations: ➢ Runoff from HVCPP and coal pads. ➢ Pumped transfers from Dam 9N. ➢ Pumped transfers from Dam 15N. ➢ Overflow from Dam 19N & Dam 34N. ❑ Supplies to the following locations: ➢ HV CPP, hose down tank. ➢ Pumped transfers to Dam 15N (if required). ➢ Storage overflows to Dam 15N. ❑ Storage to be drawn down with a minimum 300mm freeboard maintained.
4.5	Dam 17N	❑ Mine water collection and transfer storage: ❑ Receives inflows from the following locations: ➢ Pumped transfers from Dam 11N. ➢ Pumped transfers from Dam 9N. ➢ Pumped transfers from Hunter River Fresh Water Offtake. ➢ Pumped transfers from Dam 15N. ❑ Supplies to the following locations: ➢ North CHPP, hose down tank. ➢ Pumped transfers to Dam 18N. ❑ Storage intended to be operated with a minimum 500mm freeboard maintained. ❑ Storage overflows to Farrells Creek (not permitted to overflow).
4.6	Dam 18N	❑ Mine water collection and transfer storage: ❑ Receives inflows from the following locations: ➢ Pumped transfers from Dam 17N. ➢ Pumped transfers from Dam 9N. ❑ Supplies to the following locations: ➢ HV CPP, hose down tank (emergency supply). ➢ Vehicle Washdown. ❑ Storage intended to be operated with a minimum 500mm freeboard maintained. ❑ Storage overflows to Farrells Creek
4.7	Dam 19N	❑ Mine water collection and transfer storage: ❑ Storage overflows to Dam16 N.
4.8	Dam 20N	❑ Sedimentation dam for rehabilitated catchments. ❑ Receives inflows from the following locations: ➢ Overflows from Dam 21N. ➢ Catchment runoff. ❑ There is currently no pump in Dam 20N. ❑ Water seeps from Dam 20N into the alluvial plains. ❑ Storage overflows to Alluvial land (emergency only)

Table A6 – HVO North OPSIM - Operational Guidelines (con't)

Item	Operational Description	Operating Rules
4.9	Dam 21N	❑ Mine water collection and transfer storage. ❑ Receives inflows from the following locations: ➢ Pumped transfers from Dam 9N. ➢ Overflows from Dam 9N. ❑ Supplies to the following locations: ➢ Pumped transfer to Dam 11N (priority). ➢ Pumped transfer to Dam 9N. ❑ Storage overflows to Dam 20N.
4.10	Dam 27N (East In-Pit Tailings Dam) - Inactive	❑ Inactive tailings storage facility. ❑ Supplies to the following locations: ➢ Seepage to Dam 21N. ❑ Storage overflows to 21N.
4.11	Dam 28N (Centre Tailings Dam) - Inactive	❑ Inactive tailings storage facility. ❑ Supplies to the following locations: ➢ Seepage to Dam 30N. ❑ Storage overflows to North Void Spoil.
4.12	Dam 29N (North Pit Void Tailings Dam) - Active	❑ Fine tailings storage. ❑ 'Prescribed Dam' that must be operated in accordance with NSW Dam Safety Committee requirements. ❑ Receives inflows from the following locations: ➢ HVO North CHPP tailings placement. ❑ Supplies to the following locations: ➢ Decant water pumped to Dam 9N. ➢ Seepage to North Void. ❑ Storage overflows to North Void. ❑ Storage can seep to the Hunter River via subsurface drainage (emergency only).
4.13	North Void	❑ Mine water collection and transfer storage: ❑ Receives inflows from the following locations: ➢ Infiltration from North Pit spoil. ➢ Seepage and overflows from North Pit Final Void Tailings Dam (Dam 29N). ➢ Overflows from Dam 20N (emergency only). ❑ Supplies to the following locations: ➢ Pumped transfer to Dam 9N (if required) ❑ The Production Bore located at the North Void can pump at around 70L/s, however it is not currently used.
4.14	Dam 33N	❑ Mine water collection and transfer storage: ❑ Storage overflows to Dam 34N.

Table A6 – HVO North OPSIM - Operational Guidelines (con't)

Item	Operational Description	Operating Rules
4.15	Dam 34N	❑ Mine water collection and transfer storage. ❑ Receives inflows the following locations: ➢ Overflows from Dam 33N. ➢ Overflows from Dam 35N. ❑ Storage overflows to Dam 16N.
4.16	Dam 35N	❑ Sedimentation dam. ❑ Storage overflows to Dam 34N.
	<u>General</u>	❑ All storages and pits receive local catchment runoff and lose water through evaporation and seepage.

B APPENDIX

HYDROLOGICAL AND HYDRAULIC MODEL DEVELOPMENT

B.1 OVERVIEW

This appendix presents the methodology results used to estimate design discharges for the Hunter River and the Unnamed Tributary that crosses the proposed extension area. The development and calibration of the TUFLOW hydraulic model used to estimate design flood levels, extents, velocities and bed shear is also provided.

B.2 ESTIMATION OF HUNTER RIVER DESIGN DISCHARGES

B.2.1 Methodology

Design flood discharges were estimated from a flood frequency analysis (FFA) of recorded flows in the Hunter River. The following gauges were selected for FFA due to their length of historical record and proximity to HVO North.

- Hunter River at Liddell (210083) – 41 years (1969-2009) of data –located approximately 7.0 (river) kms upstream; and
- Hunter River at Singleton (210001) – 97 years (1913-2009) – located approximately 50.0 (river) kms downstream.

The methodology recommended in Book 4, Section 2 of Australian Rainfall and Runoff (IEAust, 1987) was used to fit a Log-Pearson Type III distribution to an annual series of recorded peak flood discharges at the above 2 locations.

The catchment area of the Hunter River to Liddell is similar to the catchment at HVO North at 13,400km^2, whereas the Singleton catchment is 22% greater as it includes the catchments of Wollombi Brook and Glennies Creek. The Singleton Gauge was used to validate the Liddell data.

B.3 AVAILABLE STREAMFLOW DATA

The peak annual discharges recorded at the selected gauge sites were obtained from the NOW PINEENA database. A summary of the available peak series data for each gauge is given below in Table B.7. It is of note that the annual data is presented for standard calendar years (January-December).

Table B.7 Summary of Annual Peak Series Data

Gauging Station Name	Gauging Station No.	Period of Record	Years Without Data	Years of Available Data
Hunter River at Liddell	210083	1969-2009	0	41
Hunter River at Singleton	210001	1913-2009	0	97

Figure B.7.1 shows the Liddell Station rating curve and the stream flow gaugings used to create the rating. Gauged data is available up to a flow of 11,568ML/day (134m^3/s), which is equivalent to the 1 to 2 Year ARI design discharge.

The available rating curve for the Singleton Station is shown in Figure B.7.2. The rating curve is based on gauged data up to 457,509ML/day (5,295m^3/s), which is equivalent to the 20 and 50

Year ARI design discharge and therefore is likely to provide a reasonably good representation of flood flows at that station.

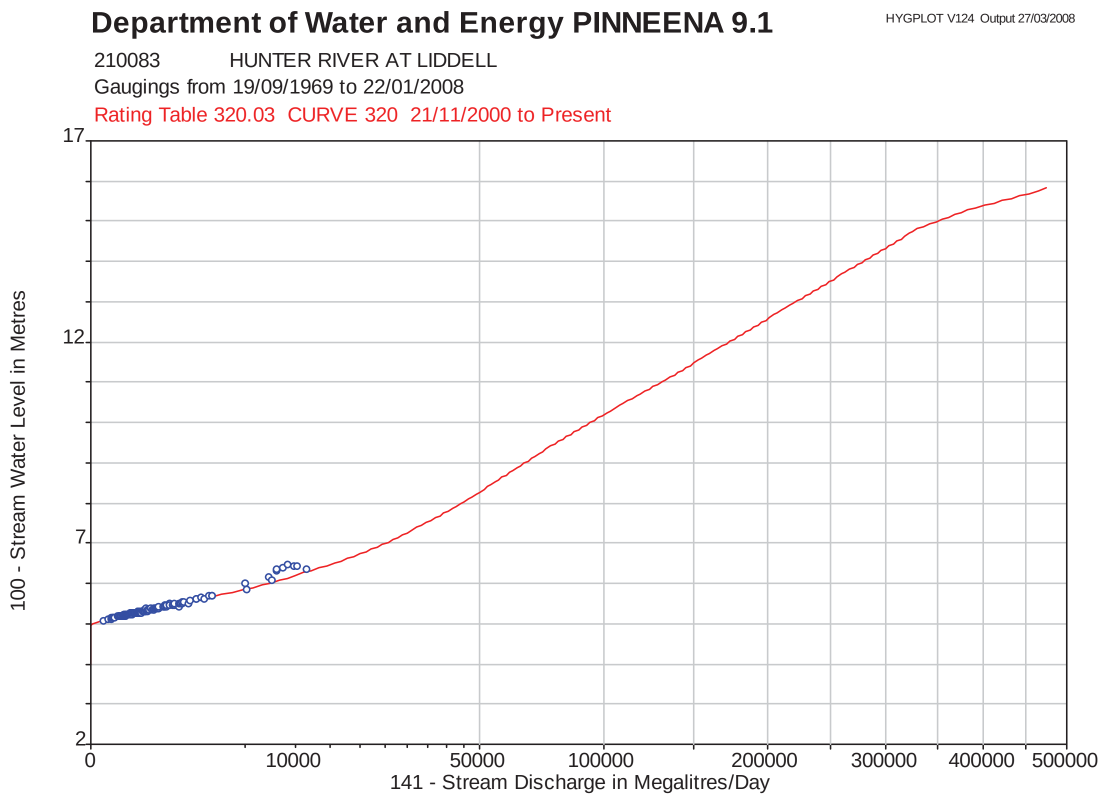

Figure B.7.1 Available Rating Curve, Hunter River at Liddell (210083)

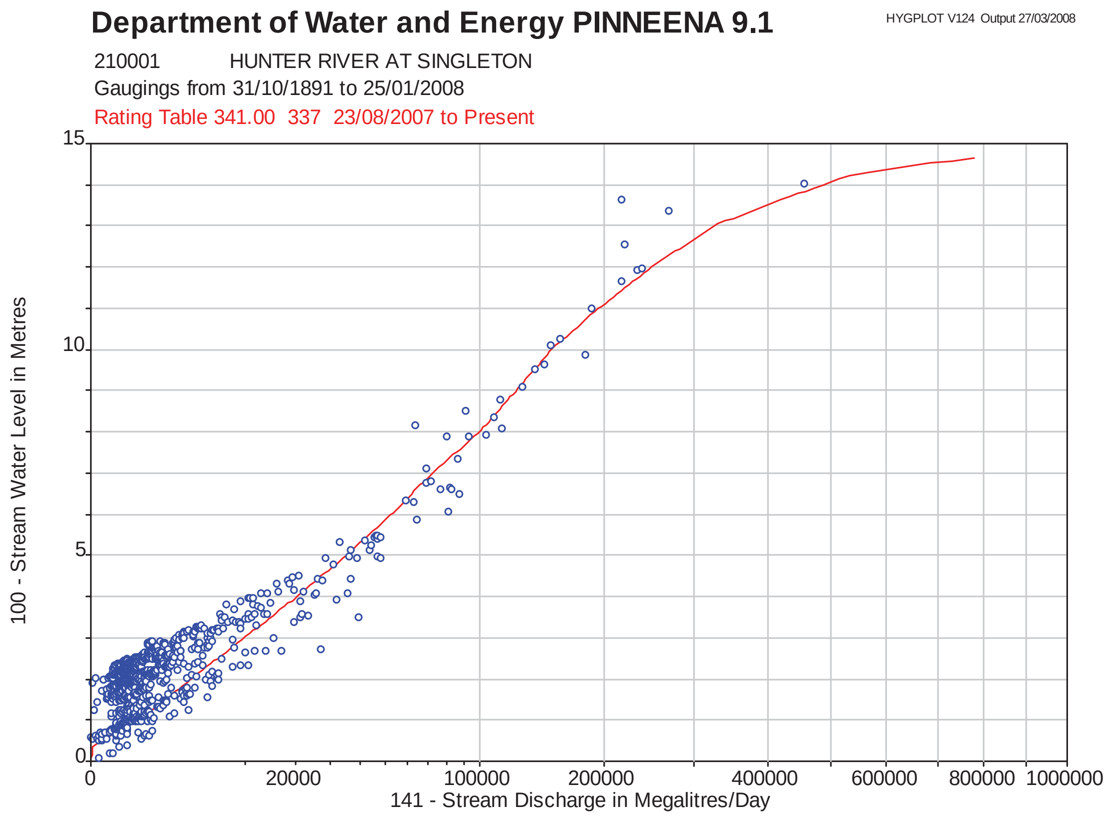

Figure B.7.2 Available Rating Curve, Hunter River at Singleton (210001)

B.3.1 Flood Frequency Analysis Results

Table B.8 show the results of the FFA results for the Hunter River at Liddell and Singleton. Figure B.7.3 and Figure B.7.4 shows the plot of the fitted flood frequency distributions at the two sites. The following is of note with regards to the FFA results:

- There is generally a good agreement between the design discharge estimates up to the 10 year ARI event at the two stations. The Singleton discharges are greater as would be expected given the larger catchment area.
- The estimated 50 year ARI discharge at Liddell is similar to the 50 year ARI discharge at Singleton whereas the 100 year ARI discharge is greater.
- It is expected that the shorter duration of recorded flows at Liddell and the fact that a theoretical high flow rating has been used at the station would give a high level of uncertainty for design flow estimates in excess of say the 10 year ARI flood and this may preclude the use of this data to estimate higher flows.

A correlation of historical peak discharges at the two stations for events in excess of 1,000m^3/s show that peak flows at Liddell are generally 85% of the peak flows at Singleton. Whilst this correlation is approximate, it has been adopted as a conservative assumption to derive design discharges at the proposed extension area for events greater than the 10 year ARI event. The Liddell design flows have been adopted for discharges up to this event. Note that the adopted flows are marginally lower than those estimated in the previous flood study at the site by Lyall and Associates (2005), who based their estimates on the Liddell flows.

Table B.8 Flood Frequency Analysis Results, Hunter River at Liddell (210083) and Hunter River at Singleton (210001)

ARI (Years)	Estimated Peak Discharge (m³/s)		
	Liddell	Singleton	Adopted
2	297	490	297
5	1149	1551	1149
10	2279	2790	2279
20	3978	4501	3825
50	7376	7658	6509
100	11074	10872	9241

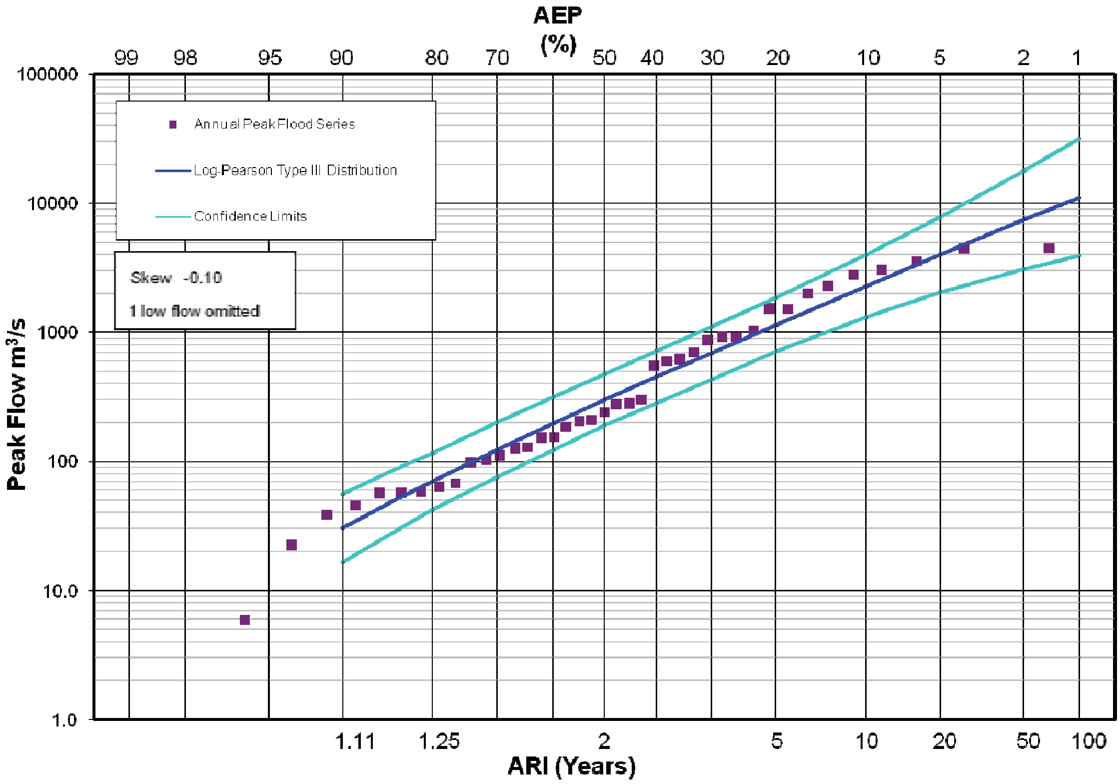

Figure B.7.3 Flood Frequency Distribution, Hunter River at Liddell (210083)

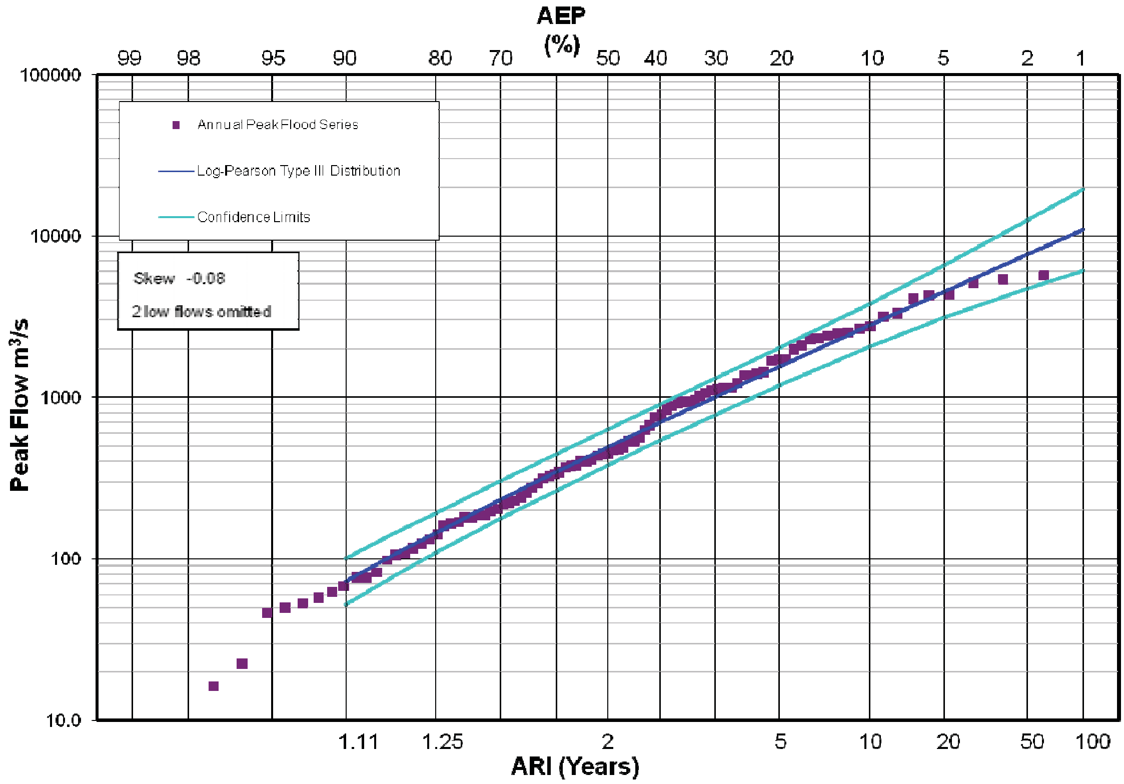

Figure B.7.4 Flood Frequency Distribution, Hunter River at Singleton (210001)

B.3.2 Adopted Hydrographs

The largest recorded event at Liddell occurred in June 2007 with a peak discharge of 4463m³/s. The adopted peak discharges were applied to the June 2007 event hydrograph to create hydrographs for the hydraulic model. The adopted hydrographs are shown in Figure B.7.5.

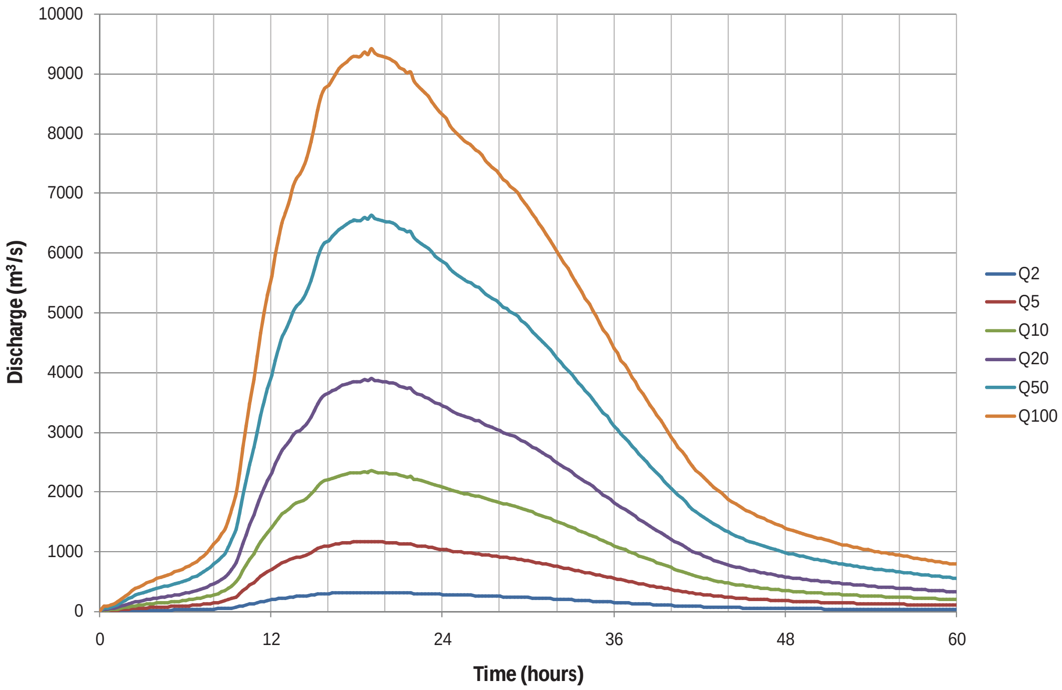

Figure B.7.5 Adopted Hydrographs, Hunter River at Liddell

B.4 ESTIMATION OF DESIGN DISCHARGES – UNNAMED TRIBUTARY

B.4.1 Methodology

The 'Rafts' runoff-routing model (XP Software, 2001) was used to estimate design flood discharges for the Unnamed Tributary that drains across the proposed extension area. The RAFTS model consists of six nodes, each representing a subcatchment of the area draining to the Hunter River as shown in Figure B.7.6. The model was validated against Rational Method discharge estimates using the methodology given in ARR (IEAUST, 1998). The validated RAFTS model was then used to estimate design flood discharge hydrographs for the 2, 5, 10, 20, 50 and 100 year ARI storm events for a range of durations up to 72 hours.

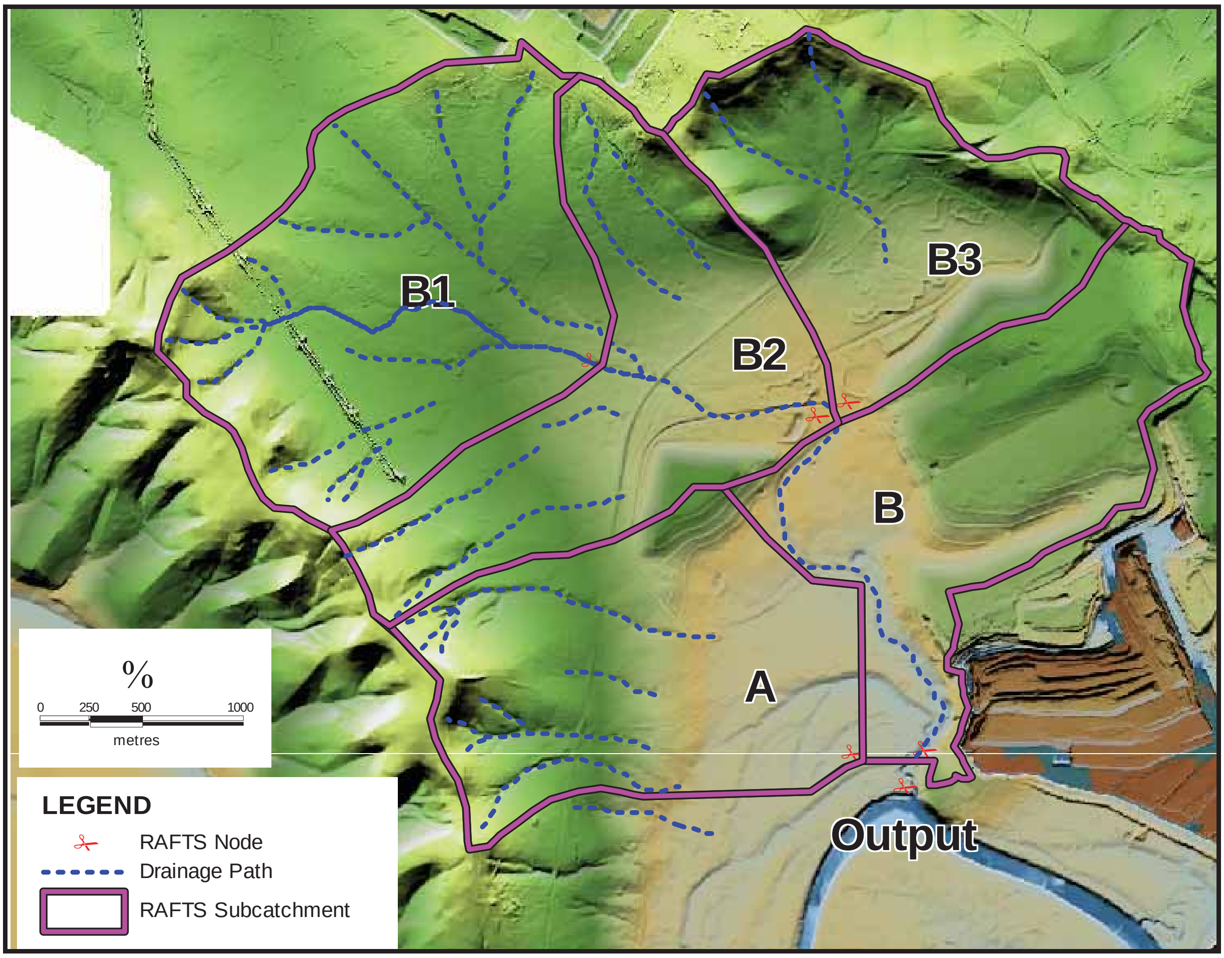

Figure B.7.6 Unnamed Tributary RAFTS Subcatchments

B.4.2 Adopted Design Rainfalls

Design rainfall patterns and intensities for the site were determined using standard procedures in ARR (IEAust, 1998).

B.4.3 Rational Method Calculations

The Rational Method was used to estimate design flood discharges for the Unnamed Tributary. The method recommended for *Eastern New South Wales* in Section 1.4.1a of Book IV of

Australian Rainfall and Runoff (Volume 1)(IEAust, 1998). A time of concentration (t_c) of 121 minutes and a C_{10} value of 0.2 were adopted using this method. The peak discharges estimated from the Rational Method are shown in Table B.9.

B.4.4 Model Validation and Adopted Design Discharges

Table B.9 shows a comparison of Rational Method and RAFTS model design discharges for the Unnamed Tributary to the Hunter River. The peak discharges from the RAFTS model are for the 6 hour duration storm. The rafts model validation was achieved using the following parameters:

- Catchment Manning's n = 0.045;
- Zero % Impervious;
- 15mm initial loss;
- 2.5mm/hr continuing loss; and
- BX= 2.

The RAFTS discharges are in close agreement with the Rational Method discharges and have been adopted to represent design flows for the Unnamed Tributary in this study.

Table B.9 Comparison of Unnamed Tributary Design Discharges, Rational Method and RAFTS Model.

ARI (Years)	Rational Method (m^3/s)	RAFTS (m^3/s)
2	8.2	7.2
5	12.4	13.4
10	15.9	17.0
20	20.5	22.4
50	27.8	29.8
100	34.7	35.7

B.5 HYDRAULIC MODELLING

B.5.1 Modelling Overview

The TUFLOW two-dimensional hydraulic model (WBM, 2008) was used to simulate the flow patterns of the Hunter River channel and floodplain in the vicinity of HVO North and the proposed extension areafor the three development scenarios.

The TUFLOW model represents hydraulic conditions on a fixed grid by solving the full two-dimensional depth, averaged momentum and continuity equations for free surface flow. The model automatically calculates breakout points and flow directions within the study area.

The model was used to estimate flood extents and velocities for the 2, 5, 10, 20, 50 and 100 year ARI design floods along the Hunter River. The discharges given in Table 6.2 and 6.3 were adopted as boundary inflows to the TUFLOW model.

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B.5.2 Tuflow Model Configuration

Figure B.7.7 shows the spatial extent of the TUFLOW model at HVO North. The modelled study area covers approximately 34km^2. A 10m grid size and a 5 second time step were adopted for the two dimensional model.

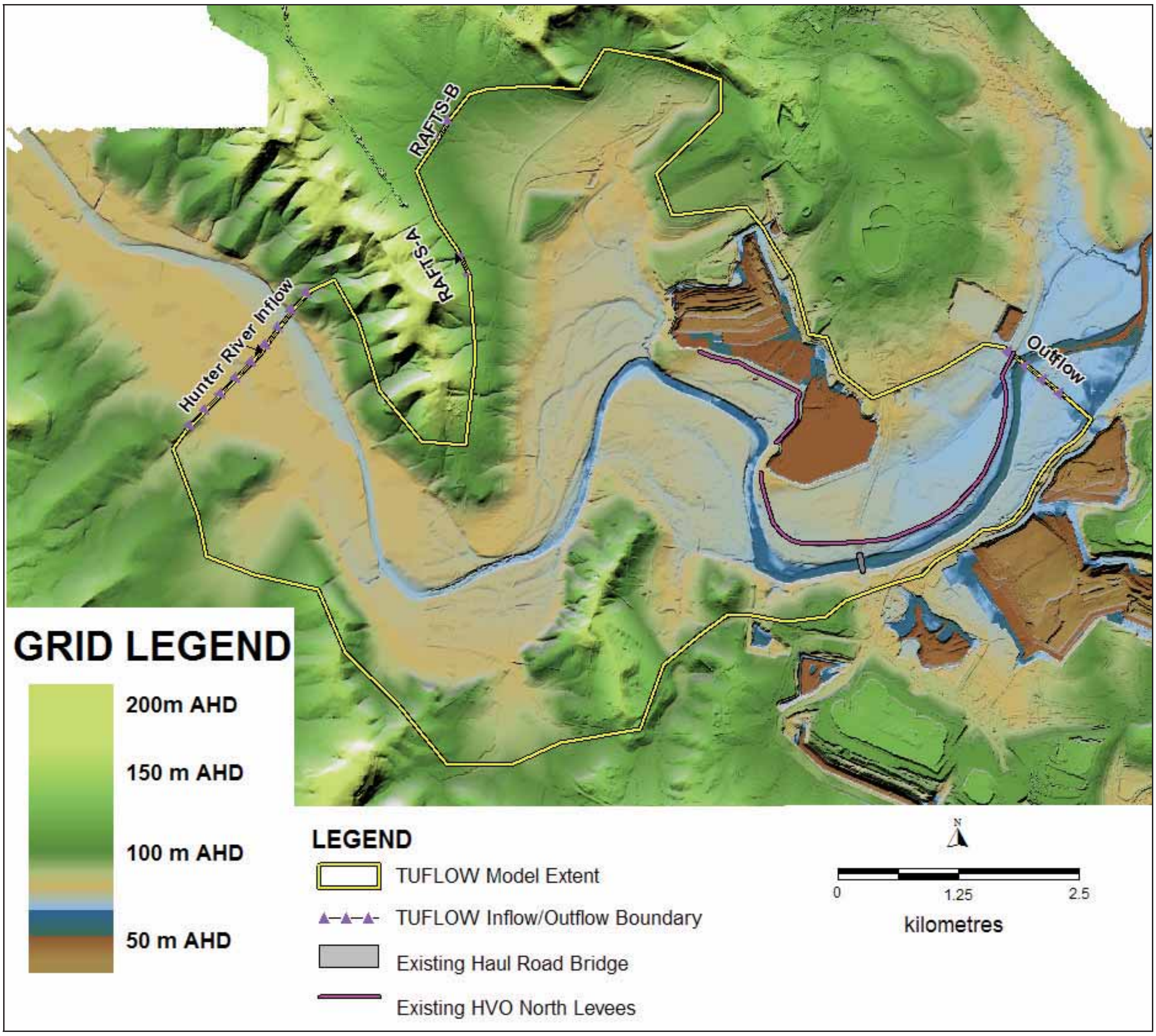

Figure B.7.7 Existing TUFLOW Model Configuration

B.5.3 Adopted Manning's 'n' Values

The TUFLOW model uses Manning's 'n' values to represent hydraulic resistance (notionally channel or floodplain roughness). In the absence of suitable calibration data for the hydraulic model, Manning's 'n' values were selected based on typical published values (for example, those of Chow, 1959). The adopted Manning's n values are given in Table B.10.

Table B.10 Adopted Manning's 'n' values

Location	Adopted Manning's 'n'
Grassed Floodplain	0.04
River Channel and bank	0.06

B.5.4 Inflow and Outflow Boundaries

Figure B.7.7 shows the locations of the inflow and outflow boundaries used in the TUFLOW model. Table B.11 shows the TUFLOW boundary type for each inflow location. The Hunter River inflow hydrographs were developed from the FFA as described in Section B.1. The Unnamed Tributary inflows (RAFTS-A and RAFTS-B) correspond to the node names used in the XP-RAFTS model (see Section B.4).

A rating curve, with a hydraulic gradient of 0.07% (representative of the floodplain slope), was adopted for the downstream boundary of the model.

Table B.11 TUFLOW Inflow Boundaries

Boundary	Hydrograph Source	Location
Hunter River Inflow	FFA	Hunter River
RAFTS-A	RAFTS	Unnamed Tributary
RAFTS-B	RAFTS	Unnamed Tributary

B.5.5 Existing Hydraulic Structures

The TUFLOW model includes the existing haul road bridge across the Hunter River between HVO North and HVO South. The location of the bridge is shown in Figure B.7.7.

The existing haul road bridge was modelled as a layered flow constriction based on the Arkhill Engineers drawing No. 1938-11131 dated August 2003. Table B.12 shows the flow configuration data adopted for the existing haul road bridge.

Table B.12 Existing Haul Road Bridge Configuration Data

Road Bridge Properties	
Min. Bridge Deck Level	65 AHD
Bridge Deck Depth	1m
Bridge Length	140m
Number of Piers	10
Pier Diameter	1.2m x 5
Approx Distance between Piers	10m
Estimated Pier Blockage Factor	12%
Rail guard height	0.5m
Rail guard blockage Factor	80%

B.5.6 Model Verification

The June 2007 event is the largest recent flood at the Liddell Gauge. Based on the flood frequency analysis given in Table B.8, the June 2007 flood had an ARI of between 20 and 50 years at Liddell. Mine site staff indicated that the bridge was inundated to a depth of approximately 1m above the deck level during this event. A photograph of the flooding at the existing haul road bridge near the peak of the flood is shown in Figure B.7.8.

The existing conditions TUFLOW model was run using the recorded discharge hydrograph for the June 2007 event at Liddell. The modelled flood depths and extent for the June 2007 event is shown in Figure B.7.9. The predicted water level over the haul road bridge is approximately 0.7-0.9m which is consistent with the observed flood level at this location.

Figure B.7.8 Haul Road Bridge during June 2007 Event

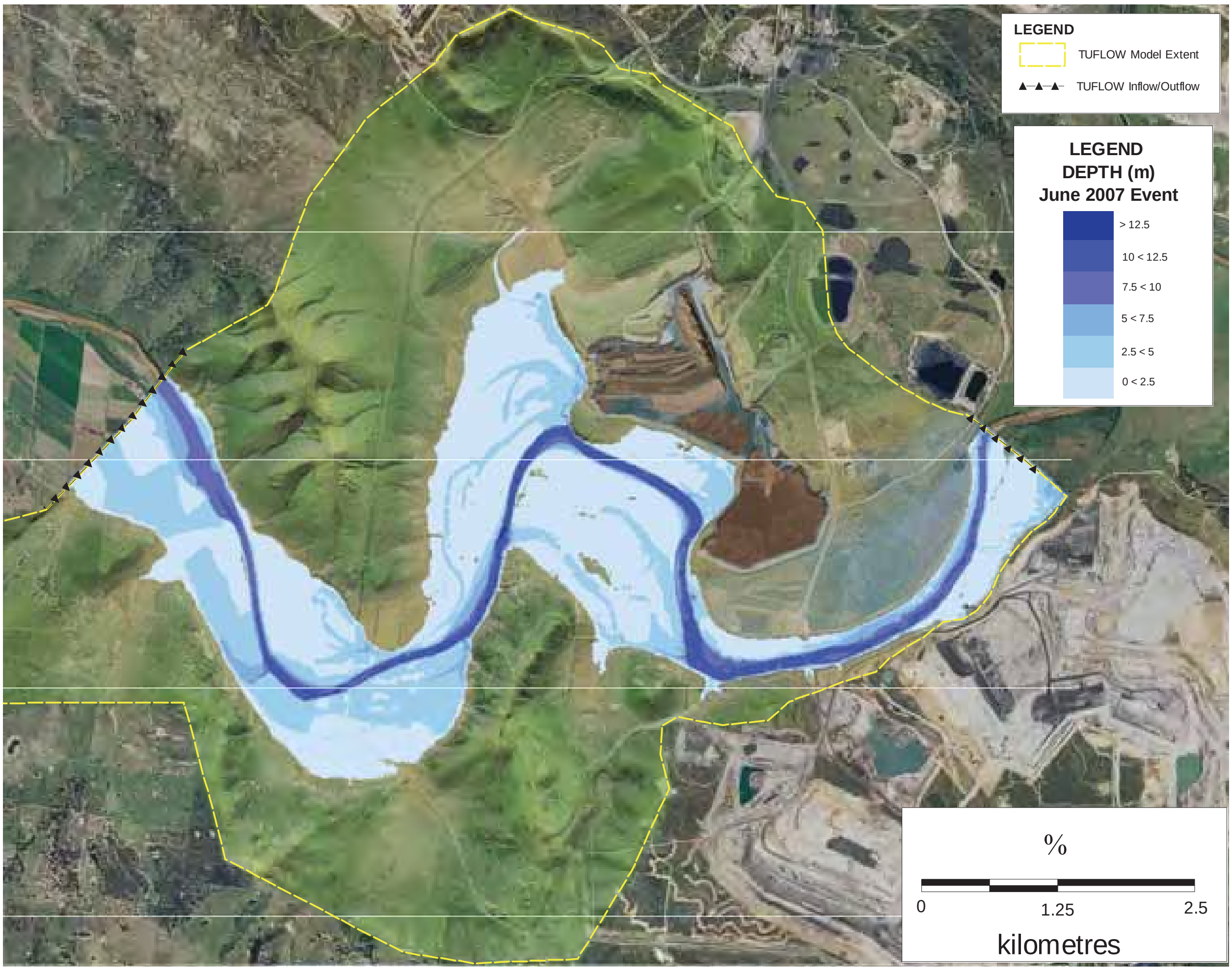

Figure B.7.9 Modelled Flood Depth June 2007 Event

Appendix E

Soils and land resource study

EMGA | MitchellMcLennan

FINAL

Soil Survey and Land Resource Assessment

Carrington West Wing

August 2010

EMG00-002

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

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APPENDICES

1.0 INTRODUCTION

GSS Environmental (GSSE) was commissioned by EMGA Mitchell McLennan Pty Limited (EMGA MM) on behalf of Coal & Allied Operations Pty Limited (Coal & Allied) to undertake a land resource assessment for the environmental assessment of the Carrington West Wing proposal.

1.1 Background

Hunter Valley Operations (HVO) is situated in the Upper Hunter Valley coalfields of New South Wales approximately 18 km west of Singleton. This region contains rich thermal and metallurgic coal resources and several nearby open cut coal mines including Ravensworth Narama to the east, and Warkworth Mine, Wambo Mine and United Colliery to the south. A general locality plan showing HVO within the region is shown in **Figure 1**.

The mining and processing activities at HVO are geographically divided by the Hunter River into HVO South and HVO North, with movements of coal, coarse and fine reject, overburden, topsoil, equipment, water, materials and personnel between the two areas. While HVO South and HVO North each have separate approvals, HVO is owned and managed as one operation.

HVO North comprises the active Carrington, West, and North Pits. Carrington Pit is a truck and shovel operation, approved to mine 10 million tonnes per annum (Mtpa) of run of mine coal (ROM). The pit is well developed with significant areas of rehabilitation established. An opportunity has been identified to extend mining operations in the Carrington Pit to the south west (**Figure 2**).

1.2 Project Description

The proposed extension area comprises a surface area of approximately 137 ha and is predominantly cleared of native vegetation. The extension will allow for the extraction of approximately 17 million tonnes (mt) of in-situ coal from mining of coal reserves in the Broonie, Bayswater and Vaux seams.

The proposed extension will have a life of approximately six (6) years. Mining will be completed within the existing development consent period, which is currently approved to 2025.

As part of the proposal, two (2) out-of-pit overburden emplacements are proposed on rehabilitated land immediately north of the proposed extension area, in addition to in-pit disposal.

Supplementary activities proposed to support the extension include:

- the approved footprint of the Carrington evaporative sink will be extended for the long term management of groundwater post-mining;
- the impermeable groundwater barrier wall previously assessed for the western paleochannel will be realigned further south, to prevent groundwater migration from the Hunter River into the mine, and migration of water from the mine into the Hunter River alluvium;
- a two stage, temporary levee and diversion system will be established to ensure that the proposed extension area is protected from flooding and to enable the diversion of an unnamed tributary of the Hunter River (referred to herein as the ‘Unnamed Tributary’) that presently runs in a southerly direction across the footprint of the extension; and
- a service corridor will be constructed along the southern boundary of the proposed extension area. This may incorporate water pipelines, an all weather access road, mining equipment, substations and other services.

The proposal will not result in change to the mining extraction rates, the life of mine, mining methods, mining equipment, employment, processing or mine services, product transport, operating hours or environmental management systems. The project area is entirely on land owned by Coal & Allied.

Excavation of the open cut pit and construction of out-of-pit overburden stockpiles, haul roads and other service roads will result in ground disturbance and therefore will impact on the land resource within the project area. To ensure sufficient topsoil resources are available for post-mining rehabilitation, it is important that all suitable soil reserves are identified and recovered ahead of the proposed disturbance. The following report presents the results of the survey undertaken by GSSE and the assessment of soil resources, land capability and agricultural suitability classification within the proposed extension area.

1.3 Report Objectives

The major objectives of the assessment undertaken by GSSE are:

- assess areas to be disturbed by the proposal at a sufficient detail to satisfy the requirements of the Department of Industry and Investment (DII);
- assess pre and post-mining rural land capability and class assessment in accordance with Department of Environment, Climate Change and Water (DECCW) guidelines including figures of each;
- assess pre and post-mining agricultural suitability assessment in accordance with DII guidelines;
- assess topsoil resources for mining rehabilitation, management and mitigation measures;
- assess suitable post-mining land uses for the open cut operations; and
- assess potential impacts of the proposal on alluvial soils of the Hunter River.

1.4 Geology

The basic geologic structures in the Carrington area are well understood due to the development of previous and current mining operations. In the proposed extension area a 10 – 20 m thick unconsolidated zone overlies the Mount Arthur, Piercefield, Vaux, Broonie and Bayswater seams, separated by varying interburdens. The target seams in the proposed extension area are the Vaux, Broonie and Bayswater seams. Similar to other Carrington Pits, the Bayswater seams are the thickest and most consistent.

1.5 Topography

The proposed extension area consists of low undulating slopes and flat low lying areas that have been cleared for agricultural purposes. The topography within the proposed extension area gently slopes from west to east.

1.6 Vegetation

The proposed extension area has been highly modified through clearing and farming activities and is predominantly pasture. Remnant tree species in the area include Grey Box (*Eucalyptus molccana)* and Narrow-leaved Ironbarks (*Eucalyptus crebra).*

FIGURE 1

Location Plan

Version:	Date:	Author:	Checked:	Approved:
1	05/11/09	AR	KM	CR
2	02/02/10	AR	KM	CR

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

Project: Carrington West Wing Modification

Client: EMGA Mitchell McLennan Pty Ltd

File: Fg1_EMG00-002_Location Plan_v2

Projection: MGA94 Zone 56

LEGEND

Proposed Pit Extension Footprint

Soil Test Pit Locations

FIGURE 2

Soil Test Pit Locations

Version:	Date:	Author:	Checked:	Approved:
1	05/11/09	AR	KM	CR
2	02/02/10	AR	KM	CR

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

Project: Carrington West Wing Modification

Client: EMGA Mitchell McLennan Pty Ltd

File: Fg2_EMG00-002_Pit Locations_v2

Projection: MGA94 Zone 56

2.0 SURVEY METHODOLOGY

2.1 Introduction

A soil survey was undertaken in September 2009 by GSSE to:

1. classify and determine the soil profile types of the proposed extension area;
2. assess the suitability of the current topsoil material for future rehabilitation;
3. identify pre and post-mining rural land capability and agricultural suitability classifications; and
4. identify any potentially unfavourable soil material for rehabilitation within the proposed extension area.

The survey was conducted in accordance with the methodology outlined in this section. The soils and land resource assessment results are presented in **Section 3** of this report.

2.2 Soil Mapping

A base soils map was developed using the following resources and techniques.

1) Aerial photographs and topographic maps

Aerial photo and topographic map interpretation was used as a remote sensing technique, allowing detailed analysis of the landscape and mapping of features expected to be related to the distribution of soils within the surface area.

2) Previous soil survey results

A survey of the region (including the areas surveyed in this assessment) was undertaken by Kovac and Lawrie (1991) at a scale of 1:250,000. The survey map and report present a broadscale guide to the soil and landscape unit distribution in the upper Hunter Valley region and provide a framework for more detailed surveys.

3) Stratified observations

Following production of a base soils map, surface soil exposures, topography and vegetation throughout the potential disturbance areas were visually assessed to verify potential soil units, delineate soil unit boundaries and determine preferred locations for targeted subsurface investigations.

2.3 Soil Profiling

Ten (10) soil profiles were assessed at selected sites throughout the proposed extension area to enable soil profile descriptions to be made. Subsurface exposure was generally undertaken by backhoe excavation of test pits to 1.2 m deep. The test pit locations were chosen to provide representative profiles of the soil types encountered during the survey. The soil layers were generally distinguished on the basis of changes in texture, structure and colour. Soil colours were assessed according to the Munsell Soil Colour Charts (Macbeth, 1994). Photographs of soil profile exposures were also taken (refer to **Plates 1** to **6**).

Soil profiles were also observed through the use of surface exposures located in existing track cuttings, gullies and creek banks. Soil test pit locations are shown in **Figure 2.**

2.4 Soil Field Assessment

Soil profiles within the survey area were assessed generally in accordance with the Australian Soil and Land Survey Field Handbook soil classification procedures (McDonald et al, 1998). Soil layers at each profile site were also assessed according to a procedure devised by Elliot and Veness (1981) for the recognition of suitable topdressing material. This procedure assesses soils based on grading, texture, structure, consistence, mottling and root presence. The system remains the benchmark for land resource assessment in the Australian coal mining industry. A more detailed explanation of the Elliot and Veness procedure is presented in **Appendix 1** to this report.

2.5 Laboratory Testing

Soil samples were collected from the exposed soil profiles and subsequently sent to the NSW Land and Property Management Authority Soil Conservation Service Laboratory at Scone, NSW for analysis. Samples were analysed to establish the suitability of surface and near-surface soil horizons as potential growth media, and identify high value soils and, conversely, soils that may have properties that are deleterious to vegetation establishment. Samples were analysed from the following sites (as shown on **Figure 2**):

- Test Pit 1 – 1/1, 1/2, & 1/3;
- Test Pit 2 – 2/1, 2/2 & 2/3;
- Test Pit 3 – 3/1, 3/2 & 3/3;
- Test Pit 4 – 4/1, 4/2 & 4/3;
- Test Pit 5 – 5/1, 5/2 & 5/3;
- Test Pit 6 – 6/1, 6/2 & 6/3;
- Test Pit 7 – 7/1, 7/2 & 7/3;
- Test Pit 8 – 8/1, 8/2 & 8/3;
- Test Pit 9 – 9/1, 9/2, 9/3 & 9/4; and
- Test Pit 10 – 10/1, 10/2 & 10/3.

Soil horizons are signified by /1 /2/3 in the sample ID, with the surface horizon being /1 and subsoil horizons being /2 and /3. The samples were subsequently analysed for the following parameters.

- Colour.
- Particle Size Analysis.
- Emerson Aggregate Test.
- pH.
- Electrical Conductivity.
- Cation Exchange Capacity and exchangeable cations.

A description of the significance of each test and typical values for each soil characteristic are included in **Appendix 2**.

The laboratory test results were used in conjunction with the field assessment results to determine the depth of soil material that is suitable for recovery and use as a growth medium for rehabilitation of disturbed areas. Similarly, potentially unfavourable soil material was identified. The soil test results for the soil survey are provided in **Appendix 3**.

2.6 Land Capability Assessment

The land capability assessment of the proposed extension area was conducted in accordance with DECCW's rural land capability classification system. It recognises the following three types of land uses:

- land suitable for cultivation;
- land suitable for grazing; and
- land not suitable for rural production.

These capability classifications identify limitations on the use of the land as a result of the interaction between the physical resources and a specific land use. The principal limitation recognised by these capability classifications is the stability of the soil mantle (Soil Conservation Service, 1986).

The method of land capability assessment takes into account a range of factors including climate, soils, geology, geomorphology, soil erosion, topography, and the effects of past land uses. The classification does not necessarily reflect the existing land use, rather it indicates the potential of the land for uses such as crop production, pasture improvement and grazing.

The system allows for land to be allocated into eight possible classes (with land capability decreasing progressively from Class I to Class VIII). The classes are described in **Table 1** below.

A description of land capability classification for all land within the project area is discussed further in **Section 3.5**.

Table 1 – Rural Land Capability Classes

Rural Land Capability Classification System		
Land Class	**Land Suitability**	**Land Definition**
Class I	Regular Cultivation	No erosion control requirements
Class II	Regular Cultivation	Simple requirements such as crop rotation and minor strategic works
Class III	Regular Cultivation	Intensive soil conservation measures required such contour banks and waterways
Class IV	Grazing, occasional cultivation	Simple practices such as stock control and fertiliser application
Class V	Grazing, occasional cultivation	Intensive soil conservation measures required such contour ripping and banks
Class VI	Grazing only	Managed to ensure ground cover is maintained
Class VII	Unsuitable for rural production	Green timber maintained to control erosion
Class VIII	Unsuitable for rural production	Should not be cleared, logged or grazed
U	Urban areas	Unsuitable for rural production
SF	State Forests	Unsuitable for rural production
M	Mining & quarrying areas	Unsuitable for rural production
Source: Soil Conservation Service of NSW (1986).		

2.7 Agricultural Suitability Assessment

The agricultural suitability assessment of the survey area was conducted in accordance with DII's agricultural suitability classification system. The system consists of five classes, providing a ranking of lands according to their productivity for a wide range of agricultural activities with the objective of determining the potential for crop growth within certain limits.

The classification is based upon the effects of climate, topography and soil characteristics, the cultural and physical requirements for various crops and pastures, and existing socio-economic factors including local infrastructure and geographic location. These factors combine to determine the productive potential of the land and its capacity to produce crops, pastures and support livestock. The classes are described in **Table 2** below.

Table 2 – Agricultural Suitability Classes

Agricultural Suitability Classification System		
Land Class	**Agricultural Suitability**	**Land Definition**
Class 1	Highly productive land suited to both row and field crops	Arable land suitable for intensive cultivation where constraints to sustained high levels of agricultural production are minor or absent.
Class 2	Highly productive land suited to both row and field crops	Arable land suitable for regular cultivation for crops but not suited to continuous cultivation. It has a moderate to high suitability for agriculture but edaphic (soil factors) or environmental constraints reduce the overall level of production and may limit the cropping phase to a rotation with sown pastures.
Class 3	Moderately productive lands suited to improved pasture and to cropping within a pasture rotation	Grazing land or land well suited to pasture improvement. It may be cultivated or cropped in rotation with pasture. The overall level of production is moderate as a result of edaphic or environmental constraints. Erosion hazard or soil structural breakdown limit the frequency of ground disturbance, and conservation or drainage works may be required.
Class 4	Marginal lands not suitable for cultivation and with a low to very low productivity for grazing	Land suitable for grazing but not for cultivation. Agriculture is based on native or improved pastures established using minimum tillage. Production may be high seasonally but the overall level of production is low as a result of a number of major constraints, both environmental and edaphic.
Class 5	Marginal lands not suitable for cultivation and with a low to very low productivity for grazing	Land unsuitable for agriculture or at best suited only to light grazing. Agricultural production is very low or zero as a result of severe constraints, including economic factors, which preclude improvement.
Source: NSW Land & Water Conservation (1988)		

3.0 RESULTS

3.1 Desktop Review

3.1.1 Soil Landscape units

Three landscape units underpin the proposed extension area. These are the Hunter, Dartbrook and Liddell units as delineated by the Soil Landscapes of the Singleton 1:250,000 Sheet (Kovac & Lawrie, 1991). **Table 3** describes these landscape units.

Table 3 – Landscape Units

Landscape Unit	Geology	Typical Landform	Typical Soils*
Hunter (hu)	*Quaternary alluvium* *Parent material:* Alluvial	Level plains and river terraces of the Hunter River with elevations of 20-60m. Slopes are 0-3%. The width of the plains ranges from 200m-3200m. Local relief is generally less than 10m.	The main soil types for this landscape unit are all formed in alluvium. They include Brown Clays and Black Earths on prior stream channels and tributary flats. Alluvial Soils (loams and sands) occur on levees and flats adjacent to the present river channel. Red Podzolic Soils are located on old terraces, with Non-calcic Brown Soils and yellow Solodics Soils in some drainage lines.
Dartbrook (db)	*Singleton Coal Measures and Quaternary alluvium* *Parent rock:* Calcareous shale and sandstone, some alluvium sediments.	Undulating rises and low hills. Slopes are gentle (0-10%) and long and smooth (100 – 2500m); local relief of 30-80m.	Typically Brown Clays and some Black Earths occur on upper to midslopes and Prairie Soils on the Alluvial flats. In other areas Red – brown Earths occur on the upper slopes, Chocolate Soil-Red-brown Earth intergrades on midslopes and Chocolate soils on the lower slopes.
Liddell (ld)	*Singleton Coal Measures* *Parent rock:* Lithic sandstone, shale, mudstone, conglomerate, siltstone, and coal seams.	Undulating low hills ranging in elevation from 140-220m; sloped 4-7% with local relief of 60-120m.	Typically yellow Soloths occur on slopes with some yellow Solodic Soils on conclave slopes. Earthy and Siliceous Sands are present on mid to lower slopes where the parent material is more sandy.
* Soils defined using the Great Soil Groups (Stace et al., 1968)			

Source: Kovac & Lawrie (1991)

3.2 Soil Results

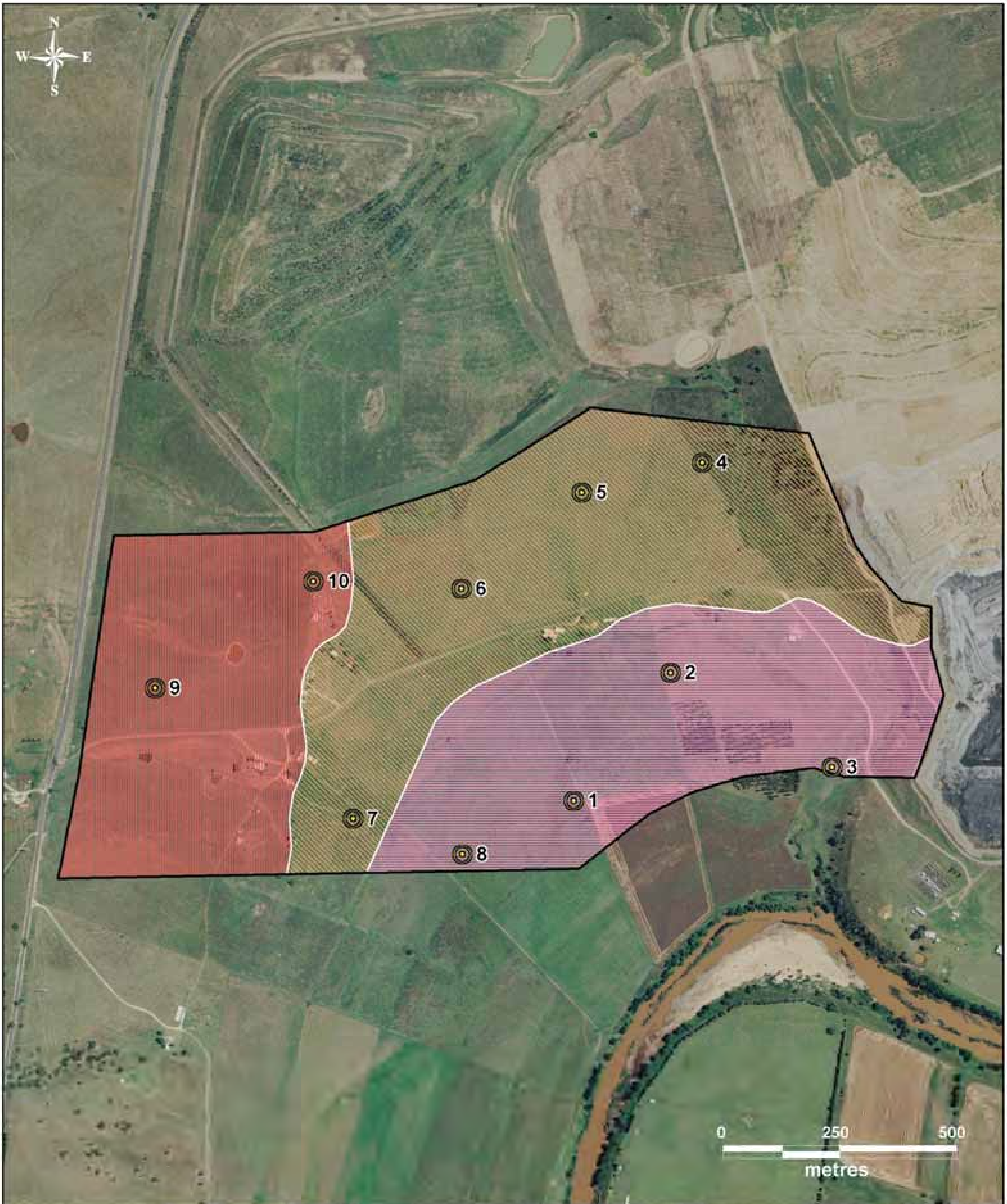
3.2.1 Proposed Extension Area Soil units

A site inspection was undertaken in September 2009 to classify the soil profile types associated with the proposed extension area. The objective of the field assessment was to observe soil profiles (to a maximum depth of 1.2 m). No shallow aquifers (i.e. < 1.5 m depth) were identified. The following soil units were identified within the proposed extension area:

- Brown Uniform Silty Clay Loam (43.9 ha);
- Brown Uniform Silty Clay (56.8 ha); and

- Red Brown Duplex Loam (36.1 ha).

The distribution of these soils is illustrated in **Figure 3**. Exposed profiles of major soil units are shown in **Plates 1, 3** & **5.** Landscape photos of areas where each soil unit was observed are shown in **Plates 2, 4** & **6**. A glossary of commonly used soils terms is presented in **Appendix 4**.



LEGEND

- Proposed Pit Extension Footprint
- Soil Test Pit Locations
- Red/Brown Loam Duplex (38.1ha)
- Brown Uniform Silty Clay (56.8ha)
- Brown Uniform Silty Clay Loam (43.9ha)

Version:	Date:	Author:	Checked:	Approved:
1	05/11/09	AR	KM	CR
2	02/02/10	AR	KM	CR

FIGURE 3

Soil Landscape Units

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

Project: Carrington West Wing Modification

Client: EMGA Mitchell McLennan Pty Ltd

File: Fg3_EMG00-002_Soil Units_v2

Projection: MGA94 Zone 56

Brown Uniform Silty Clay Loam

<u>*Description:*</u> The Brown Uniform Silty Clay Loam soil unit generally consists of yellowish brown and brown silty clay loams throughout the profile. These moderately structured soils range from slightly alkaline to moderately alkaline at depth. The soils are generally non-saline and have moderate fertility. The topsoil and subsoil are non-sodic.

<u>*Location:*</u> These soils cover 32% or 43.9 ha of the proposed extension area and are present on the lower slopes near its southern boundary. Profile sites 1, 2, 3 and 8 occur within this unit.

<u>*Landuse:*</u> The land overlying these soils is dominated by open grazing farmland. Farm tracks and sparse low lying shrubs transect the area.

<u>*Management:*</u> The top 1.20 m of this soil is suitable for stripping and reuse as a topdressing medium in rehabilitation. Soil at further depths may be suitable; however restrictions on pit depth prevented further investigation. This soil requires only the standard erosion and sediment control measures if disturbed.

Table 4 – Brown Uniform Silty Clay Loam Profile

LAYER	DEPTH (m)	DESCRIPTION
1	0.00 to 0.20	Brown (10YR 4/3), moderate consistence silty clay loam. A weak to moderate pedality (angular blocky 20-50 mm) soil with slight to moderate alkalinity (pH 7.6 to 8.1), very low to low dispersion (Emerson Aggregate Test (EAT) 5 & 3(1)), non-saline (0.05 – 0.09 dS/m), roots common to many and nil stones. Approximate sample depth 0.20 m. Clear even boundary to Layer 2.
2	0.20 to 0.45	Brown (10YR 4/3) moderate consistence silty clay loam. Moderate pedality (angular blocky 10-20 mm) soil with moderate to strong alkalinity (pH 8.2 – 9.1), very low to low dispersion (EAT 5 & 3(2)), non-saline (0.08 – 0.15dS/m), roots few to common and nil stones. Approximate sample depth 0.40 m. Clear and even boundary to Layer 3.
3	0.45 – 1.20 +	Brown (10YR 4/3), moderate consistence silty clay loam. Moderate pedality (angular blocky 10 mm) soil with moderate alkalinity (pH 8.1 – 8.7), very low to low dispersion (EAT 5 & 3(2)), non-saline 0.06 to 0.10 dS/m), no roots or stones. Approximate sample depth 1.00 m.

Plate 1 – Brown Uniform Silty Clay Loam Profile

Plate 2 – Brown Uniform Silty Clay Loam Landscape

Brown Uniform Silty Clay

Description: The Brown Uniform Silty Clay soil unit generally consists of brown to dark greyish brown silty clays to medium clays throughout the profile. These moderately drained soils range from neutral to moderately alkaline at depth. The soils are generally non-saline with moderate fertility. The topsoil and subsoil are non-sodic to moderately sodic.

Location: These soils cover 41.52% or 56.8 ha of the proposed extension area and are found on the mid to lower slopes and flat areas located near the northern portion of the proposed extension area. Profile sites 4, 5, 6 and 7 occur within this soil unit.

Landuse: The land overlying these soils is dominated by open grazing farmland. Farm tracks and sparse low lying shrubs transect the area.

Management: The top 0.20 m of soil is suitable for stripping and reuse as a topdressing medium in rehabilitation. The subsoil is generally not suitable for stripping and re-use during rehabilitation operations due to very high clay content, massive structure and moderate salinity. Whilst this subsoil is unsuitable for use as a topdressing material, consideration may be given to selectively stripping and conserving this material for use as an intermediate layer between reshaped overburden and the final topdressing layer.

Table 5 – Brown Uniform Silty Clay Profile

LAYER	DEPTH (m)	DESCRIPTION
1	0.00 to 0.20	Brown (10YR 4/3) to Dark Greyish Brown (10YR 4/2), moderate consistence silty clay. Moderate pedality (angular blocky 10-50mm) soil with neutral to slight alkalinity (pH 6.6 to 7.7), slight to nil dispersion (EAT 3(3) to 3(1)), non-saline (0.05-0.06 dS/m), roots many (upper level to common at depth) and <2% stones (5-20 mm). Approximate sample depth 0.10 m. Clear even boundary to Layer 2.
2	0.20 to 0.90	Dark Greyish Brown (10YR 4/2) moderate to strong consistence silty clay. Weak to moderate pedality (angular blocky 20-50 mm) soil with slight to moderate alkalinity (pH 8.0 to 8.8), very low to low dispersion (EAT 5 to 3(1)), non saline to moderately saline (0.08 to 0.56 dS/m), roots few and stones nil. Approximate sample depth 0.70 m. Clear and even boundary to Layer 3.
3	0.90 – 1.20 +	Brown (10YR 4/3) to Dark Greyish Brown (10YR 4/2) strong consistence medium clay. An apedal massive soil that is moderately alkaline (pH 8.5 to 8.8), low to moderate dispersion (EAT 5 to 2(2)), moderately saline (0.22 to 0.88 dS/m), roots and stones nil. Approximate sample depth 1.10 m.

Plate 3 – Brown Uniform Silty Clay Profile

Plate 4 – Brown Uniform Silty Clay Landscape

Red Brown Duplex Loam

Description: The Red Brown Duplex Loam soil unit generally consists of reddish brown to brown loams and silty clay loams which overlie a texture contrast to brown to reddish brown clay subsoil. These moderately drained soils range from moderately acidic to neutral in the upper layers, to moderately and strongly alkaline at depth. The soils are non-saline in the upper layers, ranging to saline at depth. The topsoil and subsoils are non-sodic.

Location: The soils cover 26.38% or 36.1 ha of the proposed extension area and are found on the mid to lower slopes in the north western portion of the proposed extension area. Profile sites 9 and 10 occur within this soil unit.

Landuse: The land overlying these soils is dominated by open grazing farmland. Farm tracks and sparse low lying shrubs transect the area.

Management: The top 0.10 m of soil is suitable for stripping and reuse as a topdressing medium in rehabilitation. The lower layers are generally unsuitable due to the limiting factors of massive structure, moderate potential for dispersion and high alkalinity. Whilst this subsoil is unsuitable for use as a topdressing material, consideration may be given to selectively stripping and conserving this material for use as an intermediate layer between reshaped overburden and the final topdressing layer.

Table 6 – Red Brown Duplex Loam Profile

LAYER	DEPTH (m)	DESCRIPTION
1	0.00 to 0.10	Brown (7.5YR 5/3) weak consistence silty clay loam. A moderate pedality (10-50 mm angular blocky peds) soil that is neutral to moderate acidity (pH 6.8 to 5.8), very low to low dispersion (EAT 5 & 3(1)), non-saline (0.07 to 0.11 dS/m), roots common and 2% to 10% stones (<10 mm). Approximate sample depth 0.05 m. Sharp and even boundary to Layer 2.
2	0.10 to 0.80	Brown (7.5YR 5/3) moderate consistence clay. A weakly structured (20-40mm angular blocky peds) soil that is neutral to moderately alkaline (pH 7.5 to 8.8), moderately dispersive (EAT 2(2)), non-saline (0.08 dS/m), roots few to none and <10% stones (<10 mm). Approximate sample depth 0.70 m. Clear and even boundary to Layer 3.
3	0.80 to 1.20m +	Strong Brown (7.5YR 5/6) strong consistence clay. An apedal massive soil that is strongly alkaline (pH 9.4), low dispersion (EAT 3(1), saline (1.60 dS/m), roots none and stones <10%. Approximate sample depth 1.00 m.

Plate 5 – Red Brown Duplex Loam Profile

Plate 6 – Red Brown Duplex Loam Landscape

3.3 Topdressing Suitability and Availability

Laboratory soil analytical results (refer **Appendix 3**) were used in conjunction with the field assessment (refer **Appendix 1**) to determine the depth of soil material suitable for recovery and re-use as a topdressing material in rehabilitation. Structural and textural properties of subsoils, stoniness, dispersion potential, sodicity and acidity/alkalinity are the most common and significant limiting factors in determining depth of soil suitability for re-use. The recommended stripping depth for each soil unit, together with area of land and calculated volume are provided in **Table 7** below and recommended stripping depths are illustrated in **Figure 3**.

Table 7 – Recommended Stripping Depths

Soil Unit Type	Recommended Stripping Depth (m)	Area (ha)	Volume (m^3)
Brown Uniform Silty Clay Loam	1.00	43.9	439,000
Brown Uniform Silty Clay	0.20	56.8	113,600
Red Brown Duplex Loam	0.10	36.1	36,100
		Total Volume	**588,700**
		Total Volume (10% handling loss allowance)	**529,830**

Allowing for a 10% handling loss, approximately 529,830 m^3 of suitable topdressing is available within the proposed extension area. The majority of topsoil disturbance will result from the excavation of the open cut pit. The Brown Uniform Silty Clay Loams which are located primarily in the south eastern part of the proposed extension area will generate the largest topsoil resource. This is followed by the Brown Uniform Silty Clay which is evident in the central and northern parts of the proposed extension area.

3.4 Erosion Potential

All soil samples were laboratory tested for dispersion, using the EAT and sodicity, using the Exchangeable Sodium Percentage (ESP). These tests indicate the susceptibility of a soil to losing its structure and binding capacity when wet, and therefore the erosion potential of the soil. The results showed a similar pattern indicating that soils across the proposed extension area are generally non-sodic means they are less prone to erosion and surface crusting. However, within the Brown Uniform Silty Clay (test pit 4), upper and lower layers displayed a moderate to high potential for dispersion (Emerson Class 2 and ESP of 16%). In addition, the Red Brown Duplex Clay (test pit 10) also displayed a high potential for dispersion in middle layers of the subsoil (Emerson Class of 2 and ESP of 15-26%).

The appropriate erosion and sediment control measures will be in place prior to surface disturbance of these soils, as the risk of erosion is high once the subsoil is exposed. Appropriate measures are outlined in **Section 4.1** of this report.

3.5 Potential Acid Generating Material

The potential for acid generation from regolith material (topsoil and subsoil) within the proposed extension area is low. This does not include acid potential within the overburden material (consolidated bedrock below 2 – 3 m depth), which was not assessed during this survey, nor does it include the current level of acidity within the soil (i.e. pH results).

Acid Sulphate Soils (ASS), which are the main cause of acid generation within the soil mantle, are commonly found less than 5 m above sea level, particularly in low-lying coastal areas such as mangroves, salt marshes, floodplains, swamps, wetlands, estuaries, and brackish or tidal lakes. There has been little history of acid generation from regolith material in the Singleton - Muswellbrook area (which is located approximately 80 to 120 km from the coast).

The potential for acid generation from regolith material (topsoil and subsoil) within the proposed extension area is low.

3.6 Land Capability

The pre-mining and post-mining rural land capability classification of the proposed extension area, in accordance with DECCW mapping, is shown in **Figures 4** and **5.** A comparison of the pre and post-mining rural land capability classification is provided in **Table 8. No Class 1 Land capability or Agricultural Suitability Units occur within the footprint of the proposed extension.**

Table 8 – Comparison of Pre and Post-Mining Rural Land Capability Classes - Proposed Extension Area

Land Class	Pre-mining		Post-mining	
	ha	%	ha	%
Class II	65.0	47.51	65.0	47.51
Class III	44.0	32.16	64.6	47.22
Class IV	23.9	17.47	7.2	5.26
Class V	3.9	2.85	0	0
Total	**136.8**		**136.8**	

3.6.1 Pre-mining

Figure 4 illustrates the existing rural land capability classification and **Table 8** quantifies the area of each class. The proposed extension area encompasses classes II, III, IV and V lands.

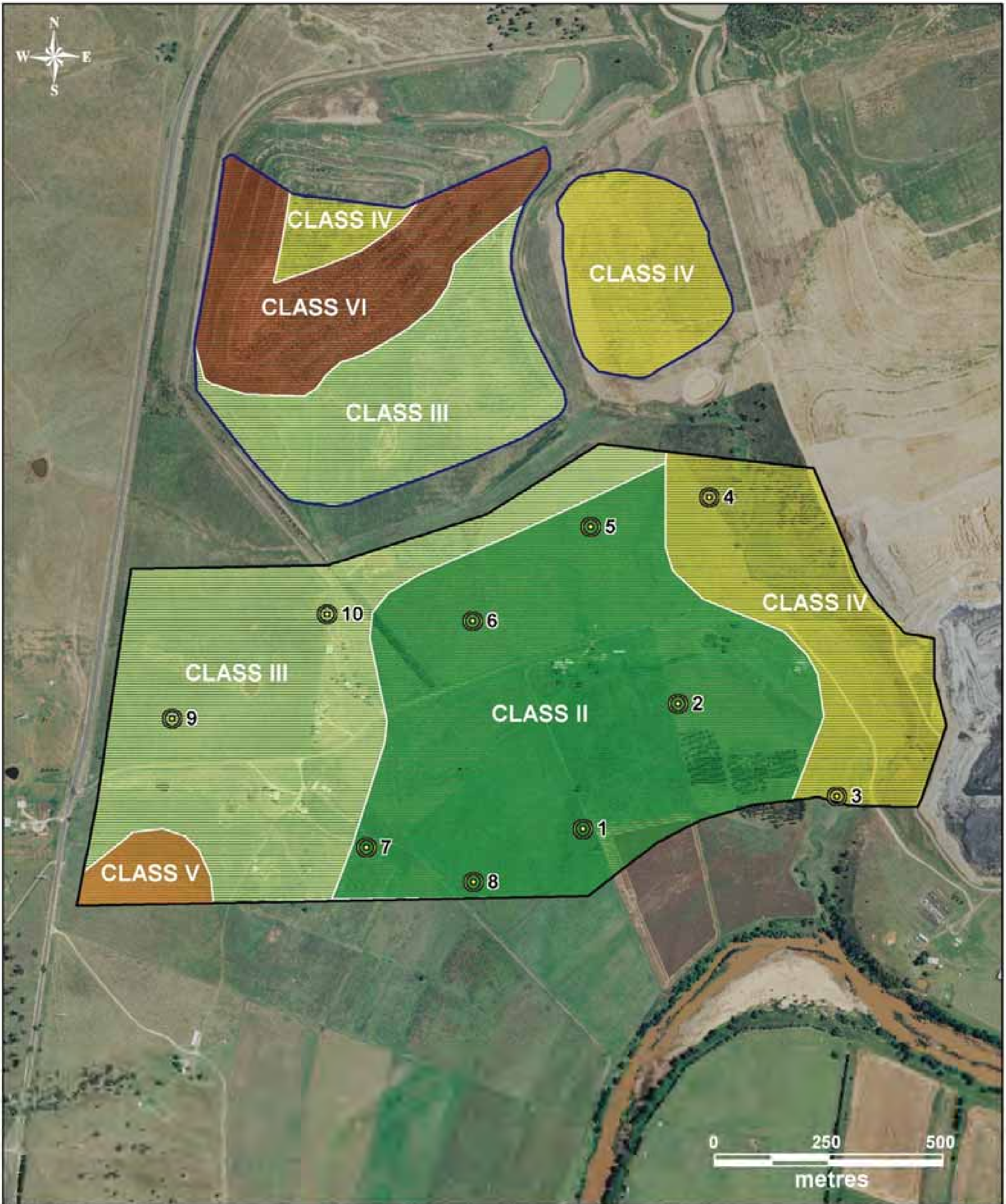
The central portion of the proposed extension area contains 65 ha of Class II land. The western portion of the proposed extension area is classified as Class III (44.0 ha). Both are suitable for a wide variety of agricultural uses and are suitable for regular cultivation.

The eastern portion of the proposed extension area is classified as Class IV (23.9 ha) land. Class IV land comprises the better classes of grazing land and whilst it can sustain cultivation for an occasional crop, it is not suitable for cultivation on a regular basis owing to limitations of erosion potential. In addition, there is a small portion of Class V (3.9 ha) land in the south west corner of the proposed extension area which is unsuitable for cultivation on a regular basis, however, the land can sustain grazing and occasional cultivation, provided structural soil conservation works are in place.

3.6.2 Post-mining

Figure 5 illustrates the proposed post-mining land capability classification and **Table 8** quantifies the area of each class. The post-mining extension area is dominated by Class II and Class III land, comprising 65 ha and 64.6 ha respectively with Class IV land comprising of 7.2 ha.

The proposed land capability classification is similar to the existing land capability classification after mining. It should be noted that Class II land will remain Class II post-mining.



LEGEND
West Wing Extension Study Area
Out-of-pit Overburden Emplacement
Soil Test Pit Locations
Land Capability Classes
Class II (65.0ha)
Class III (66.2ha)
Class IV (40.3ha)
Class V (3.9ha)
Class VI (19.6ha)

Version:	Date:	Author:	Checked:	Approved:
1	03/12/09	AR	KM	CR
2	08/02/10	AR	KM	CR
3	13/04/10	AR	KM	CR

FIGURE 4

Land Capability Classes

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

Project: Carrington West Wing Modification

Client: EMGA Mitchell McLennan Pty Ltd

File: Fg4_EMG00-002_Land Capability_v3

Projection: MGA94 Zone 56

LEGEND
West Wing Extension Study Area
Out-of-pit Overburden Emplacement
Soil Test Pit Locations
Land Capability Classes
Class II (65.0ha)
Class III (64.6ha)
Class IV (30.6ha)
Class VI (37.1ha)

Version	Date	Author	Checked	Approved
1	03/12/09	AR	KM	CR
2	08/02/10	AR	KM	CR
3	13/04/10	AR	KM	CR

FIGURE 5

Post Mining
Land Capability Classes

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

Project: Carrington West Wing Modification

Client: EMGA Mitchell McLennan Pty Ltd

File: Fg5_EMG00-002_Post Land Capability_v3

Projection: MGA94 Zone 56

There is a substantial increase in Class III land post-mining. A significant portion of Class IV land to the eastern boundary of the proposed extension area will be will be transformed into Class III land post-mining and whilst very productive, the re-contoured land will require the introduction of structural soils conservation works to maintain long term stability and productivity.

In addition, there is also an improvement in post-mining land capability classification for Class V lands. Class V lands located in the south western corner of the proposed extension area will be transformed into Class IV land post-mining. Class IV land comprises the better classes of grazing land and whilst it can sustain cultivation for an occasional crop, it is not suitable for cultivation on a regular basis owing to limitations of erosion potential.

3.6.3 Pre-mining Out of Pit Overburden Emplacement Area

Figure 4 illustrates the existing rural land capability classification of the two out-of-pit overburden emplacements that are proposed on rehabilitated land immediately north of the proposed extension area. The emplacement area encompasses classes III, IV and VI lands. **Table 9** quantifies the area of each class.

Class III land (22.2 ha) is located on the lower to flat slopes of the emplacement area and is suitable for a wide variety of agricultural uses and for regular cultivation.

The eastern and central northern portions of the emplacement areas are classified as Class IV land (16.40 ha). This land comprises the better classes of grazing land and whilst it can sustain cultivation for an occasional crop, it is not suitable for cultivation on a regular basis owing to limitations of slope and erosion potential.

Class VI land (19.6 ha) is suited to grazing only provided structural soil conservation works are in place and managed to ensure ground cover is maintained. Class VI land is located on the slopes of the existing rehabilitated land.

3.6.4 Post-mining Out of Pit Overburden Emplacement Area

Figure 5 illustrates the proposed post-mining land capability classification and **Table 9** quantifies the area of each class. The post-mining out-of-pit overburden emplacement areas are dominated by Class IV land, comprising 23.1 ha and Class VI land comprising of 35.1 ha.

The proposed land capability classification differs to the existing land capability classification after mining. The majority of the out of pit overburden emplacement area is Class III land prior to mining. This land will be transformed into Class IV and VI land post mining. The land will require the introduction of stock control, fertiliser application and managed to ensure ground cover is maintained.

Table 9 – Comparison of Pre and Post-Mining Rural Land Capability Classes – Out-of-Pit Overburden Emplacement Area

Land Class	Pre-mining		Post-mining	
	Ha	**%**	**ha**	**%**
Class III	22.2	38.14	0	-
Class IV	16.40	28.17	23.1	39.69
Class VI	19.6	33.67	35.1	60.31
Total	**58.2**		**58.2**	

3.7 Agricultural Suitability

The pre-mining and post-mining agricultural land suitability classification of the proposed extension area was carried out in accordance with Department of Industry and Investment (DII) (formerly DPI & NSW Agriculture and Fisheries) agriculture suitability classification system. The system consists of five (5) classes, providing a ranking of lands according to their productivity for a wide range of agricultural activities with the objective of determining the potential for crop growth within certain limits. A comparison of the pre and post-mining agricultural land suitability classification is provided in **Table 10**.

Table 10 – Comparison of Pre and Post-mining Agricultural Land Suitability Classes – Proposed Extension Area

Land Class	Pre-mining		Post-mining	
	ha	**%**	**ha**	**%**
Class 2	65.0	47.51	65	47.51
Class 3	67.9	49.63	64.6	47.22
Class 4	3.9	2.85	7.2	5.26
Total	**136.8**		**136.8**	

3.7.1 Pre-mining

The agricultural suitability classification of the proposed extension area is shown in **Figure 6**. The majority of the proposed extension area is classified as Class 2 or 3 agricultural suitability, covering areas of 65 ha and 67.9 ha respectively. Class 2 land includes highly productive land suited to both row and field crops, however, it is not suited to continuous cultivation. It is associated with Brown Uniform Silty Clays and Loams of the lower flat slopes in the central southern portion of the proposed extension area. Class 3 land includes moderately productive lands suited to improved pasture and to cropping within a pasture rotation. Class 3 lands are predominantly located in the eastern and western portions of the proposed extension area on mid to lower slopes. Class 4 land covers 3.9 ha of the proposed extension area and includes marginal lands not suitable for cultivation and with a low to very low productivity for grazing. These lands are located generally in the south eastern portion of the proposed extension area on mid to upper slopes.

3.7.2 Post-mining

Figure 7 illustrates the post-mining agricultural suitability classification and **Table 10** quantifies the area of each class. The post-mining extension area encompasses land capability classes 2, 3 and 4.

The post-mining agricultural suitability classification includes some 65 ha of Class 2 land, 64.6 ha of Class 3 land and 7.2 ha of Class 4 land. The proposed agricultural suitability classification is similar to the existing agricultural suitability classification after mining. There will be a relatively minor change between existing agricultural suitability and proposed suitability classification after mining. Class 3 land is reduced by approximately 3 ha. Class 3 lands whilst moderately productive, should be dominated by improved pastures for grazing and some rotational cropping. As such, there is a minor increase in Class 4 land which includes marginal lands not suitable for cultivation with a low to very low productivity for grazing.

3.7.3 Pre-mining Out of Pit Overburden Emplacement Area

The agricultural suitability classification of the out of pit overburden emplacement areas is shown in **Figure 6.** The majority of the emplacement areas are dominated by Class 3 and 4 agricultural suitability covering areas 38.6 ha and 19.6 ha respectively, as shown in **Table 11**. Class 3 land includes moderately productive lands suited to improved pasture and to cropping within a pasture rotation. Class 3 lands are predominantly located in the southern and western portions of the emplacement areas on flat to low sloping areas.

Class 4 lands covers 19.6 ha of the emplacement areas and includes marginal lands not suitable for cultivation and with a low to very low productivity for grazing. These lands are located generally in the northern portion of the emplacement area on mid to upper slopes.

3.7.4 Post-mining Out of Pit Overburden Emplacement Area

Figure 7 illustrates the post-mining agricultural suitability classification and **Table 11** quantifies the area of each class. The post-mining out of pit overburden emplacement area encompasses land capability classes 3 and 4. The post-mining agricultural suitability classification includes some 23.1 ha of Class 3 land and 35.1 ha of Class 4 land. The proposed agricultural suitability classification differs to the existing agricultural suitability classification after mining.

There will be a relatively significant change between existing agricultural suitability and proposed suitability classification after mining. The majority of the land will be transformed into Class 4 land and whilst still marginally productive, the land is unsuitable for cultivation however suitable for low productivity grazing.

Table 11 – Comparison of Pre and Post-mining Agricultural Land Suitability Classes - Out-of-Pit Overburden Emplacement Area

Land Class	Pre-mining		Post-mining	
	ha	**%**	**ha**	**%**
Class 2	0		0	0
Class 3	38.6	66.32	23.1	39.69
Class 4	19.6	33.68	35.1	60.31
Total	**58.2**		**58.2**	

LEGEND
- West Wing Extension Study Area
- Out-of-pit Overburden Emplacement
- Soil Test Pit Locations

Agricultural Suitability Classes
- Class 2 (65.0ha)
- Class 3 (106.5ha)
- Class 4 (23.5ha)

Version	Date	Author	Checked	Approved
1	05/11/09	AR	KM	CR
2	02/02/10	AR	KM	CR
3	12/04/10	AR	KM	CR

FIGURE 6

Agricultural Suitability Classes

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

Project	Carrington West Wing Modification
Client	EMGA Mitchell McLennan Pty Ltd
File	Fg6_EMG00-002_Ag Suitability_v3
Projection	MGA94 Zone 56

LEGEND
West Wing Extension Study Area
Out-of-pit Overburden Emplacement
Soil Test Pit Locations
Agricultural Suitability Classes
Class 2 (85.0ha)
Class 3 (87.7ha)
Class 4 (42.3ha)

Version	Date	Author	Checked	Approved
1	05/11/09	AR	KM	CR
2	02/02/10	AR	KM	CR
3	12/04/10	AR	KM	CR

FIGURE 7

Post Mining Agricultural Suitability Classes

GSS ENVIRONMENTAL
Environmental, Land and Project Management Consultants

Project: Carrington West Wing Modification

Client: EMGA Mitchell McLennan Pty Ltd

File: Fg7_EMG00-002_Post Ag Suitability_v3

Projection: MGA94 Zone 56

4.0 DISTURBANCE MANAGEMENT

Prior to any disturbance during project initiation, a detailed Topsoil Management Plan (TMP) will be prepared. To minimise potential impacts on soil and land resources, the following management and mitigation strategies will be implemented.

4.1 Topsoil Stripping and Handling

Where topsoil stripping and transportation is required, the following topsoil handling techniques will be implemented to prevent excessive soil deterioration.

- Topsoil will be stripped to the approximate depths stated in **Section 3.2**, subject to further investigation as required.
- Topsoil will be maintained in a slightly moist condition during stripping. Material will not be stripped in either an excessively dry or wet condition where practical.
- Stripped material will be placed directly onto reshaped overburden and spread immediately (if mining sequences, equipment scheduling and weather conditions permit) to avoid the requirement for stockpiling.
- Examples of preferential, less aggressive soil handling systems include grading or pushing soil into windrows with graders or dozers for later collection by open bowl scrapers, or for loading into rear dump trucks by front-end loaders. This minimises compression effects of the heavy equipment that is often necessary for economical transport of soil material.
- Soil that is transported by dump trucks may be placed directly into storage. Soil transported by scrapers is best pushed to form stockpiles by other equipment (e.g. dozer) to avoid tracking over previously laid soil.
- The surface of soil stockpiles will be left in an as coarsely textured condition as possible in order to promote infiltration and minimise erosion until vegetation is established, and to prevent anaerobic zones forming.
- As a general rule, where practical stockpile heights will be maintain to a maximum of 3 m. Clayey soils should be stored in lower stockpiles for shorter periods of time compared to sandier soils.
- If long-term stockpiling is planned (i.e. greater than 12 months), seed and fertilise stockpiles as soon as possible. A rapid growing and healthy annual pasture sward provides sufficient competition to minimise the emergence of undesirable weed species. The annual pasture species will not persist in the rehabilitation areas but will provide sufficient competition for emerging weed species and enhance the desirable micro-organism activity in the soil.
- Prior to re-spreading stockpiled topsoil onto reshaped overburden (particularly onto designated tree seeding areas), an assessment of weed infestation on stockpiles will be undertaken to determine if individual stockpiles require herbicide application and / or “scalping” of weed species prior to topsoil spreading.
- An inventory of available soil will be maintained to ensure adequate topsoil materials are available for planned rehabilitation activities.
- Topsoil will be spread to a nominal depth of less than 10 cm.
- For Class II lands selective stripping and stockpiling of soil horizons or groups of similar horizons will be undertaken.

4.2 Topsoil Re-spreading

Where possible, suitable topsoil will be re-spread directly onto reshaped areas. Where topsoil resources allow, topsoil will be spread to a nominal depth of 10 cm on all re-graded spoil. Topsoil will be spread, treated with fertiliser or ameliorants (if required – refer **Section 3.3**) and seeded in one consecutive operation, to reduce the potential for topsoil loss to wind and water erosion.

For Class II land reinstatement the following management and mitigation strategies will be implemented:

- Re-instating the soil profile in the reverse order of stripping;
- Implement a post reinstatement soil conditioning programme (selective tillage, organic amendments, etc.); and
- Introduce and maintain a post reinstatement soil and crop performance monitoring programme for up to 5 years.

4.3 Landform Design, Erosion Control and Seeding

Rehabilitation strategies and concepts proposed below have been formulated according to results of industry-wide research and experience.

4.3.1 Post-Disturbance Re-grading

The main objective of regrading is to produce slope angles, lengths and shapes that are compatible with the proposed land use and not prone to an unacceptable rate of erosion. Integrated with this is a drainage pattern that is capable of conveying runoff from the newly created catchments whilst minimising the risk of erosion and sedimentation.

4.3.2 Erosion and Sediment Control

The most effective means of controlling surface flow on disturbed areas is to construct contour furrows or contour banks at intervals down the slope. The effect of these is to divide a long slope into a series of short slopes with the catchment area commencing at each bank or furrow. This prevents runoff from reaching a depth of flow or velocity that will cause erosion. As the slope angle increases, the banks or furrows must be spaced closer together until a point is reached where they are no longer effective.

Contour ripping across the grade is by far the most common form of structural erosion control on mine sites as it simultaneously provides some measure of erosion protection and cultivates the surface in readiness for sowing.

Graded banks are essentially a much larger version of contour furrows, with a proportionately greater capacity to store runoff and/or drain it to some chosen discharge point. The banks are constructed away from the true contour, at a designed gradient (0.5% to 1%) so that they drain water from one part of a slope to another; for example, towards a watercourse or a sediment control dam.

Eventually, runoff that has been intercepted and diverted must be disposed of down slope. The use of engineered waterways using erosion blankets, ground-cover vegetation and/or rip rap is recommended to safely dispose of runoff down slope.

The construction of sediment control dams is recommended for the purpose of capturing sediment laden runoff prior to off-site release. Sediment control dams are responsible for improving water quality throughout the mine site and, through the provision of semi-permanent water storages, enhance the ecological diversity of the area.

The following points are considered when selecting sites for sediment control dams where possible.

- Each dam is located so that runoff may be easily directed to it, without the need for extensive channel excavation or for excessive channel gradient. Channels must be able to discharge into the dam without risk of erosion. Similarly, spillways must be designed and located so as to safely convey the maximum anticipated discharge.
- The material from which the dam is constructed must be stable. Dispersible clays should be treated treatment with, gypsum and/or bentonite to prevent failure of the wall by tunnel erosion. Failure by tunnelling is may occur in dams which store a considerable depth of water above ground level, or whose water level fluctuates widely. Dams should always be well sealed, as leakage may lead to instability, as well as allowing less control over the storage and release of water.
- The number and capacity of dams should be related to the total area of catchment and the anticipated volume of runoff for appropriate intensity and duration rainfall events. The most damaging rains, in terms of erosion and sediment problems are localised, high intensity storms.

4.3.3 Seedbed Preparation

Thorough seedbed preparation should be undertaken to ensure optimum establishment and growth of vegetation. All topsoiled areas should be lightly contour ripped (after topsoil spreading) to create a “key” between the soil and the spoil. Ripping will be undertaken on the contour and the tynes lifted for approximately 2 m every 200 m to reduce the potential for channelised erosion. Best results are typically obtained by ripping when soil is moist and when undertaken immediately prior to sowing. The respread topsoil surface will be scarified prior to, or during seeding, to reduce run-off and increase infiltration. This can be undertaken by contour tilling with a fine-tyned plough or disc harrow.

5.0 CONCLUSION

The soil survey and land resource assessment conducted by GSSE for the proposed disturbance area associated with the proposal found the area to be dominated by brown uniform silty clay loams on the lower slopes, brown uniform silty clays on mid to lower slopes and red brown duplex loams on mid to lower slopes in the north west of the proposed extension area.

The current land use for most of the proposed extension area was identified as predominately cattle grazing, with a small area of cultivation associated with the better soils in the south near the Hunter River. Land capability for most of the proposed extension area was identified as Class II and III both suitable for a wide variety of agricultural uses; whilst small areas in the east and west were identified as being of lower value (Class IV – V). The proposed land classification is similar to the existing land capability classification after mining. The post-mining extension area will be dominated by Class II and Class III land, with a small portion of Class IV land. A significant portion of Class IV land within the proposed extension area will be will be transformed into Class III land post-mining. Class III and IV land whilst very productive, will require the introduction of structural soils conservation works to maintain long term stability and productivity.

The proposed land capability classification differs to the existing land capability classification after mining in the out of pit overburden emplacement areas. The majority of the out of pit overburden emplacement areas is Class III land prior to mining. This land will be transformed into Class IV and VI land post mining. The land will require the introduction of stock control, fertiliser application and managed to ensure ground cover is maintained.

In addition, the post-mining agricultural suitability classification of the proposed extension area includes some 65 ha of Class 2 land, 64.6 ha Class 3 land and 7.2 ha of Class 4 land. The proposed agricultural suitability classification is similar to the existing agricultural suitability classification after mining. There will be a relatively small change between existing agricultural suitability and proposed suitability classification after mining. Class 3 land is reduced by approximately 3 ha. This land whilst moderately productive, should be dominated by improved pastures for grazing and some rotational cropping.

There will also be a significant change between existing agricultural suitability and proposed suitability classification after mining in the out of pit overburden emplacement area. The majority of the land will be transformed into Class 4 land and whilst still marginally productive, the land is unsuitable for cultivation however suitable for low productivity grazing.

The majority of the soils within the proposed extension area (brown uniform silty clay loams and brown uniform silty clays) are suitable for stripping to a depth of 100 cm and 20 cm respectively for use as for rehabilitation topdressing purposes. Below a depth of 20 cm for the brown uniform silty clay, the subsoils have been identified as being of unsuitable structure and texture (high clay content) and moderate salinity. The red brown duplex loam is generally suitable for stripping to a depth of 10 cm; below this depth, the subsoils are generally unsuitable due to limiting factors of high clay content, moderate potential for dispersion and high alkalinity.

6.0 REFERENCES

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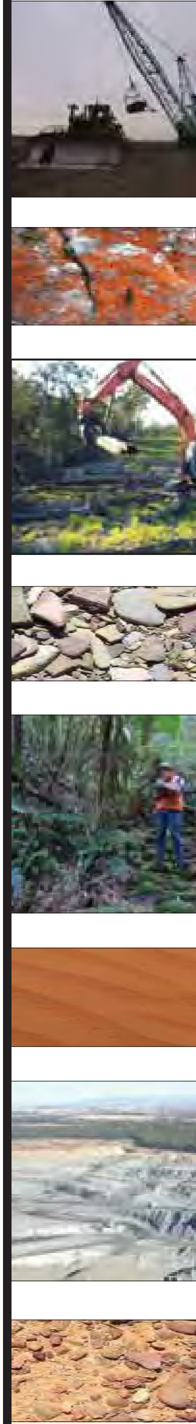


Field Assessment Procedure

APPENDIX 1

FIELD ASSESSMENT PROCEDURE

Elliott and Veness (1981) have described the basic procedure, adopted in this survey, for the recognition of suitable topdressing materials. In this procedure, the following soils factors are analysed. They are listed in decreasing order of importance.

Structure Grade

Good permeability to water and adequate aeration are essential for the germination and establishment of plants. The ability of water to enter soil generally varies with structure grade (Charman, 1978) and depends on the proportion of coarse peds in the soil surface.

Better structured soils have higher infiltration rates and better aeration characteristics. Structureless soils without pores are considered unsuitable as topdressing materials.

Consistence - Shearing Test

The shearing test is used as a measure of the ability of soils to maintain structure grade.

Brittle soils are not considered suitable for revegetation where structure grade is weak or moderate because peds are likely to be destroyed and structure is likely to become massive following mechanical work associated with the extraction, transportation and spreading of topdressing material.

Consequently, surface sealing and reduced infiltration of water may occur which will restrict the establishment of plants.

Consistence - Disruptive Test

The force to disrupt peds, when assessed on soil in a moderately moist state, is an indicator of solidity and the method of ped formation. Deflocculated soils are hard when dry and slake when wet, whereas flocculated soils produce crumbly peds in both the wet and dry state. The deflocculated soils are not suitable for revegetation and may be identified by a strong force required to break aggregates.

Mottling

The presence of mottling within the soil may indicate reducing conditions and poor soil aeration. These factors are common in soil with low permeabilities; however, some soils are mottled due to other reasons, including proximity to high water-tables or inheritance of mottles from previous conditions. Reducing soils and poorly aerated soils are unsuitable for revegetation purposes.

Macrostructure

Refers to the combination or arrangement of the larger aggregates or peds in the soil. Where these peds are larger than 10 cm (smaller dimension) in the subsoil, soils are likely to either slake or be hardsetting and prone to surface sealing. Such soils are undesirable as topdressing materials.

Texture

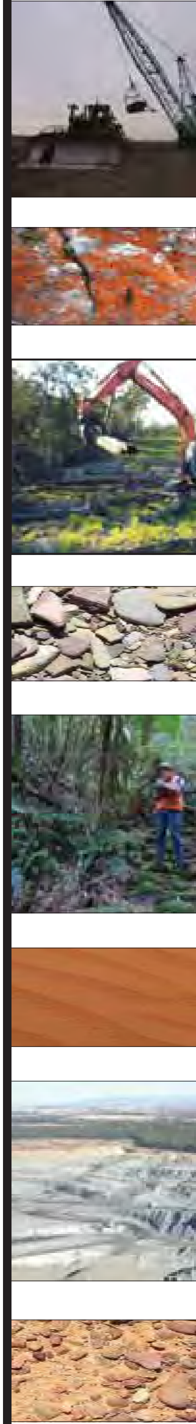
Sandy soils are poorly suited to plant growth because they are extremely erodible and have low water holding capacities. For these reasons soils with textures equal to or coarser than sandy loams are considered unsuitable as topdressing materials for climates of relatively unreliable rainfall, such as the Hunter Valley.

Root Density and Root Pattern

Root abundance and root branching is a reliable indicator of the capability for propagation and stockpiling.

Field Exposure Indicators

The extent of colonisation of vegetation on exposed materials as well as the surface behavior and condition after exposure is a reliable field indicator for suitability for topdressing purposes. These layers may alternate with other layers which are unsuitable. Unsuitable materials may be included in the topdressing mixture if they are less than 15cm thick and comprise less than 30 per cent of the total volume of soil material to be used for topdressing. Where unsuitable soil materials are more than 15 cm thick they should be selectively discarded.



Soil Information

APPENDIX 2

TEST SIGNIFICANCE AND TYPICAL VALUES

Particle Size Analysis

Particle size analysis measures the size of the soil particles in terms of grainsize fractions, and expresses the proportions of these fractions as a percentage of the sample. The grainsize fractions are:

clay	(<0.002 mm)
silt	(0.002 to 0.02 mm)
fine sand	(0.02 to 0.2 mm)
medium and coarse sand	(0.2 to 2 mm)

Particles greater than 2 mm, that is gravel and coarser material, are not included in the analysis.

Emerson Aggregate Test

Emerson aggregate test measures the susceptibility to dispersion of the soil in water. Dispersion describes the tendency for the clay fraction of a soil to go into colloidal suspension in water. The test indicates the credibility and structural stability of the soil and its susceptibility to surface sealing under irrigation and rainfall. Soils are divided into eight classes on the basis of the coherence of soil aggregates in water. The eight classes and their properties are:

Class 1 - very dispersible soils with a high tunnel erosion susceptibility.

Class 2 - moderately dispersible soils with some degree of tunnel erosion susceptibility.

Class 3 - slightly or non-dispersible soils which are generally stable and suitable for soil conservation earthworks.

Class 4-6 - more highly aggregated materials which are less likely to hold water. Special compactive efforts are required in the construction of earthworks.

Class 7-8 - highly aggregated materials exhibiting low dispersion characteristics.

The following subdivisions within Emerson classes may be applied:

(1) slight milkiness, immediately adjacent to the aggregate
(2) obvious milkiness, less than 50% of the aggregate affected
(3) obvious milkiness, more than 50% of the aggregate affected
(4) total dispersion, leaving only sand grains.

Salinity

Salinity is measured as electrical conductivity on a 1:5 soil:water suspension to give EC (1:5). The effects of salinity levels expressed as EC at 25° (*d*S/cm), on plants are:

0 to 1	very low salinity, effects on plants mostly negligible.
1 to 2	low salinity, only yields of very sensitive crops are restricted.
greater than 2	saline soils, yields of many crops restricted.

pH

The pH is a measure of acidity and alkalinity. For 1:5 soil:water suspensions, soils having pH values less than 4.5 are regarded as strongly acid, 4.5 to 5.0 moderately acidic, and values greater than 7.0 are regarded as alkaline. Most plants grow best in slightly acidic soils.

LABORATORY TEST METHODS

Particle Size Analysis

Determination by sieving and hydrometer of percentage, by weight, of particle size classes: Gravel >2mm, Coarse Sand 0.2-2 mm, Fine Sand 0.02-0.2 mm, Silt 0.002-0.2 mm and Clay <0.002 mm SCS Standard method. Reference - Bond, R, Craze B, Rayment G, and Higginson (in press 1990) **Australia Soil and Land Survey Laboratory Handbook**, Inkata Press, Melbourne.

Emerson Aggregate Test

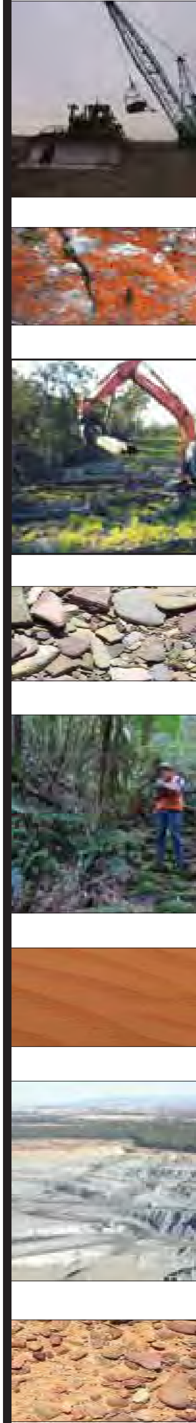
An eight class classification of soil aggregate coherence (slaking and dispersion) in water. SCS Standard Method closely related to Australian Standard AS1289. The degree of dispersion is included in brackets for class 2 and 3 aggregates. Reference - Bond R., Craze, B., Rayment, G., Higginson, F.R., (in press 1990). **Australian Soil and Land survey Laboratory Handbook**, Inkata Press, Melbourne.

EC

Electrical Conductivity determined on a 1:5 soil:water suspension. Prepared from the fine earth fraction of the sample. Reference - Bond R, Craze B, Rayment G, Higginson FR (in press 1990) **Australian Soil and Land Survey Handbook.** Inkata Press, Melbourne.

pH

Determined on a 1:5 soil:water suspension. Soil refers to the fine earth fraction of the sample. Reference - Bond, R., Craze, B., Rayment, G., Higginson, F.R. (in press 1990). **Australian Soil and Land Survey Handbook.** Inkata Press, Melbourne.



Soil Test Results

APPENDIX 3

Department of Lands

Soil Conservation Service

SOIL TEST REPORT

Scone Research Centre

REPORT NO:	SCO09/263R1
REPORT TO:	Klay Marchant GSS Environmental PO Box 907 Hamilton NSW 2303
REPORT ON:	Thirty one soil samples HVO South
PRELIMINARY RESULTS ISSUED:	Not issued
REPORT STATUS:	Final
DATE REPORTED:	14 October 2009
METHODS:	Information on test procedures can be obtained from Scone Research Centre

TESTING CARRIED OUT ON SAMPLE AS RECEIVED
THIS DOCUMENT MAY NOT BE REPRODUCED EXCEPT IN FULL

SR Young

SR Young
(Laboratory Manager)

SOIL AND WATER TESTING LABORATORY
Scone Research Service Centre

Report No: SCO09/263R1
Client Reference: Klay Marchant
GSS Environmental
PO Box 907
Hamilton NSW 2303

Lab No	Method	P7B/1 Particle Size Analysis (%)					P9B/2	C1A/4	C2A/3	C5A/3 CEC & ex cation (me/100g)			Colour	
	Sample Id	clay	silt	f sand	c sand	gravel	EAT	EC (dS/m)	pH	CEC	Na	ESP	Dry	Moist
1	HVO South 1-1	29	35	36	<1	0	5	0.09	8.1	44.4	1.0	2	10YR4/3	10YR2/2
2	HVO South 1-2	30	38	32	<1	0	3(1)	0.08	8.5	45.4	1.9	4	10YR4/3	10YR2/2
3	HVO South 1-3	31	33	36	<1	0	5	0.06	8.3	45.1	1.4	3	10YR4/3	10YR3/2
4	HVO South 2-1	39	43	18	<1	0	3(1)	0.05	8.1	47.4	1.0	2	10YR4/3	10YR3/2
5	HVO South 2-2	34	48	18	<1	0	3(2)	0.15	9.1	48.9	6.3	13	10YR4/3	10YR3/2
6	HVO South 2-3	43	41	16	<1	0	3(2)	0.10	8.7	47.4	3.6	8	10YR4/3	10YR2/2
7	HVO South 3-1	35	39	25	1	0	5	0.05	7.6	47.1	0.8	2	10YR4/4	10YR3/2
8	HVO South 3-2	32	48	20	<1	0	5	0.12	8.2	46.4	0.9	2	10YR4/3	10YR2/2
9	HVO South 3-3	40	46	14	<1	0	5	0.08	8.1	47.5	1.0	2	10YR4/3	10YR2/2
10	HVO South 4-1	57	40	1	2	0	3(3)	0.06	6.9	42.2	1.2	3	10YR4/3	10YR2/2
11	HVO South 4-2	65	28	5	2	0	3(2)	0.56	8.8	49.8	7.6	15	10YR4/2	10YR2/2
12	HVO South 4-3	67	25	6	2	<1	2(2)	0.88	8.7	45.6	7.3	16	10YR5/4	10YR3/3

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	Sample Id	clay	silt	f sand	c sand	gravel	EAT	EC (dS/m)	pH	CEC	Na	ESP	Dry	Moist
13	HVO South 5-1	41	44	14	1	0	3(1)	0.05	7.1	43.5	0.6	1	10YR4/2	10YR2/2
14	HVO South 5-2	56	31	8	5	0	3(1)	0.54	8.8	45.0	4.6	10	10YR4/2	10YR2/2
15	HVO South 5-3	55	31	9	5	0	3(1)	0.58	8.6	43.1	4.2	10	7.5YR4/2	7.5YR2.5/2
16	HVO South 6-1	47	43	9	1	0	3(1)	0.05	6.6	43.7	0.5	1	10YR4/3	10YR3/2
17	HVO South 6-2	43	40	16	1	0	5	0.08	8.0	45.4	1.2	3	10YR4/2	10YR2/2
18	HVO South 6-3	56	30	12	2	0	4	0.22	8.8	49.9	3.3	7	10YR4/2	10YR2/2
19	HVO South 7-1	36	31	31	2	0	3(2)	0.12	7.7	47.3	0.5	1	10YR4/3	10YR2/2
20	HVO South 7-2	40	33	26	1	0	5	0.11	8.6	48.5	1.5	3	10YR4/2	10YR2/2
21	HVO South 7-3	57	28	13	2	0	5	0.49	8.5	50.4	3.6	7	10YR4/2	10YR2/2
22	HVO South 8-1	24	27	49	<1	0	5	0.07	8.2	42.5	0.6	1	10YR4/3	10YR2/2
23	HVO South 8-2	27	29	44	<1	0	5	0.12	8.5	42.2	1.1	3	10YR4/3	10YR2/2
24	HVO South 8-3	32	38	30	<1	0	5	0.23	8.2	43.7	1.4	3	10YR4/3	10YR2/2

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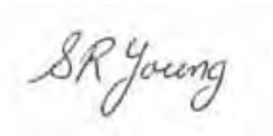
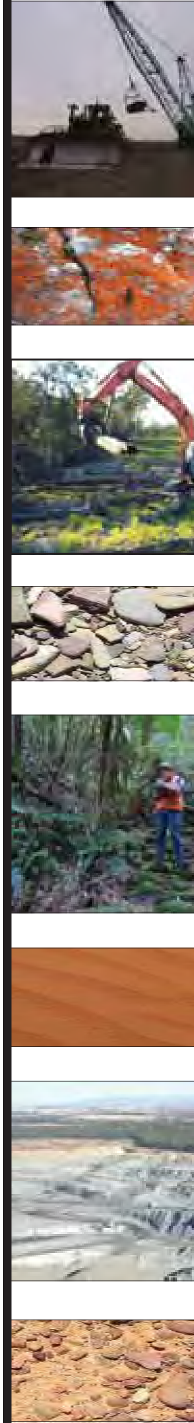
Lab No	Method	P7B/1 Particle Size Analysis (%)					P9B/2	C1A/4	C2A/3	C5A/3 CEC & ex cation (me/100g)			Colour	
	Sample Id	clay	silt	f sand	c sand	gravel	EAT	EC (dS/m)	pH	CEC	Na	ESP	Dry	Moist
25	HVO South 9-1	32	17	34	17	0	3(1)	0.11	5.8	34.7	0.4	1	7.5YR4/3	7.5YR3/2
26	HVO South 9-2	53	16	19	10	2	3(1)	0.08	7.5	40.5	0.8	2	7.5YR4/3	7.5YR3/3
27	HVO South 9-3	53	13	16	14	4	4	0.73	8.9	43.0	5.4	13	7.5YR4/4	7.5YR3/4
28	HVO South 9-4	52	21	15	11	1	4	1.60	8.8	42.1	6.9	16	5YR5/6	5YR3/4
29	HVO South 10-1	16	18	40	25	1	5	0.07	6.8	14.0	0.3	2	7.5YR5/3	7.5YR3/3
30	HVO South 10-2	51	11	23	14	1	2(2)	0.46	8.8	30.7	4.6	15	7.5YR5/4	7.5YR4/6
31	HVO South 10-3	50	16	19	14	1	3(1)	1.20	9.4	37.4	9.9	26	7.5YR5/6	7.5YR4/4



END OF TEST REPORT

Glossary



A Horizon

The original top layer of mineral soil divided into A_1 (typically from 5 to 30 cm thick; generally referred to as topsoil

Alluvial Soils

Soils developed from recently deposited alluvium, normally characterise little or no modification of the deposited material by soil forming processes, particularly with respect to soil horizon development.

Brown Clays

Soil determined by high clay contents. Typically, moderately deep to very deep soils with uniform colour and texture profiles, weak horizonation mostly related to structure differentiation.

Consistence

Comprises the attributes of the soil material that are expressed by the degree and kind of cohesion and adhesion or by the resistance to deformation or rupture.

Electrical Conductivity

The property of the conduction of electricity through water extract of soil. Used to determine the soluble salts in the extract, and hence soil stability. (Soil Landscapes of Singleton 1991)

Emmerson's Aggregate Test (EAT)

A classification of soil based on soil aggregate coherence when immersed water. Classifies soils into eight classes and assists in identifying whether soils will slake, swell or disperse (Soil Landscapes of Singleton, 1991)

Gravel

The >2 mm materials that occur on the surface and in the A_1 horizon and include hard, coarse fragments.

Lithosols

Stony or gravelly soils lacking horizon and structure development. They are usually shallow and contain a large proportion of fragmented rock. Textures usually range from sands to clay loams.

Loam

A medium, textured soil of approximate composition 10 - 25% clay, 25 - 50% silt and <50% sand.

Mottling

The presence of more than one soil colour in the same soil horizon, not including different nodule or cutan colours.

Particle Size Analysis (PSA)

The determination of the of the amount of the different size fractions in a soil sample such as clay, silt, fine sand, coarse sand and gravel. (Soil Landscapes of Singleton 1991)

Pedality

Refers to the relative proportion of peds in the soil (as strongly pedal, weakly pedal or non-pedal).

pH

A measure of the acidity or alkalinity of a soil.

Solodic Soils

Strong texture differentiation with a very abrupt wavy boundary between A and B horizons, a well-developed bleached A2 horizon and a medium to coarse blocky clay B horizon.

Soloths

Similar to a solodic soil but acidic throughout the profile. Tends to be a more typical soil of the humid regions where the exchangeable cations in the B Horizon of the solodised soils have been leached out.

Podzolics

Podzolic soils are acidic throughout and have a clear boundary between the topsoil and subsoil. The topsoils are loams with a brownish grey colour. The lower part of the topsoil has a pale light colour and may be bleached with a nearly white, light grey colour.

Ped

An individual, natural soil aggregate. (Soil Landscapes of Singleton 1991)

Sodicity

A measure of exchangeable sodium in the soil. High levels adversely affect soil stability, plant growth and/or land use.

Soil mantle

The upper layer of the Earth’s mantle, between consolidated bedrock and the surface, that contains the soil. Also known as the regolith.

Appendix F

Noise and vibration study

www.coalandallied.com.au

Carrington West Wing

Noise and Vibration Assessment

Prepared for Coal & Allied Operations Pty Limited | 01 October 2010

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Carrington West Wing

Noise and Vibration Assessment - Final

J09026 | Prepared for Coal & Allied Operations Pty Limited | October 2010

Prepared by	**Najah Ishac**	Approved by	**Luke Stewart**
Position	Director	Position	Director
Signature		Signature	
Date	01 October 2010	Date	01 October 2010

This Report has been prepared in accordance with the brief provided by the Client and has relied upon the information collected at or under the times and conditions specified in the Report. All findings, conclusions or recommendations contained within the Report are based only on the aforementioned circumstances. Furthermore, the Report is for the use of the Client only and no responsibility will be taken for its use by other parties.

Document Control

Version	Date	Prepared by	Reviewed by
1	23 December 2009	Najah Ishac	Luke Stewart
2	31 March 2010	Najah Ishac	Luke Stewart
3	30 April 2010	Najah Ishac	Luke Stewart
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5	21 June 2010	Najah Ishac	Jodi Kelehear
6	06 September 2010	Najah Ishac	Jodi Kelehear
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Executive Summary

This report was prepared for Coal & Allied to assess environmental noise and vibration associated with noise emissions resulting from the Carrington West Wing modification (the proposal). This assessment forms part of the environmental assessment prepared by EMGA Mitchell McLennan Pty Limited for the proposal.

Noise from the proposal was assessed against the Department of Environment, Climate Change and Water's (DECCW) Industrial Noise Policy (INP) and the NSW Department of Planning's (DoP) Consent Noise Limits. The assessment also considers the proposal's potential to trigger property acquisitions according to the 'Zone of Affectation' test typically applied by DoP.

To assess the potential for noise impacts on residences nearest the mine as a result of the proposal, two mine plans (representing operating stages Years 1 and 5) were considered. The assessment includes predictions based on an acoustically unmitigated and mitigated equipment fleet. The mine plans and equipment locations for the proposal used in the noise modelling present worst-case operating scenarios. Further, the results assume all modelled plant and equipment operate simultaneously. In practice, such an operating scenario would be unlikely to occur. This allows a conservative assessment of the potential impacts from the proposal on the area surrounding the mine.

This assessment investigates the proposal's potential to give rise to sleep disturbance within residences, as well as its contribution to the cumulative noise received at residences from all industrial operations in the region. The assessment also considers potential noise impacts from blasting required by the Proposal.

Noise and vibration from blasting were assessed against the criteria promulgated by the Australian and New Zealand Environment and Conservation Council (ANZECC) and the site's current Consent Conditions.

The assessment was undertaken using the Environmental Noise Model (ENM) prediction software which predicts total noise levels at residences from the concurrent operation of multiple noise sources and with consideration of factors such as the lateral and vertical location of plant, source-to-receiver distances, ground effects, atmospheric absorption, topography of the mine and surrounding area and meteorological conditions.

Operational noise levels to residences were predicted with consideration of the various meteorological conditions prevalent at site which includes 'calm', wind and temperature gradient conditions.

The assessment concluded that operational noise will comply with the consented criteria for all receivers not already within a zone of affectation during 'calm' meteorological conditions for both day and night periods.

With the adoption of mitigation, required during adverse winds (which are a feature during the night period only), noise levels are predicted to satisfy the operational consent levels at most privately owned residences and satisfy the consent acquisition levels at all privately owned residences not already within a zone of affectation.

Pro-active and reactive noise mitigation and monitoring measures will be implemented, including real time noise monitoring at Jerrys Plains. Ongoing noise monitoring will be used to assess the performance of the mining operations against the predicted noise levels and to manage any potential impacts.

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1 Introduction

1.1 Background

Coal & Allied Operations Pty Limited (Coal & Allied) owns and operates the Hunter Valley Operations (HVO) mining complex located 24 kilometres (km) north-west of Singleton in the Singleton Local Government Area (LGA) as shown in Figure 1.1. The mining and processing activities at HVO are geographically divided by the Hunter River into north of the Hunter River (HVO North) and south of the Hunter River (HVO South), with movements of coal, coarse and fine reject, overburden, topsoil, equipment, water, materials and personnel occurring between the two areas. While HVO South and HVO North each have separate planning approvals, HVO is managed as one operation.

The HVO North operations comprise the active Carrington, West and North Pits (refer to Figure 1.2). Carrington Pit is a truck and shovel operation, approved to mine 10 million tonnes (Mt) of run of mine (ROM) coal per annum. The pit is well developed and significant areas of rehabilitation are established. An opportunity has been identified to extend mining operations in the Carrington Pit to the south-west. A description of the Carrington West Wing proposal (referred to as the 'proposal') is provided below.

1.2 Proposal description

The extension comprises a surface area of approximately 137ha and is predominantly cleared of native vegetation. The extension will allow for the extraction of approximately 17mt of in-situ coal from mining of coal reserves in the Broonie, Bayswater and Vaux seams.

Mining in the extended pit will have a life of approximately six years and will be completed within the existing development consent period, which is currently approved to 2025.

Overburden will be disposed of in-pit, as well as at two out-of-pit overburden emplacement areas to be established on previously disturbed and rehabilitated land immediately north of the proposed pit extension area.

Supplementary activities proposed to support the extension include:

- The approved footprint of the Carrington evaporative sink will be extended for the long term management of groundwater post-mining.
- The impermeable groundwater barrier wall previously assessed for the western paleochannel will be realigned further south, to prevent groundwater migration from the Hunter River into the mine, and migration of water from the mine into the Hunter River alluvium.
- A two stage, temporary levee and diversion system will be established to ensure that the proposed extension area is protected from flooding and to enable the diversion of an unnamed tributary of the Hunter River that presently runs in a southerly direction across the footprint of the extension.
- A service corridor will be constructed along the southern boundary of the proposed extension area. This may incorporate water pipelines, an all weather access road, mining equipment, substations and other services.

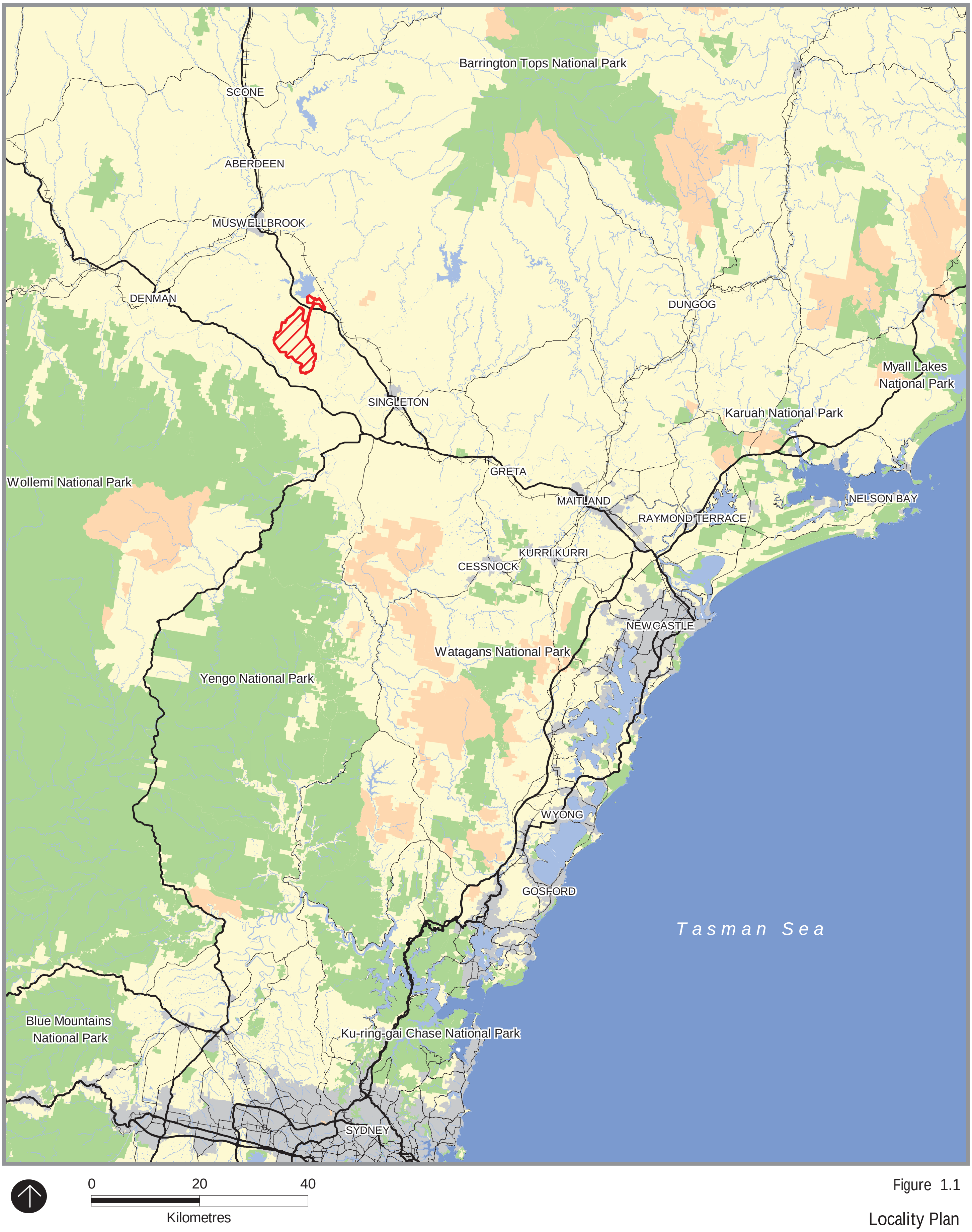
The proposal will not result in change to the mining extraction rates, mining methods, mining equipment, employment, processing or mine services, product transport, operating hours or environmental management systems. The project area is entirely on land owned by Coal & Allied.

1.3 About this report

This report was prepared for Coal & Allied to assess environmental noise and vibration associated with the proposal and will form the basis of the noise assessment component of the associated environmental assessment.

The assessment is based on two 'worst case' mining stages, namely Years 1 and 5 of the planned six year operations in the proposed extension area. Worst case mining stages were selected based on the concentration and proximity of mining equipment to the various assessment locations.

Carrington Pit is approved under Development Consent No. DA 450-10-2003. The *West Pit Extension and Minor Modifications Environmental Impact Statement* (EIS) ERM 2003 accompanied the application for development consent. The EIS included a detailed noise and vibration assessment that provides relevant background information and noise modelling for the proposal. The noise assessment carried out for this report has been prepared in accordance with the Department of Environment, Climate Change and Water (DECCW) *Industrial Noise Policy* (INP), which was published in January 2000.



HVO North current development consent boundary
NPWS estate
State forest
Urban area
Highways/ Main Roads
River/ waterway
Lake
Railway

Figure 1.1

Locality Plan

Carrington West Wing Modification

C:\GIS\EMGA\9016 Carrington West Wing Modification\Figures\March 2010

Figure 1.2

Regional setting

Carrington West Wing Modification

1.4 Acoustic glossary

A number of technical terms used in this report. These are explained in Table 1.1.

Table 1.1 Glossary of terms

Term	Definition
ABL	Assessment Background Level (ABL) is defined in the INP as a single figure background level for each assessment period (day, evening and night). It is the tenth percentile of the measured L_{90} statistical noise levels.
dB(A)	Noise is measured in units called decibels (dB). There are several scales for describing noise, the most common being the 'A-weighted' scale. This attempts to closely approximate the frequency response of the human ear.
dB(LinPeak)	The peak sound pressure level (not RMS) expressed as decibels with no frequency weighting.
L_1	The noise level exceeded for 1% of a measurement period.
L_{10}	A noise level which is exceeded 10% of the time. It is approximately equivalent to the average of maximum noise levels.
L_{90}	Commonly referred to as the background noise. This is the level exceeded 90% of the time.
Leq	The summation of noise over a selected period of time. It is the energy average noise from a source, and is the equivalent continuous sound pressure level over a given period.
Lmax	The maximum root mean squared (RMS) sound pressure level received at the microphone during a measuring interval.
MIC_{8ms}	Maximum Instantaneous Charge (with a minimum 8 milli-sec delay).
Peak Particle Velocity (PPV)	The maximum velocity of a particle of the transmission medium, used in assessment of vibration.
RBL	The Rating Background Level (RBL) is an overall single figure background level representing each assessment period over the whole monitoring period. The RBL is used to determine the intrusiveness criteria for noise assessment purposes and is the median of the ABLs.
RMS	Root Mean Square which is a measure of the mean displacement (velocity or acceleration) of a vibrating particle.
sigma-theta (σ_θ)	The standard deviation of horizontal wind fluctuation.
Sound power level	This is a measure of the total power radiated by a source. The sound power of a source is a fundamental location of the source and is independent of the surrounding environment.
Temperature inversion	A positive temperature gradient. A meteorological condition where atmospheric temperature increases with altitude to some height.

The following indicates what an average person perceives about noise levels in practice:

- noise differences of less than approximately 2dB are generally imperceptible; and
- a difference of around 10dB seems to be a doubling or halving of loudness.

1.5 Representative receptors

The following noise assessment includes graphical representations of the potential noise emissions from the proposal in the form of noise contours. In addition, to provide a higher level of accuracy for specific off-site locations, noise levels at a number of surrounding receptors were modelled individually. The closest privately owned residences are west and south west of the proposed extension area and include one property on Lemington Road and several others along the Golden Highway (or Jerrys Plains Road). The existing ambient noise environment at these properties is typical of rural residential locations, with influence from agricultural activities, road traffic noise, existing mining noise and otherwise natural sounds.

A total of 13 receptors were considered representative of assessable locations surrounding the project area. Of these 13 representative receptors, nine are private residential properties or representatives thereof (Receptor No's 1 through to 6 and 13, 14 and 39) while the others are owned by another mine, have agreements with Coal & Allied, are under existing mine noise affectation zones or are subject to a private landholder agreement. These are shown in Table 1.2 and illustrated in Figures 3.1 to 3.3 in Section 3. The receptor number convention is consistent with the *West Pit Extension and Minor Modifications EIS*, ERM 2003. In addition, Figure 3.3a shows the locations of all receptors at Jerrys Plains. This figure illustrates that the representative receptors selected include the private residence in Jerrys Plains which is closest to the proposed extension area (Receptor No. 1), as well as a representative residence near the centre of Jerrys Plains (Receptor No. 13) and another near its northern limit (Receptor No. 14).

Table 1.2 Surrounding representative receptors used for modelling purposes

Receptors		MGA coordinates		Direction from Mine
No.	**Property Owner**	**Easting**	**Northing**	**Compass Point**
1	Hayes (Jerrys Plains closest residence)	304370	6402057	SW
2	Skinner	305031	6401340	SW
3	Gee	305309	6401091	SW
4	Muller	306145	6399742	S
5	Bowman	317920	6399141	SE
6	Moxey	318008	6399952	SE
7[1]	Stapleton	315949	6403170	SE
8[3]	Ravensworth Operations Owned	313683	6403978	SE
10[2]	Moses	306916	6402126	SW
11[3]	Wambo Owned	307123	6399079	S
13[4]	Jerrys Plains Centre	303294	6402832	W
14[4]	Jerrys Plain North	302484	6403431	W
39	Warkworth Village Representative	314396	6394821	S

1. *These private residences are currently inside a zone of affectation or subject to a private land holder agreement with mines other than HVO.*
2. *These private residences are currently inside a HVO zone of affectation or subject to a private land holder agreement.*
3. *Mine owned.*
4. *Additional Jerrys Plains locations were added to provide a better representation of the area.*

2 Consent noise and vibration limits

2.1 Introduction

Consent for the proposal is being sought as a modification to Development Consent No. DA 450-10-2003which was issued by the Minister for Infrastructure and Planning in 2004. As such, the results of the noise and vibration assessment for the proposal will be compared to the existing noise and vibration limits specified in the Development Consent No. DA 450-10-2003. These limits include:

- noise limits;
- land acquisition limits; and
- blasting limits.

These limits are provided in the tables below.

2.2 Noise limits

The noise limits specified for the Development Consent No. DA 450-10-2003 are provided in Table 2.1 and are based on an INP approach to the development of project specific criteria.

Table 2.1 Development consent noise limits

Day/Evening/Night $L_{Aeq(15\ minute)}$	Night $L_{A1(1\ minute)}$	Property number[1]
40	46	4 – (from year 1 to year 7)
36	46	4 – (from year 8 to year 21)
40	46	Jerrys Plains Village –residence locations 13 and 14 (years 20 and 21)
39	46	2, 3, 11, 19, 31, 36, 54
38	46	1,18, 51 and 52 (from year 1 to year 19)
40	46	1, 18, 51 and 52 (years 20 and 21)
35	46	All other residential or sensitive receptors, excluding the receptors listed above.

2.3 Land acquisition criteria

The relevant condition of consent regarding land acquisition criteria is as follows.

> *If the noise generated by the development exceeds the criteria provided in Table 2.2 (below), the Applicant shall, upon receiving a written request for acquisition from the landowner, acquire the land in accordance with the procedures in conditions 9-11 of schedule 5 of the consent (DA 450-10-2003).*

Table 2.2 Land acquisition criteria

Day/Evening/Night ($L_{Aeq(15 minute)}$)	Property number
43	11
42	7
41	All residential or sensitive receptors, excluding the receptors listed in condition 1 of the consent.

2.4 Blast limits

2.4.1 Airblast overpressure limits

The relevant condition of consent regarding airblast overpressure limits is as follows.

> *The Applicant shall ensure that the airblast overpressure level from blasting at the development does not exceed the criteria provided in* Table 2.3 *(below) at any residence on privately-owned land.*

Table 2.3 Airblast overpressure limits

Airblast overpressure level (dB(Lin Peak))	Allowable exceedance
115	5% of the total number of blasts in a 12 month period
120	0%

2.4.2 Ground vibration impact assessment criteria

The relevant condition of consent regarding ground vibration level is as follows.

> *The Applicant shall ensure that the ground vibration level from blasting at the development does not exceed the criteria provided in Table 2.4 (below) at any residence on privately-owned land.*

Table 2.4 Ground vibration impact assessment criteria

Peak particle velocity (mm/s)	Allowable exceedance
5	5% of the total number of blasts in a 12 month period
10	0%

3 Noise modelling

3.1 Modelling scenarios

The Carrington Pit was assessed as part of HVO North in the *West Pit Extension and Minor Modifications EIS*, ERM 2003. A similar approach has been adopted for modelling and assessment for the proposal.

Two operating scenarios were modelled to cover the life of the proposal, comprising operational years 1 and 5 of the planned six years. Corresponding operating years for other pits within HVO North were also included in the model. These were Year 8 and Year 14 of the modelling undertaken by ERM 2003, as these are considered to be the closest match in expected operations during Year 1 and Year 5 of the proposal respectively. It should be noted that the North Pit operations were not included as these have ceased operations.

The mine plans and equipment locations which were used in the noise modelling are provided in *Appendix A*. They present worst-case operating scenarios in terms of potential noise impacts. This allows a conservative assessment of the potential impacts from the proposal on the area surrounding the mine.

3.2 Plant noise levels

Typical equipment used during earth-moving and associated operations in the pit and overburden emplacement areas, together with corresponding sound power levels used in modelling are listed in Table 3.1. These are indicative and are based on measurements obtained from equipment at the existing operations, coal preparation plants and loading points. These are consistent with those of the *West Pit Extension and Minor Modifications EIS*, ERM 2003.

Table 3.1 Equipment sound power levels

Typical item	Representative $L_{eq,15minute}$ sound power level, dB(A)
Haul truck	114
Large drill	118
Medium drill	118
Shovels (2800, 4100 and 5700)	118
Fuel truck	103
Lube truck	103
Water truck	116
Front end loader (L1400)	113
Dragline	114
Excavator	113
Dozer	116
Dozer	110
Rubber tyred dozer	116
Grader	113
Scraper	110
Pump	113
Light plant	104

Table 3.1 Equipment sound power levels

Typical item	Representative $L_{eq,15minute}$ sound power level, dB(A)
Cable reeler	115
CPPs and loading points	112
Conveyor	83 per linear metre

3.3 Mining equipment and plant schedule

The typical equipment schedules for the modelled mining scenarios are described in Table 3.2 and cover equipment in both West Pit and Carrington Pit. The Year 1 scenario includes equipment in both the existing Carrington Pit and the proposed extension area. However, by Year 5 the existing Carrington Pit is expected to complete operations. The specific type of plant used may vary, however, the quoted sound emissions will remain representative. It should be noted that daytime and night time (including evening) operations vary only with respect to the use of lighting plant at night.

Table 3.2 Typical mining equipment schedule

Description	Modelled Year			
	Year 1		Year 5	
	West Pit Year 8	Carrington Year 1	West Pit Year 14	Carrington Year 5
Loader	1	1	2	-
Excavator	0	-	3	-
Shovel	2	2	2	1
CAT cable reeler	1	-	1	-
Coal haul to HVCPP	6	-	8	-
Coal haul to HCPP	7	-	19	-
Diesel pump	4	6	4	3
Dragline	1	-	1	-
Drill	3	2	4	1
Dozer	6	7	10	2
Electric pump	8	-	8	-
Grader	2	2	4	1
Coal from HCPP to NLP	6	-	6	-
Lighting plant	8	8	13	2
West Pit reject	1	-	1	-
Rubber tyred dozer	1	-	1	-
Scraper	1	-	0	-
Water truck	2	1	4	1
Waste truck	19	17	19	7
Fuel/Lube Truck	0	-	0	-
TOTAL	**79**	**46**	**110**	**18**

In addition to the mining and dumping operations described above, other coal transportation and processing activities form part of the existing HVO North. These were included in the noise model as on-going activities and comprise:

- coal truck haulage from south of the Hunter River to the Hunter Valley Coal Preparation Plant (HVCPP) - 17 haul trucks were dedicated to these activities;
- auxiliary coal haulage (can occur intermittently) using road trucks to transport coal between the HVCPP and Hunter Valley Load Point, (HVLP) and between the HVLP to Newdell Load Point, (NLP) and Ravensworth Coal Terminal, (RCT) - conservatively eight trucks were dedicated to this activity;
- Belt Line Conveyor – this conveyor system spans several kilometres between the HVCPP and HVLP;
- conveyor from Howick Coal Preparation Plant (HCPP) to Bayswater Power Station;
- HVCPP and HCPP; and
- HVLP, NLP and RCT.

3.4 Calculation procedures

The Environmental Noise Model (ENM) is a type of noise prediction software and was used for modelling noise emissions for this proposal. The model takes into account distance, ground effects, atmospheric absorption and topographic detail. The software package is accepted by DECCW. Initial calculations were performed using a calm weather scenario, that is, no wind or temperature gradients. Assumed night time air temperature and relative humidity were 10°C and 80 per cent, respectively. Noise levels during other conditions are discussed later.

The model incorporates three-dimensional digitised ground contours for the surrounding land and mine plans. Contours of the mine and overburden emplacement areas for the two modelling scenarios were superimposed on surrounding base topography. Mining equipment was placed at various locations and heights, representing realistic operating conditions throughout the life of the proposal. These locations were chosen to represent operations for each period and represent worst case situations.

The noise model predicts L_{eq} noise levels based on equipment sound power levels determined from measurements conducted at West Pit. The results assume all modelled plant and equipment operate simultaneously. In practice, such an operating scenario would be unlikely to occur. The results are therefore considered conservative.

3.5 Calm weather results

Table 3.3 summarises noise modelling results for calm weather conditions. These results represent all newly modelled operations for Year 1 and Year 5. It is clear from Table 3.3 that mine operations will satisfy consent noise limits during calm weather conditions at all private residences modelled that are not already within a zone of affectation.

Table 3.3 Noise projections under calm weather scenario - $L_{eq,15minute}$ dB(A)

Location	Day, evening and night time		Consent limits
Receptor No.	Year 1	Year 5	Day/Evening/Night
1	20	19	38-40
2	21	20	39
3	23	21	39
4	30	27	36-40
5	21	19	35
6	20	17	35
7[1]	30	29	36-40
8[3]	35	34	NA
10[2]	48	45	NA (Acquisition)
11[3]	31	30	39
13[4]	14	10	40
14[4]	12	9	40
39	16	10	35

1. These private residences are currently inside a zone of affectation or subject to a private land holders agreement with mines other than HVO.

2. These private residences are currently inside a HVO zone of affectation or subject to a private land holders agreement.

3. Mine owned.

4. Additional Jerrys Plains locations were added to provide a better representation of the area.

3.6 Predicted noise levels - prevailing weather conditions

Under various wind and temperature gradient conditions, noise levels may increase or decrease compared with calm conditions, ie zero wind and negligible temperature gradient. This is due to refraction of sound propagating through the atmosphere, brought about by a change in sound speed with height. Sound levels increase when the wind blows from source to receiver or under temperature inversion conditions and decrease when the wind blows from receiver to source or under temperature lapse conditions.

The INP sets out recommended procedures to assess noise under a range of meteorological conditions. Specific adverse meteorological conditions which are referred to as 'INP weather conditions' are typically used in assessments, in lieu of monitored data. Site specific hourly weather data was obtained and analysed to establish relevant 'feature' weather conditions (as defined in the INP). These were used for modelling purposes and are consistent with the conditions assessed in the *West Pit Extension and Minor Modifications Environmental Impact Statement*, ERM 2003, ie a range of INP wind conditions, as defined by ERM (2003), and a 3°C/ 100m temperature inversion.

Table 3.4 indicates that without mitigation, predicted noise levels for adverse INP weather conditions are above the consent noise limits for eight of the assessed locations. For Year 1, conservative predictions are up to 4dB higher than the acquisition limits for Receptor's No.1 to 3, up to 3dB higher for Receptor No.13 and 2dB higher for Receptor No.14.

Hence, a review by Coal & Allied mine planners was undertaken to further refine the required plant at night in order to reduce noise emissions. During the modelled adverse easterly winds at night time, it was considered possible to further manage operations by standing down non-critical plant or operating equipment in-pit.

For Year 1 such plant operating modifications include the truck, dozer and light plant on the outer dump, pumps, water-cart, grader and drill, as well as one of the dozers and two of the trucks in the proposed extension area. A similar reduction of plant at the existing pit was used that included reducing that pit's fleet by two drills and two dozers. This is considered to be a modest reduction in the total fleet shown in Table 3.2.

For year 5 operations, an even more modest reduction in the total fleet was modelled that included, standing down or relocating non-critical plant such as a pump, grader and water cart, as well as a drill, dozer and shovel.

This resulted in reduced overall received noise levels as shown in Table 3.4 for 'Year 1 Mitigated' and 'Year 5 Mitigated'. With these controls in place during adverse easterly winds, noise levels are predicted to satisfy the operational consent levels at most of the assessed locations, and satisfy the consent acquisition levels at all privately owned residences not already within a zone of affectation. The worst case noise levels for the two modelled scenarios are shown in Figure 3.1 and Figure 3.2, and for all new stages combined in Figure 3.3.

It is important to note that for the Carrington Pit (including the proposed extension area), a comparison between the modelled wind affected and the calm results demonstrates a significant increase in noise for Jerrys Plains properties under weather enhanced conditions. This is borne from the presence of significant topography between the Carrington Pit and Jerrys Plains. A ridge spanning several kilometres and up to 200m above sea level, is approximately 100m higher than the Carrington Pit and provides significant benefit during calm weather conditions. However, under adverse (easterly) winds the modelling software suggests the ridge is providing very little resistance to mine noise.

Previous field validation of the ENM software by the author has demonstrated that ENM can over predict noise levels by at least 3dB under wind enhanced conditions (eg EMGA Mitchell McLennan 2010, ERM 2002, Ishac 2010, Ishac 2007 and Ishac and Bullen 2006). Similar field validation studies have been undertaken by others and presented at technical seminars at the Australian Acoustics Society of NSW gatherings in 2009.

Where significant topography exists such as the aforementioned ridge, the ENM over-predictions are likely to be more than 3dB. In practice, the increase in noise between calm to adverse weather demonstrated for Jerrys Plains is considered atypical. This expected overestimation by the software between calm and adverse weather results is consistent with the previous study in 2003, where the acoustic shielding benefits of the ridge are almost completely nullified under adverse winds. Additionally, the modelling assumes simultaneous operations of all equipment. The background noise at properties is also expected to rise during such adverse wind conditions due to wind induced vegetation noise and other mining or industrial activities. These will assist in masking noise from the proposal.

Any potential exceedances could be adequately managed with the aid of real time noise and weather monitoring.

One of the main differences between the two mining stages assessed is the expected completion of mining in the current Carrington Pit by Year 5.

For further clarity on the potential impacts at Jerrys Plains, Figure 3.3a was produced and focuses on the detailed property locations in that town, along with the predicted noise contours for operations at the Carrington Pit alone. The Year 5 result is shown as this represents the worst case for Jerrys Plains, as demonstrated in Table 3.4. The noise contours clearly demonstrate the minor nature of the noise contribution from the proposed operations at Carrington Pit. The noise levels at all Jerrys Plains properties are shown to range from below 30dB(A) at some receptors to 35dB(A) at the closest receptor (location 1).

The results also demonstrate good correlation with the predicted noise levels presented in the ERM 2003 study. Specifically, the current study shows that the predicted mitigated noise levels from combined Carrington and West Pit operations during adverse INP weather conditions are unchanged or lower than those assessed as part of the ERM (2003) EIS at all representative receivers, including those at Jerrys Plains. For example, the 2003 study predicted up to 41dB(A) at Jerrys Plains assessment locations 13 and 14. The results in Table 3.4 are consistent with this and are dominated by the West Pit contribution.

Table 3.4 **Predicted noise levels under INP derived weather conditions - $L_{eq,15minute}$ dB(A)**

Location	Year 1					Year 5					Consent Limits	
Receptor No.	Carrington (Existing & Pit Extension)		West Pit	Total (Carrington & West Pit)		Carrington (Pit Extension Only)		West Pit	Total (Carrington & West Pit)		Day/Evening/Night	
	Unmitigated	Mitigated	(Yr8 - ERM 2003)	Unmitigated	Mitigated	Unmitigated	Mitigated	(Yr14 - ERM 2003)	Unmitigated	Mitigated	Operational	Acquisition
1	44	34	35	45	38	40	35	38	42	40	38-40	>41
2	44	34	34	45	37	41	36	36	42	39	39	>41
3	44	35	34	45	37	41	37	36	42	39	39	>41
4	41	35	34	41	38	39	34	34	40	37	36-40	>41
5	28	26	28	30	30	16	12	27	27	27	35	>41
6	25	23	27	29	28	22	21	26	27	27	35	>41
7[1]	35	33	36	39	38	28	24	36	37	36	36-40	>42
8[3]	43	41	42	45	44	30	26	42	42	42	NA	NA
10[2]	55	44	39	55	45	51	46	40	51	47	NA (Acquisition)	NA
11[3]	39	35	34	40	38	38	34	35	40	37	39	>41
13[4]	42	32	41	44	41	37	33	41	43	41	40	>41
14[4]	39	30	41	43	41	35	31	41	42	41	40	>41
39	25	22	30	30	31	18	16	30	30	30	35	>41

1. *These private residences are currently inside a zone of affectation or subject to a private land holders agreement with mines other than HVO.*
2. *These private residences are currently inside a HVO zone of affectation or subject to a private land holders agreement.*
3. *Mine owned.*
4. *Additional Jerrys Plains receptors were added to provide a better representation of the area.*
5. *'>' means greater than.*

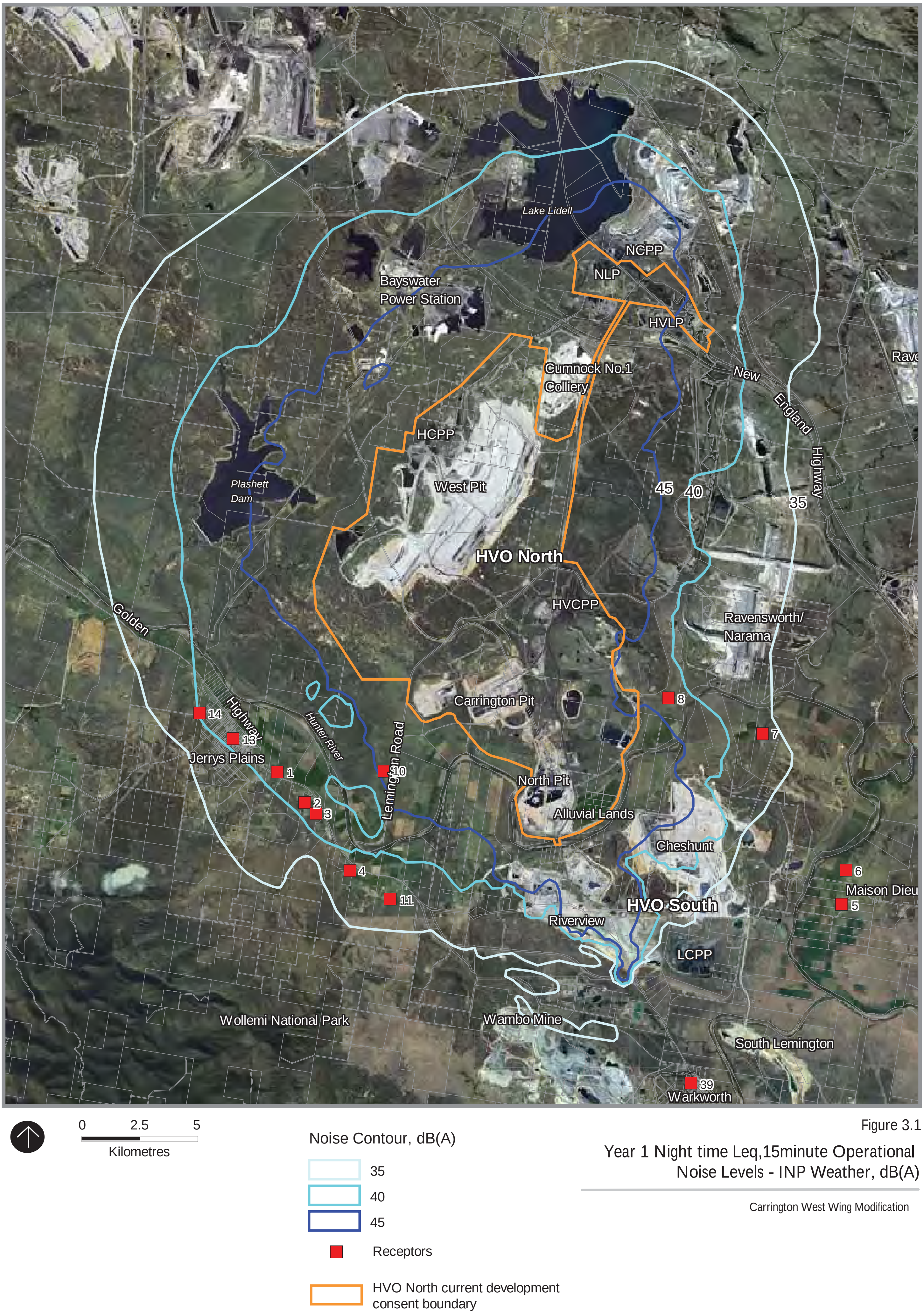
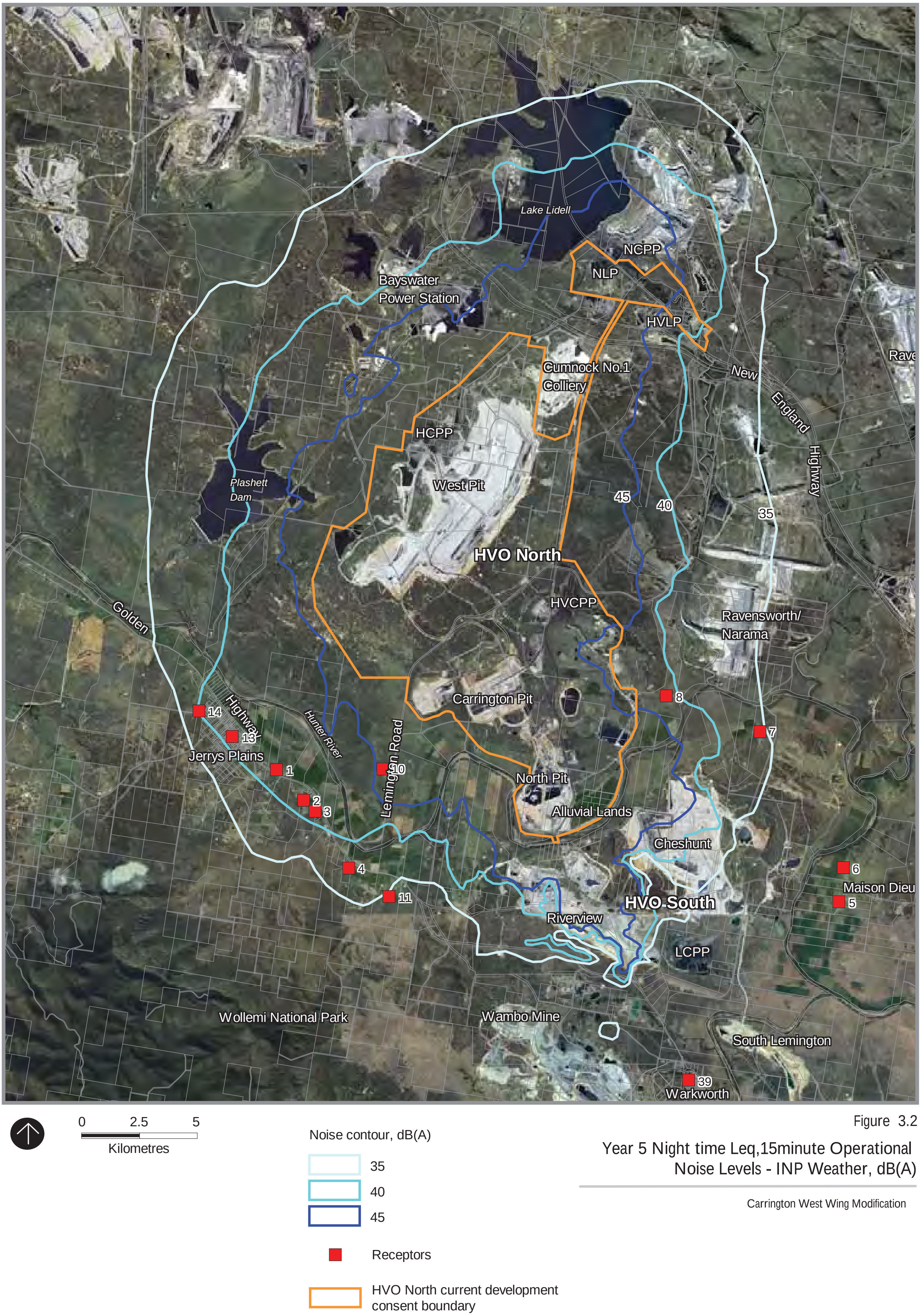


Figure 3.1

Year 1 Night time Leq,15minute Operational Noise Levels - INP Weather, dB(A)

Carrington West Wing Modification

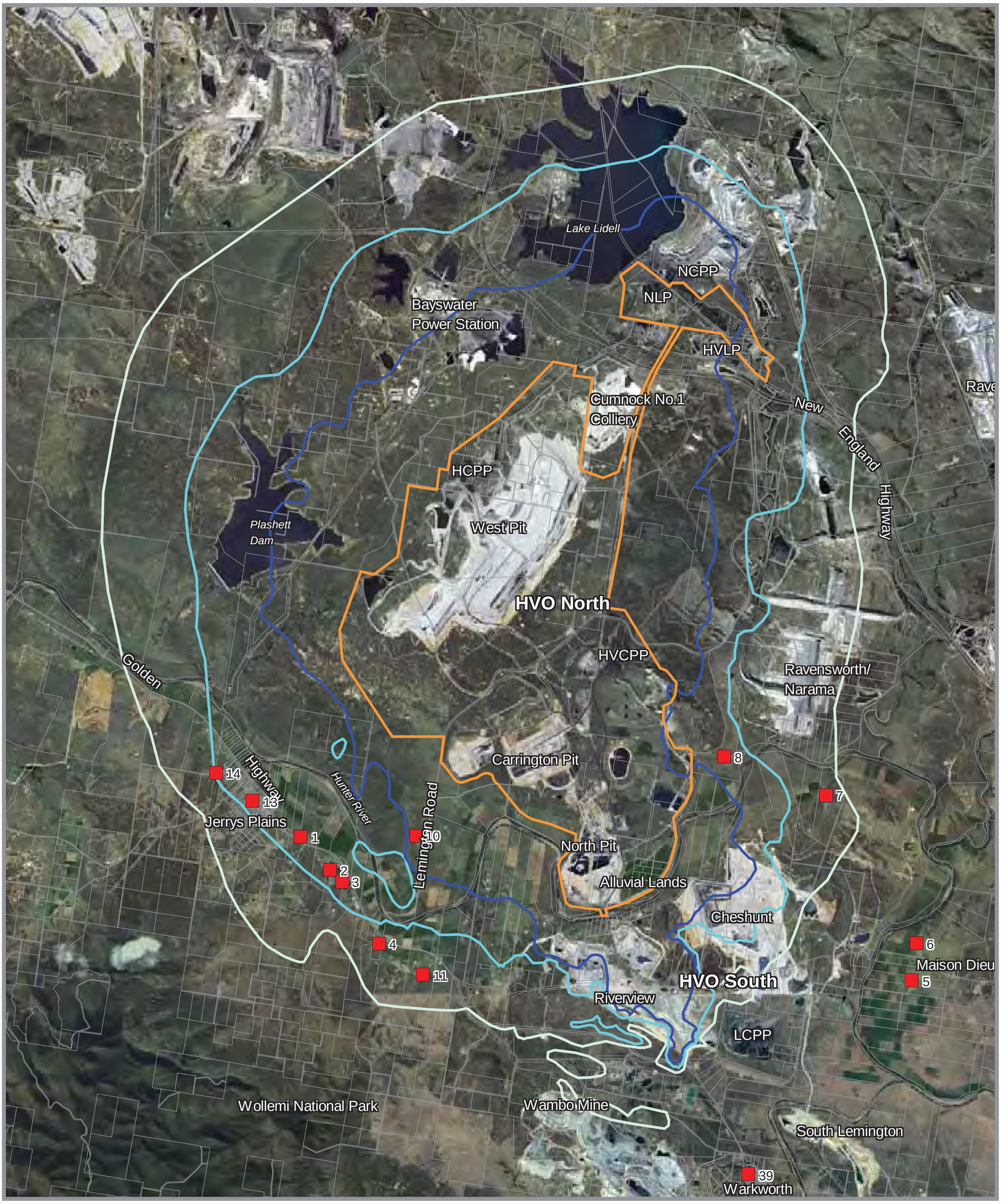


C:\GIS\EMGA\9016 Carrington West Wing Modification\Figures\March 2010

Figure 3.2

Year 5 Night time Leq,15minute Operational Noise Levels - INP Weather, dB(A)

Carrington West Wing Modification



0 2.5 5
Kilometres

Noise contour, DB(A)

35
40
45

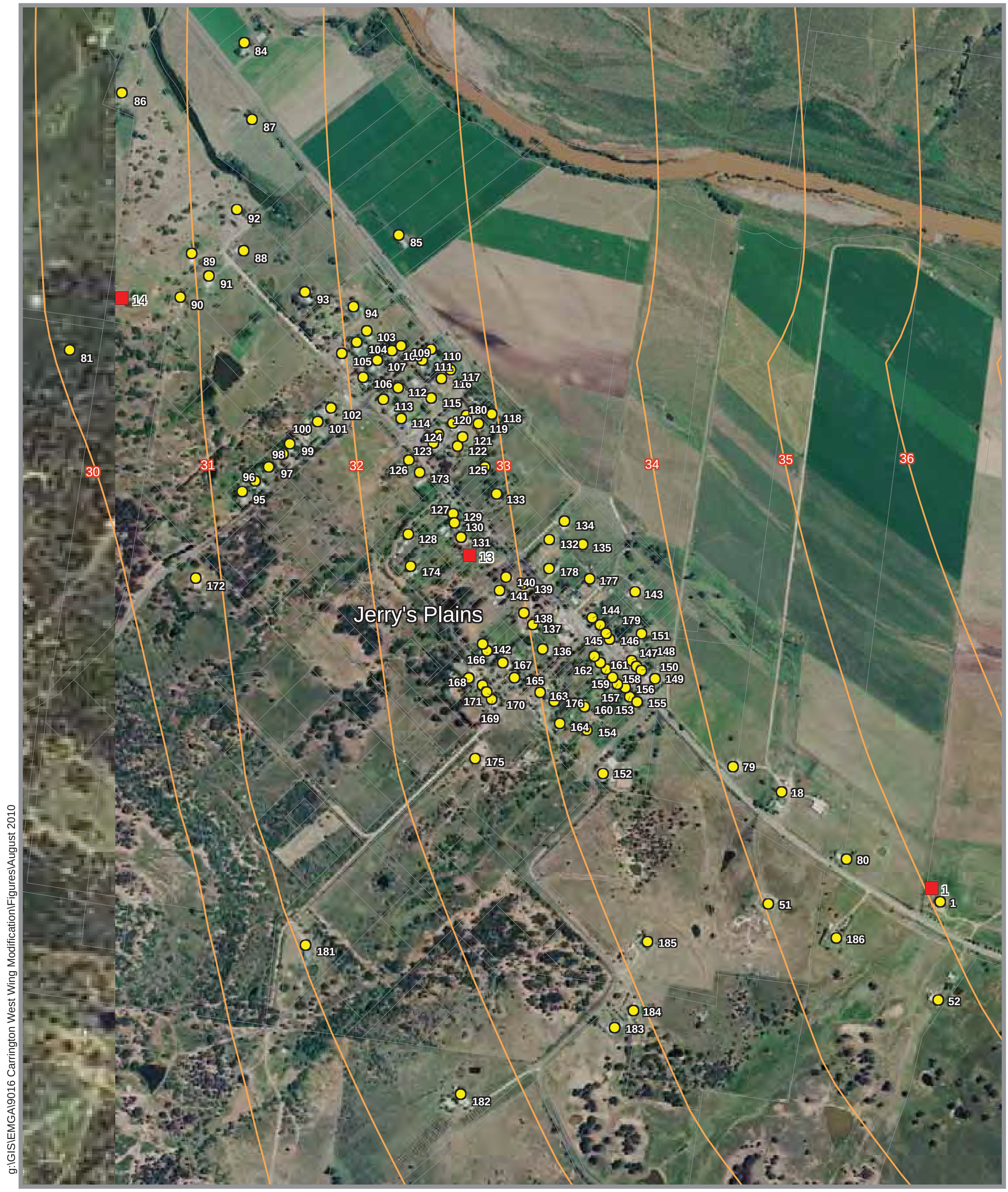
Receptors

HVO North current development consent boundary

Figure 3.3

Year 1 and 5 Combined Night time Leq,15minute Operational Noise Levels - INP Weather, dB(A)

Carrington West Wing Modification



0 200 400
Metres

Receptors

Other private residences

Noise contour, DB(A)

Figure 3.3a

Year 5 Mitigated INP Weather Noise Levels (CWW Only) For Jerrys Plains Area

Carrington West Wing Modification

3.7 Sleep disturbance

Transient noise sources, such as shovel gates banging, truck engines revving fast and vehicle reversing alarms, have the potential for sleep disturbance to nearby residents. Table 3.5 presents noise levels for the noisiest of these sources measured by ERM 2003.

Table 3.5 Maximum transient noise

Noise source	Measured L_{max} noise level, dB(A)	Distance from source (metres)	Sound Power Level, dB(A)
Shovel gate banging	60	400	120
Bulldozer with reversing alarm	69	80	115

A single truck movement may also cause sleep disturbance, particularly if it is isolated from other mine-related noise. From the model results, it was determined that for most cases, truck movements would give higher noise levels at residences than the events listed in Table 3.5. The maximum sound power level (L_{max}) of haul trucks was measured at up to 125dB(A)L_{max}.

Maximum noise levels were calculated under INP wind conditions for each location for both operational scenarios. Table 3.6 shows calculated maximum noise levels from the highest ranked source for a given receptor. This is based on the typical equipment locations used for mining operations and corresponds to the maximum sound power level for the particular item of plant, generally that for a truck or 125dB(A). Calculations were undertaken for a single event, rather than the simultaneous operation of a number of plant items because the values given are instantaneous maxima and such events are not expected to occur simultaneously. The criteria used to assess sleep disturbance are based on the DECCW's background plus 15dB for the $L_{1,1min}$ noise level, which in this case is conservatively approximated by the maximum noise level, L_{max}.

Table 3.6 demonstrates that calculated noise levels under prevailing weather conditions for HVO North, with the inclusion of CWW, are within the DECCW's conservative sleep disturbance criterion at all private residences assessed.

Table 3.6 Sleep disturbance impact – INP weather

Location	External L_{max} noise level from on-site plant, dB(A)		$L_{1,1min}$ night consent limit, dB(A)
Receptor No.	Year 1 (Unmitigated)	Year 5 (Unmitigated)	
1	42	40	46
2	43	40	46
3	42	41	46
4	39	38	46
5	28	28	46
6	28	27	46
7[1]	40	40	46
8[3]	46	46	NA
10[2]	53	52	NA (Acquisition)
11[3]	39	37	46
13[4]	40	37	46
14[4]	39	33	46
39	24	22	46

1. These private residences are currently inside a zone of affectation or subject to a private land holders agreement with mines other than HVO.

2. These private residences are currently inside a HVO zone of affectation or subject to a private land holders agreement.

3. Mine owned.

4. Additional Jerrys Plains locations were added to provide a better representation of the area.

3.8 Cumulative noise assessment

Adjoining industrial activity also influences the noise climate at receptors potentially exposed to the proposal. However, for the closest receptors this is limited, as the proposal constitutes the main contributor of industrial noise. Other industrial operations of significance are Riverview and Cheshunt Pits (located within HVO South), Wambo, Ravensworth-Narama and Ashton Coal Mine.

Noise from surrounding mines was sourced from the following documents:

- *Hunter Valley South Coal Project Environmental Assessment*, ERM 2008;
- *Wambo Development Project EIS*, Resource Strategies 2003;
- *White Mining Limited Ashton Coal Project EIS*, HLA-Envirosciences 2001; and
- *Extension of Mining Operations at Ravensworth Mine EIS*, ERM Mitchell McCotter 1997.

The aforementioned documents provide predicted L_{10} or L_{eq} noise levels for calm and adverse weather. For the purposes of this cumulative assessment, the following was adopted:

- for HVO South, the predicted noise levels were presented as Leq, under INP prevailing weather. These have been used as Leq weather enhanced results in this assessment;

- for the Wambo project, the Leq predicted noise levels enhanced under south easterly winds were used, as they present the worst case impact on the closest private residences being addressed. It is assumed that operations extend to 2017 or Year 5 of the proposal operations;

- for the Ashton Coal Project, the predicted results for temperature inversions were used. These range from 31dB(A) to 35dB(A) Leq for potentially the most exposed Maison Dieu residence for various operating scenarios. However, a timeline breakdown is not provided hence the upper level of the range was adopted for the cumulative assessment. This was only applicable for Maison Dieu residences; and

- for Ravensworth-Narama the predictions under a 3°C/100m temperature inversion were adopted. This is considered more appropriate than say winds in a given direction, given the relative locations of residences potentially affected by the proposal and Ravensworth-Narama. That is, winds that enhance noise from one mine will not enhance noise from the other at the same residential location.

The cumulative noise from these operations was added to the results for worst case INP weather from the proposal. This is a conservative approach as, for example, a south easterly wind that may enhance noise from Wambo experienced at a particular location will not equally enhance noise from the proposal. Nonetheless, this approach does provide a crude method of assessing cumulative noise during prevailing weather.

Table 3.7 summarises the cumulative noise effects of surrounding mines and related infrastructure. The percentage values in the parenthesis indicate the contribution of HVO North (Carrington and West Pit) in noise terms at that receptor. Also provided is the percentage contribution from Carrington Pit alone, which highlights that from a noise perspective, the contribution of Carrington Pit is predicted to be relatively minor at all assessment locations, with the exception of Receptor No. 10, which is already within a zone of affectation. As an indication, in noise terms, noise sources which contribute less than around 50% of the received noise levels are considered to be a minor contributor.

The results are for prevailing weather conditions, as described earlier, and are therefore conservative. It should be noted that, based on the information provided in corresponding EISs, Wambo and Ravensworth-Narama mines will cease operations in 2016 and 2007 respectively. However, the Ravensworth-Narama mine was presumed to operate until 2012 (Year 1 of the proposal) for assessment purposes. The predicted noise from these operations was cumulatively assessed accordingly.

Table 3.7 Cumulative night-time L_{eq} noise levels at receptor locations

Location	Cumulative L_{eq} noise level (% contribution from HVO North), dB(A)			
Receptor No.	**Year 1 (Mitigated)**		**Year 5 (Mitigated)**	
	All Mine Noise (HVO North Contribution)	**Carrington Pit Contribution**	**All Mine Noise Overall (HVO North Contribution)**	**Carrington Pit Contribution**
1	39 (79%)	32%	41 (79%)	25%
2	40 (50%)	25%	41 (63%)	32%
3	40 (50%)	32%	41 (63%)	40%
4	42 (40%)	20%	41 (40%)	20%
5	42 (6%)	3%	42 (3%)	0%
6	42 (4%)	1%	42 (3%)	1%
7[1]	43 (32%)	10%	42 (25%)	2%
8[3]	47 (50%)	25%	45 (50%)	1%
10[2]	46 (79%)	63%	48 (79%)	63%
11[3]	42 (40%)	20%	41 (40%)	20%
13[4]	42 (79%)	10%	42 (79%)	13%
14[4]	42 (79%)	6%	42 (79%)	8%
39	46 (3%)	0%	46 (3%)	0%

1. *These private residences are currently inside a zone of affectation or subject to a private land holders agreement with mines other than HVO.*
2. *These private residences are currently inside a HVO zone of affectation or subject to a private land holders agreement.*
3. *Mine owned.*
4. *Additional Jerrys Plains locations were added to provide a better representation of the area.*

A night time cumulative noise criterion equivalent to the DECCW's night time amenity goal of 40dB(A) $L_{eq,9hour}$, is applicable for a rural residence according to the INP. Results show that all private residences, not currently within a zone of affectation and where HVO North makes a substantial contribution, will satisfy or be marginally (not more than 3dB) above the DECCW's amenity goal. However, as discussed earlier, the predictions above are based on a worst case $L_{eq,15minute}$ noise level from each operation. Adopting a conservative 3dB correction that is expected between the predicted worst case $L_{eq,15minute}$ and $L_{eq,9hour}$ noise level implies that noise at private residences, not within a zone of affectation, are predicted to be below the DECCW's amenity goal. This correction is due to the inherent downtime of plant over the nine hour night-time period as compared with a worst case 15-minute noise emission level. It should be noted that this 3dB intrusiveness to amenity correction has not been applied to any results.

3.9 Other noise issues

There will be works associated with the establishment of the temporary levee and diversion system, as well as the construction of the service corroder along the southern boundary of the proposed extension area. The noise from these activities will be regulated by the operational consent noise limits of the mine, since these activities will be undertaken during mining operations occurring in other areas of the site.

The equipment and activities required for these works are not as significant as those for mining operations and hence associated noise levels are expected to be lower than those from assessed mining operations.

4 Blasting noise and vibration

4.1 Human annoyance criteria

Typically, blasting at HVO North occurs once per day, however, it is not uncommon for two blasts to be undertaken in one day at larger mines or mines having multiple pits. Blasts can occur regularly on consecutive days throughout the majority of the year.

The blast design and corresponding air blast overpressure and ground vibration are within the control of operators. The existing blast management strategy, as detailed in the HVO Blast and Vibration Management Plan and Coal & Allied environmental procedure for blasting, will be used to ensure appropriate charge masses are designed for blasting. Such charge masses (or maximum instantaneous charge, MIC) are presented in Table 4.1. These were derived from 95 per cent formulas in Blastronics Pty Limited publication for monitoring data collected at similar mines in the Hunter Valley.

The data provides an indication of the likely MIC that should be considered a maximum to achieve the blast noise and vibration limits at sensitive receptor locations. Generally the blast overpressure noise dictates the required MIC needed to meet the limits, as shown in bold. Exceptions are locations at relatively large distances from blasting where the empirical formulae suggest ground vibration is the limiting factor. However, the accuracy of the formulae is diminished at these longer distances. The main observation of note in the results is that Receptor No.10 will be too close to allow for any practical blasts to occur and hence arrangements must be made well in advance of any blasts within 900m of this residence.

Table 4.1 Carrington blast calculations

Receptor No.	Closest blast distance to proposed extension area, m	MIC to achieve limit, kg	Blastronics 95% noise overpressure, dBL	Blastronics 95% ground vibration, PPV, mm/s
1	3300	1734	**115.0**	2.9
2	2900	1177	**115.0**	2.7
3	2800	1059	**115.0**	2.6
4	3200	1581	**115.0**	2.9
5	9700	31160	113.8	**5.0**
6	9500	29888	113.9	**5.0**
7[1]	6800	15176	**115.0**	**5.0**
8[3]	4600	4697	**115.0**	3.7
10[2]	900	35	**115.0**	1.1
11[3]	3600	2251	**115.0**	3.1
13[4]	4200	3575	**115.0**	3.5
14[4]	5000	6030	**115.0**	4.0
39	9700	31160	113.8	**5.0**

1. *These private residences are currently inside a zone of affectation or subject to a private land holders agreement with mines other than HVO.*
2. *These private residences are currently inside a HVO zone of affectation or subject to a private land holders agreement.*
3. *Mine owned.*
4. *Additional Jerrys Plains locations were added to provide a better representation of the area.*

4.2 Livestock

Very little evidence is available in literature on the direct impacts that blast noise has on livestock or animals in general. Blast noise is not a new or newly introduce source for the area, and therefore it is expected that livestock and other animals are accustomed to such sources of noise. For the proposal, it is clear that the current level of noise from blasting is not going to increase significantly at receiver locations assessed. A similar level of change is therefore expected for locations where livestock or animals inhabit. Impacts to animals are therefore expected to be minimal.

4.3 Sensitive structures

The Lemington Road Bridge over the Hunter River to the south was also considered. The bridge is considered to be a relatively robust structure, given that it is serviceable and has recently been reconstructed.

4.3.1 Structural damage from blasting

For assessment of damage from blast ground vibration AS2187.2 – 2006 (Appendix J) provides frequency based criteria, derived from British Standard 7385-2 and US Bureau of Mines Standard RI 8507. Such criteria are less stringent than for human comfort levels of 5mm/s described earlier.

A report by Bill Jordan & Associates (2009): "Edinglassie Homestead & Rous Lench – Blast Vibration Vulnerability" concludes that for the assessed heritage buildings, a vibration limit of 10mm/s peak component particle vibration velocity is appropriate. The report concluded that blast vibration at this level would be safe and that the 10mm/s limit was considered conservative.

To achieve 10mm/s peak particle velocity at the bridge (due to blasting), the charge mass must be approximately 5400kg MIC or less given a minimum separation distance of approximately 2500m for the closest mining area in Year 1 of the proposal.

This is considered to be within the realm of practical limits for blast designers and should allow for normal blasting practices to occur.

5 Noise and vibration management

Environmental aspects of Coal & Allied's activities are managed under Rio Tinto Coal Australia's Health, Safety, Environment and Quality (HSEQ) Management System which is certified to the international standard ISO:14001(2004). In addition, the HVO Noise Monitoring Programme and protocol for compliance, Environmental Work Instruction – Coal & Allied Noise, and the HVO Blast and Vibration Management Plan are and will continue to be implemented at HVO, including the Carrington Pit. These will be updated where necessary to reflect the proposal.

The development consent will continue to provide the mechanism for managing noise impacts by protecting the community via the regime of monitor, manage and mitigate. The option of acquisition on request will also continue to apply where applicable.

An overview of the standard measures that will continue to be implemented during operations and those that relate specifically to the proposal are provided following.

5.1 Noise management measures

5.1.1 Standard measures

The following controls will occur under standard conditions (24 hour mining operations; construction operations during daylight hours):

- plant, machinery and haul roads will be maintained in good condition according to manufacturer's specification and all repairs conducted promptly to ensure that equipment remains in a sound operating condition;
- sound power level testing of equipment will be undertaken annually in accordance with Rio Tinto Coal Australia's HSEQ Management System;
- activities that generate complaints will be monitored and modified if monitoring results confirm that DECCW noise criteria are being exceeded;
- environmental inductions will ensure that relevant employees are aware of potential impacts on sensitive receptors from equipment and its operation;
- noise emission levels will be considered where relevant in awarding contracts and purchasing new equipment;
- attended and unattended monitoring of noise will be undertaken at representative sites, with quarterly attended monitoring undertaken by a qualified acoustic consultant to supplement site noise data;
- monitoring using both directional and non-directional monitors with frequency filtering capabilities will be undertaken to determine the noise source;
- maintenance of monitoring systems consistent with regulatory requirements, best practice analytical techniques and published standards;
- installation, operation and calibration of monitors in accordance with relevant Australia Standards;

- maintenance of all monitoring records in Coal & Allied's environmental monitoring database; and
- noise monitoring results for representative sites will be included in the Annual Environmental Management Report (AEMR).

5.1.2 Measures specific to the proposal

While the proposal is predicted to result in similar noise levels to the existing Carrington Pit, the DoP has requested that the approach to the management of noise from the whole of HVO North is considered, including the implementation of both pro-active and reactive mitigation measures. These pro-active and reactive measures are summarised below.

i Pro-active Noise Management

Using predictive weather forecasting to assess noise predictions is a developing technology. Currently, the use of predictive wind speed and direction data coupled with inversion prediction requires further research, to enable them to be used as a definitive tool to manage noise. The HVO commits to participating in ongoing research towards their practical implementation. Whilst these technologies are developing, HVO will implement some practical pro-active management to reduce the impact of noise for residents in the Jerrys Plains vicinity.

Currently, a system of mining and overburden emplacement permission rules is being developed at HVO South. Real time data from the existing weather station at the site feeds into a wind speed and direction information system displayed on an aerial map of the site. The operator of the system is able to view the information in real time via an intranet website.

The operator of the system is provided with instructions included within the site procedures on whether mining or emplacement is to be allowed or restricted during certain wind conditions. This tool is particularly useful when activities are being undertaken in areas that have been shown in assessments to increase noise at receiver locations especially under adverse conditions.

This system will be extended to include operations at HVO North following its development and implementation.

Pro-active mine planning will also be implemented to plan for contingency events, such as during prevailing wind conditions that have the potential to increase noise beyond acceptable levels. An example of this planning would be the provision of alternative areas for overburden emplacement where practical, dependent on the prevailing meteorological conditions. The management and scheduling of mobile equipment will also be undertaken and may include strategically locating equipment in shielded or bunded areas during adverse conditions. Using the overburden emplacement permissions in combination with the contingency planning and equipment scheduling allows for an integrated approach to the management of operational noise.

These pro-active management actions are supported by a system of reactive management provided by the real time noise monitoring network.

ii Reactive Noise Management

The real time noise management system at HVO North will be expanded to include the use of permanent real time directional noise monitoring at Jerrys Plains with back-to-base feed of data. This will be implemented as follows.

- A monitoring device will be installed at a suitable location in Jerrys Plains, with preference given to properties east of the Golden Highway, to ensure contamination of data from road traffic is minimised and eliminated in the direction of the mine. The monitor will also include low pass frequency filter to eliminate high frequency sounds such as insects and birds. The noise level from the direction of the CWW and West Pit operation will be split to better understand the contributions from each area.

- Data will be communicated directly to HVO via the supervisory control and data acquisition (SCADA) system.

- The system will include the use of Trigger Alarms. An alarm will be set at an appropriate trigger level for Jerrys Plains. Current practices at similar operations at HVO South are being developed as a pro-active management tool and include a two phase alarm based on the INP guidelines and incorporating real time meteorological and noise data. This system can help inform management decisions to maintain noise levels within acceptable limits. A similar system will be applied across HVO North.

- When noise levels reach the trigger level an alarm would be sent via SMS and email to the site personnel at HVO.

- In the event of an alarm, the Open Cut Examiner will be notified and operational practices reviewed to minimise the potential for noise increasing beyond compliance levels.

Ongoing noise monitoring will be used to assess the performance of the mining operations against the predicted noise levels. Specifically, a rigorous monitoring regime will be implemented during the early phases of the operations to validate the potential impacts to Jerrys Plains and better understand the behaviour of sound propagation over the ridge between these receivers and the project area.

iii Attended Monitoring

In addition to the real time noise management system, quarterly attended noise is currently, and will continue to be, undertaken at Jerrys Plains. Additional monitoring may also be undertaken in response to community requests. Quarterly attended noise monitoring will continue to reaffirm findings of the real time system and to document audible sounds.

iv Reporting of Results

The results of both attended and real time monitoring will continue to be published on the Coal & Allied website on a quarterly basis.

5.2 Blasting mitigation measures

5.2.1 Standard measures

Regular controls for blast and vibration mitigation include:

- notification procedure for nearby residents unless otherwise agreed. This includes providing the blast schedule and hotline number on the proponent's website;
- assessment of real-time weather conditions prior to blasting and no blasting when unfavourable weather conditions are present;
- blasting will occur within the hours of 7am to 6pm Monday to Saturday, with no blasting permitted on Sundays or public holidays unless otherwise agreed with DECCW;
- ensuring good blast design and evacuating the area within 300 to 500m of a blast to ensure safety from fly rock;
- implementation of HVO's Road Closure Management Plan, which will be updated to include Lemington Road;
- completion of a Ground Disturbance Permit prior to blasting activities to avoid damage to nearby subsurface utilities ie telephone lines and water pipes;
- a programme of regular monitoring, including at sensitive buildings where identified;
- investigation of any blasts if monitoring results confirm that DECCW criteria are being exceeded;
- maintenance of monitoring systems consistent with regulatory requirements and operating manuals;
- installation, operation and calibration of monitors in accordance with relevant Australian Standards;
- review of all monitoring results in Coal & Allied's environmental monitoring database; and
- monitoring results for representative sites as listed in the HVO Blast and Vibration Management Plan will be included in the AEMR.

5.2.2 Measures specific to the proposal

Consultation and arrangements must be made with Receiver No. 10 in advance of any blasts within 900m from the residence.

To achieve 10mm/s peak particle velocity at the Lemington Road bridge (due to blasting), the charge mass must be approximately 5400kg MIC or less given a minimum separation distance of approximately 2500m for the closest mining area in Year 1 of the proposal.

6 Conclusion

This study considers the potential noise impacts of the proposal. The study included:

- modelling of all major mining equipment at representative locations for two worst case snapshots;
- comparison of predicted noise and vibrations levels with the existing consent limits;
- the use of almost four years of site-specific hourly meteorological data analysed in accordance with the DECCW's INP;
- source sound power levels for all equipment measured under operational conditions at mines (as opposed to the application of catalogue values or estimations); and
- the modelling itself addressed the DECCW's INP with regard to weather effects.

The noise modelling has shown that under calm weather conditions, consent operational limits are satisfied at all private residences not currently within a zone of affectation. During adverse winds (which are a feature during the night period only), predicted mine noise levels without mitigation are above the operational consent noise limits for eight of the assessed locations. After applying restrictions to operations of specific plant, operational noise limits are satisfied at most receptors. Similarly, a comparison with the consent acquisition limits, shows that all private residences not already within a zone of affectation satisfy these limits. The noise modelling package typically over-estimates noise emissions by approximately 3dB for adverse weather conditions. Allowing for this, it is considered that predicted levels are highly unlikely to eventuate and in any case, can be managed through noise and weather monitoring and operational management. The predicted mitigated noise levels during adverse INP weather conditions are unchanged or lower than those predicted and assessed in the ERM 2003 study at all of the representative receptor locations, including at Jerrys Plains.

Ongoing noise monitoring will be used to assess the performance of the mining operations against the predicted noise levels. Specifically, a rigorous monitoring regime will be used during the early phases of the operations to validate the potential impacts to Jerrys Plains and better understand the behaviour of sound propagation over the ridge between these receivers and the project area. Coal & Allied is committed to implementing pro-active noise management actions, supported by a system of reactive management provided by the real time noise monitoring network.

Blast design will incorporate control on the maximum instantaneous charge, as described in this study, to ensure blasting-induced vibration is within acceptable limits. This will also be addressed through monitoring. Notification of a nearby landholder within a zone of affectation will be adopted in advance of blasting.

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Appendix A

Mine Plans and Equipment Locations

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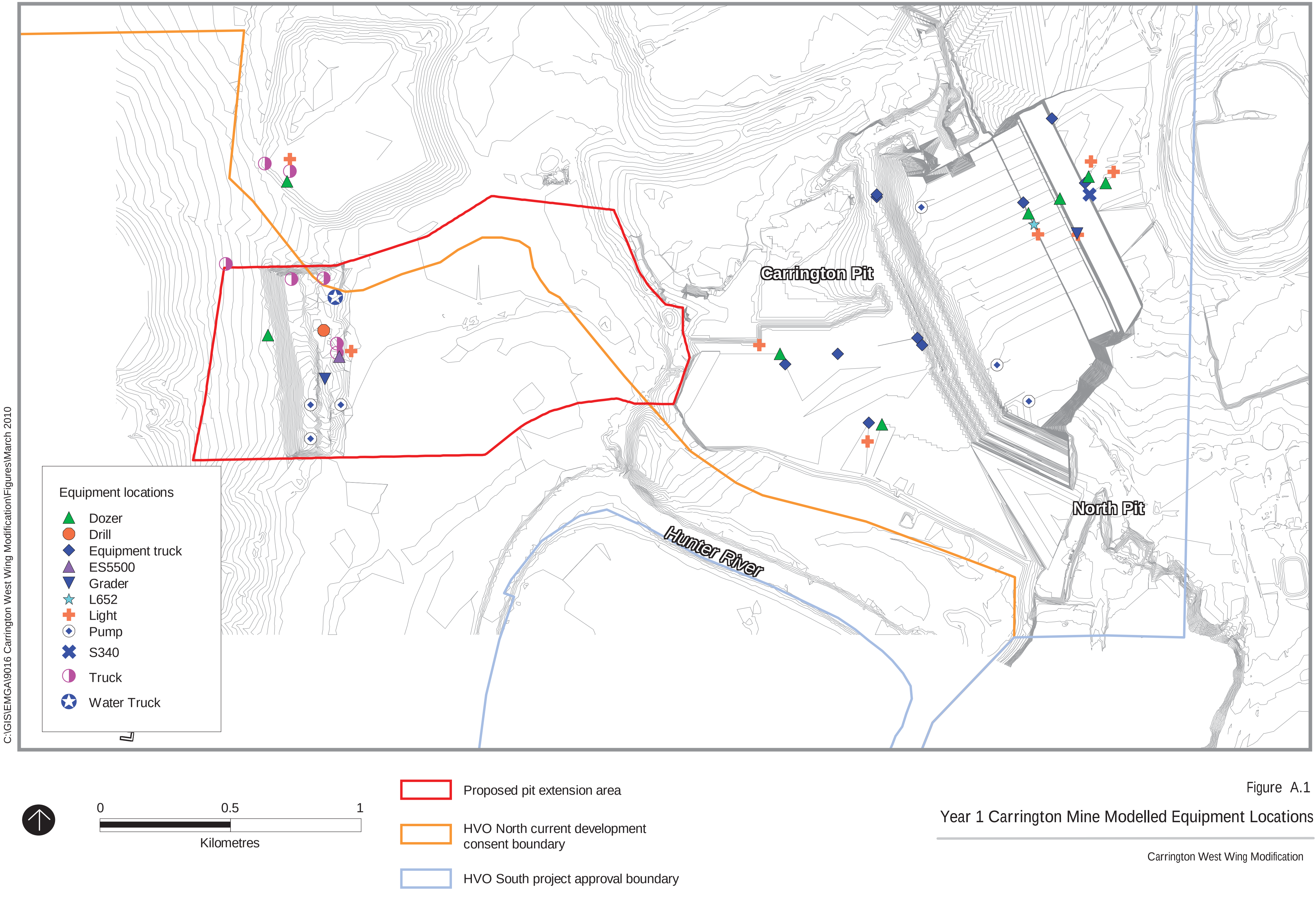

Figure A.1

Year 1 Carrington Mine Modelled Equipment Locations

Carrington West Wing Modification

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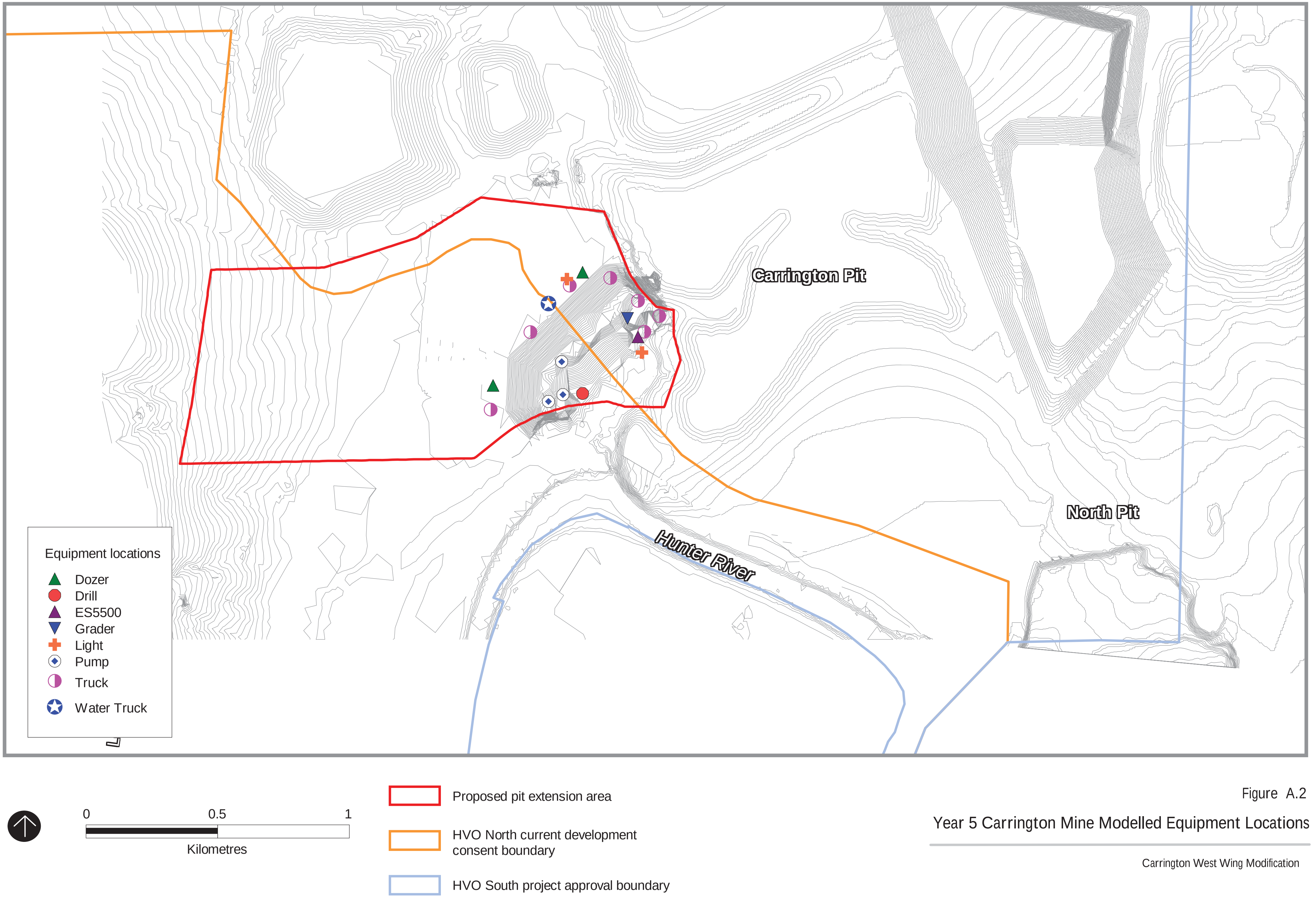

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Figure A.2

Year 5 Carrington Mine Modelled Equipment Locations

Carrington West Wing Modification

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