Annexure A

1. In addition to the property details listed on the form for Development Application 294/2018 (**Development Application**), the land to which the Development Application relates is also:

   (a) Lot 7031 in Deposited Plan 1066257;

   (b) Lot 7032 in Deposited Plan 1066257; and

   (c) the part of the unmade paper road comprised in certificate of title Volume 1956 Folio 183 shown highlighted pink in the aerial photo in Annexure A,

2. The Development Application is for Integrated Development pursuant to section 4.46 of the EPA Act and the works proposed in relation the part of the unmade paper road comprised in certificate of title Volume 1956 Folio 183 shown highlighted pink in the aerial photo in Annexure A, require approval under section 138 of the *Roads Act 1993*.

BELL QUARRY REHABILITATION PROJECT PTY LTD v LITHGOW CITY COUNCIL

Proceedings No. 2021/00091361

Statement of Commitment for development application 294/18

This statement of commitment has been prepared for Bell Quarry Rehabilitation Project Pty Ltd, the Applicant of development application 294/18 which seeks consent for the rehabilitation of the former Bell Quarry at Sandham Road, Dargan (**Proposed Development**) on Lot 23 in Deposited Plan 751631 (**Land**).

This statement of commitment will act as a foundation for how the Applicant commits to work with external stakeholders in carrying out the Proposed Development to ensure the proper rehabilitation of the Land in an environmentally satisfactory manner.

The Applicant commits to:

1. listening to and understanding any future concerns of nearby residents in relation to the operation of the Proposed Development through the establishment of a Community Consultative Committee (**CCC**). The CCC will be operated generally in accordance with the Department of Industry & Environment Community Consultative Committee Guidelines for State Significant Projects (January 2019, or its latest version);

2. rehabilitate and revegetate areas of land outside the cadastral boundaries of the Land and located in the Blue Mountains National Park which have been disturbed by previous quarrying activities on the Land in accordance with the vegetation management prepared by Cumberland Ecology and dated 16 November 2021, as may be amended in accordance with any requirements of National Parks and Wildlife Service;

3. rehabilitate and revegetate areas of land outside the cadastral boundaries of the Land and located on Lots 7031 and 7032 of Deposited Plan 1066257 as well as an unmade part of the public road known as 'Sandham Road' in accordance with the vegetation management plan proposed to be prepared in accordance with the report titled Supplementary Ecological Information prepared by Cumberland Ecology and dated 19 November 2021;

4. upgrading parts of Sandham Road in accordance with the offer to Council dated 19 November 2021 under the terms of the proposed voluntary planning agreement annexed to that offer;

5. ongoing maintenance of the unsealed portion of Sandham Road over the life of the Proposed Development, as required by consultation and agreement with Lithgow City Council as proposed in the voluntary planning agreement referred to in point 4 above; and

6. dedication or reservation of parts of the Land for environmental conservation purposes. The areas and location are to be determined in consultation with Council.

HWL EBSWORTH
LAWYERS

Our Ref: KMG:981456

19 November 2021

The General Manager
Lithgow City Council
180 Mort Street
LITHGOW NSW 2790

Email: council@lithgow.nsw.gov.au

Dear Sir/Madam

Bell Quarry Rehabilitation Project Pty Ltd v Lithgow City Council
Land and Environment Court Proceedings no. 2021/91361
Property: Lot 23 in DP 751631 - Sandham Road, Newnes Junction
Letter of offer to enter into a voluntary planning agreement

1. Purpose of this correspondence

1.1 This correspondence is a formal of offer on behalf of Bell Quarry Rehabilitation Project Pty Ltd (**Applicant**) to enter into a Planning Agreement pursuant to section 7.4 of the *Environmental Planning and Assessment Act 1979* (**EPA Act**) in support of development application 294/18 (**Development Application**) for the rehabilitation of Bell Quarry at Lot 23 in Deposited Plan 751631 (**Site**)

1.2 This letter is provided to Lithgow City Council (**Council**) together with the proposed planning agreement to formalise the offer and if accepted by Council, progress the agreement as expeditiously as possible.

2. Offer

Upgrade works

2.1 Council's Statement of Facts and Contentions filed on 21 July 2021 states at contention 12(c) that traffic impacts in relation to the proposed heavy vehicle movements over Sandham Road may be resolved by condition of consent.

2.2 Specifically it is stated that the recommendations of Council's Engineer for the widening and sealing of Sandham Road would address local concerns as to dust and public safety.

2.3 The Applicant has considered the matters raised by Council in its Statement of Facts and Contentions filed on 21 July 2021 and sought expert advice from Mr Brett

Maynard of GTA Consultants in relation to the extent of road improvements reasonably required to address the matters raised by Council in its SOFAC.

2.4 Whilst the Applicant does not agree that the wholesale upgrades required by Council are in fact required as a result of proposed development, in an effort to resolve the traffic contention, the Applicant is prepared to make a monetary contribution to Council for the carrying out of the following road upgrades:

(a) Widening of Sandham Road in select locations along the existing sealed section to provide passing bays which will allow safe passing between a truck-and-dog and a car and would also address the use of Sandham Road by non-quarry trucks and school buses;

(b) The length of the widening would be dependent on the existing road features and would be a minimum of 30 metres long (20 metres plus basic tapes).

2.5 The Applicant considers the most appropriate locations for the upgrade works listed in 2.4 are as per the locations shown in the photos in Annexure A.

2.6 In addition to the above the Applicant is also prepared to make a monetary contribution to Council for the basic safety upgrade of the approximately 1250 m2 long sealed section of the road comprising of warning signage and guide posts.

2.7 The costing of the road upgrade works in paragraphs 2.4 to 2.6 above has been estimated by the Applicant to be $138,512 plus GST. A cost summary report is provided at Annexure B.

Maintenance of Sandham Road (unsealed section - access to the site)

2.8 In addition to the monetary contribution referred to above, the Applicant agrees to maintain specified parts of the unsealed portion of Sandham Road to the standard existing at the date of the commencement of any development consent granted in relation to the Development Application.

2.9 A road survey will be carried out and provided to Council prior to the commencement of works under any development consent relating to the Development Application.

2.10 It is proposed that annual inspections of Sandham Road will be conducted with a Council officer and the Applicant's representative at its cost, to identify any maintenance works required to be carried out. Any required maintenance works will be carried out within a reasonable time period. This will ensure that Sandham Road is maintained to a safe standard and in accordance with the abovementioned road survey.

Dedication / reservation of parts of the Site for environmental conservation purposes

2.11 The Applicant proposes dedication or reservation of parts of the Land once rehabilitated and revegetated for environmental conservation purposes. The areas and location are to be determined in consultation with Council.

3. Section 7.12 developer contributions

3.1 The development of the Site would otherwise be subject to, and this offer does not propose to affect the application of the provisions of the *Section 94A Development Contributions Plan* for Lithgow City Council dated October 2015.

4. **Next steps**

4.1 The Applicant formally offers to pay a monetary contribution to Council in the amount of $140,000 for the purposes of the upgrade works listed in paragraphs 2.4 to 2.6 of the letter.

4.2 This letter of offer and draft planning agreement is submitted to Council for consideration as part of the Development Application.

4.3 We look forward to Council's response in relation to the proposed offer and draft planning agreement.

4.4 Please contact the writers should you wish to discuss.

Yours faithfully

Kirston Gerathy
Partner
HWL Ebsworth Lawyers

+61 2 9334 8628
kgerathy@hwle.com.au

Kara Mezinec
Senior Associate
HWL Ebsworth Lawyers

+61 2 9334 8737
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HWL EBSWORTH
LAWYERS

Annexure A

Location ID1

GTAconsultants

Location ID2

Location ID3

Location ID4

Location ID5

Location ID6

Location ID7

Note: 2 options, widen one side only

SUMMARY OF WIDENING

ID1 = 20m

ID2 = 20m

ID3 = 25m

ID5 = 50m

ID6 = 50m

ID6 = 15m

ID7 = 30m

Total length = 210m

Total area = 210m length x 2m widening = $420m^2$

Annexure B

Bell Quarry Road Widening

Item	Description	Qty	Unit	Rate	Amount
1	Establishment (site Amenities, Floats)	1	LS	$5,000.00	$5,000.00
2	Survey & supervision	1	LS	$12,000.00	$12,000.00
3	Tree prunning including remval of dead branches along sandham road	1	LS	$30,000.00	$30,000.00
4	Traffic Control (2 men crew)	140	Hrs	$98.00	$13,720.00
5	Earthworks + Swale drain	420	M2	$55.00	$23,100.00
6	Base and subbase	840	M2	$25.00	$21,000.00
7	Asphalt	420	M2	$43.57	$18,300.00
8	Road Marking and guide posts	1	LS	$2,800.00	$2,800.00
9	Sub total				$125,920.00
10	GST	1	LS	10%	$12,592.00
11	**Total inclusive of GST**	1	LS		$138,512.00

Deed

Lot 23 in Deposited Plan 751631, Sandham Road, Dargan NSW 2786

Planning Agreement

Under s7.4 of the *Environmental Planning and Assessment Act 1979*

Lithgow City Council

and

Bell Quarry Rehabilitation Project Pty ltd

Date:

Lot 23 in Deposited Plan 751631
Sandham Road, Dargan

Planning Agreement

Table of Contents

Lot 23 in Deposited Plan 751631

Sandham Road, Dargan

Summary Sheet

Council:

Name: Lithgow City Council
Address: 180 Mort Street, Lithgow NSW 2790
Telephone:
Email:
Representative: The General Manager

Developer:

Name: Bell Quarry Rehabilitation Project Pty Ltd
Address: Level 1, Suite1, 181 Macquarie Street, Parramatta NSW 2150
Telephone:
Email:
Representative: Robin Chalouhi

Land:

See definition of *Land* in clause 1.1.

Development:

See definition of *Development* in clause 1.1.

Development Contributions:

See Clause 8.

Application of s7.11, s7.12 and s7.24 of the Act:

See clause 7.

Registration:

See clause 15.

Restriction on dealings:

See clause 16.

Dispute Resolution:

See Part 3.

Lot 23 in Deposited Plan 751631, Sandham Road, Dargan

Under s7.4 of the *Environmental Planning and Assessment Act 1979*

Parties

Lithgow City Council ABN 59 986 092 492 of 180 Mort Street, Lithgow NSW 2790

and

Bell Quarry Rehabilitation Project Pty Ltd ACN 64 614 764 144 of Level 1, Suite 1, 181 Macquarie Street, Parramatta NSW 2150

(**Developer**)

Chalouhi Rural Pty Ltd ACN 603 687 350 of Level 1, Suite 1, 181 Macquarie Street, Parramatta NSW 2150

(**Land Owner**)

Background

A The Land Owner owns the Land.

B On 29 November 2018, the Developer made a Development Application to Council to carry out the Development on the Land.

C The Land Owner consents to the Development being carried out on the Land.

D The Developer has offered to make Development Contributions in connection with the Development and in accordance with this Deed.

Operative provisions

Part 1 - Preliminary

1 Interpretation

1.1 In this Deed the following definitions apply:

Act means the *Environmental Planning and Assessment Act 1979* (NSW).

Approval includes approval, consent, licence, permission or the like.

Authority means the Commonwealth or New South Wales government, a Minister of the Crown, a government department, a public authority established by or under any Act, a council or county council constituted under the *Local Government Act 1993*, or a person or body exercising functions under any Act including a commission, panel, court, tribunal and the like.

Bank Guarantee means an irrevocable and unconditional undertaking without any expiry or end date in favour of the Council to pay an amount or amounts of money to the Council on demand issued by:

(a) one of the following trading banks:
  - (i) Australia and New Zealand Banking Group Limited,
  - (ii) Commonwealth Bank of Australia,
  - (iii) Macquarie Bank Limited,
  - (iv) National Australia Bank Limited,
  - (iv) St George Bank Limited,
  - (v) Westpac Banking Corporation, or

(b) any other financial institution approved by the Council in its absolute discretion.

Claim includes a claim, demand, remedy, suit, injury, damage, loss, Cost, liability, action, proceeding or right of action.

Construction Certificate has the same meaning as in the Act.

Contribution Item means an item of Development Contribution specified in Column 1 of Schedule 1.

Cost means a cost, charge, expense, outgoing, payment, fee and other expenditure of any nature.

CPI means the *Consumer Price Index (All Groups – Sydney)* published by the Australian Bureau of Statistics.

Deed means this Deed and includes any schedules, annexures and appendices to this Deed.

Department means the Department of Planning, Industry and Environment.

Development means the rehabilitation of the former Bell Quarry located at Lot 23 in Deposited Plan 751631 through the importation of VENM, ENM and comparable material.

Development Application has the same meaning as in the Act.

Development Consent has the same meaning as in the Act.

Development Contribution means a monetary contribution, the dedication of land free of cost, the carrying out of work, or the provision of any other material public benefit, or any combination of them, to be used for, or applied towards a public purpose, but does not include any security or other benefit provided by a Party to the Council to secure the enforcement of that Party's obligations under this Deed for the purposes of s7.4(3)(g) of the Act.

Dispute means a dispute or difference between the Parties under or in relation to this Deed.

GST has the same meaning as in the GST Law.

GST Law has the same meaning as in *A New Tax System (Goods and Services Tax) Act 1999* (Cth) and any other Act or regulation relating to the imposition or administration of the GST.

Item means an item specified in Column 1 of Schedule 1.

Land means the land comprised in Lot 23 in Deposited Plan 751631.

Maintain means works to bring an item to a state of reasonable condition and in accordance with relevant standards applicable at the time of construction of the item, including:

(a) repairing any defects due to use of poor materials or due to poor workmanship; and
(b) removing graffiti or repairing or replacing any item damaged as a consequence of vandalism, provided that works required as a consequence of graffiti or vandalism do not exceed $100,000 per annum.

Maintained and Maintenance have corresponding meanings.

Monetary Contribution means the total $ amount specified in Column 1, Item 1 of Schedule 1 indexed quarterly in accordance with the CPI from the date on which this Deed is executed until the Monetary Contribution is provided to Council in accordance with Schedule 1.

Party means a party to this Deed.

Regulation means the *Environmental Planning and Assessment Regulation 2000*.

1.2 In the interpretation of this Deed, the following provisions apply unless the context otherwise requires:

1.2.1 Headings are inserted for convenience only and do not affect the interpretation of this Deed.

1.2.2 A reference in this Deed to a business day means a day other than a Saturday or Sunday on which banks are open for business generally in Sydney.

1.2.3 If the day on which any act, matter or thing is to be done under this Deed is not a business day, the act, matter or thing must be done on the next business day.

1.2.4 A reference in this Deed to dollars or $ means Australian dollars and all amounts payable under this Deed are payable in Australian dollars.

1.2.5 A reference in this Deed to a $ value relating to a Development Contribution is a reference to the value exclusive of GST.

1.2.6 A reference in this Deed to any law, legislation or legislative provision includes any statutory modification, amendment or re-enactment, and any subordinate legislation or regulations issued under that legislation or legislative provision.

1.2.7 A reference in this Deed to any agreement, deed or document is to that agreement, deed or document as amended, novated, supplemented or replaced.

1.2.8 A reference to a clause, part, schedule or attachment is a reference to a clause, part, schedule or attachment of or to this Deed.

1.2.9 An expression importing a natural person includes any company, trust, partnership, joint venture, association, body corporate or governmental agency.

1.2.10 Where a word or phrase is given a defined meaning, another part of speech or other grammatical form in respect of that word or phrase has a corresponding meaning.

1.2.11 A word which denotes the singular denotes the plural, a word which denotes the plural denotes the singular, and a reference to any gender denotes the other genders.

1.2.12 References to the word 'include' or 'including' are to be construed without limitation.

1.2.13 A reference to this Deed includes the agreement recorded in this Deed.

1.2.14 A reference to a Party to this Deed includes a reference to the employees, agents and contractors of the Party, the Party's successors and assigns.

1.2.15 A reference to 'dedicate' or 'dedication' in relation to land is a reference to dedicate or dedication free of cost.

1.2.16 Any schedules, appendices and attachments form part of this Deed.

1.2.17 Notes appearing in this Deed are operative provisions of this Deed.

2 Status of this Deed

2.1 This Deed is a planning agreement within the meaning of s7.4(1) of the Act.

3 Commencement

3.1 This Deed commences and has force and effect on and from the date when the Parties have:

3.1.1 both executed the same copy of this Deed, or

3.1.2 each executed separate counterparts of this Deed and exchanged the counterparts.

3.2 The Parties are to insert the date when this Deed commences on the front page and on the execution page.

4 Application of this Deed

4.1 This Deed applies to the Land and the Development.

5 Warranties

5.1 The Parties warrant to each other that they:

5.1.1 have full capacity to enter into this Deed, and

5.1.2 are able to fully comply with their obligations under this Deed.

6 Further agreements

6.1 The Parties may, at any time and from time to time, enter into agreements relating to the subject-matter of this Deed that are not inconsistent with this Deed for the purpose of implementing this Deed.

7 Application of s7.11, s7.12 and s7.24 of the Act to the Development

7.1 This Deed does not exclude the application of ss7.11, 7.12 or 7.24 to the Development.

7.2 The benefits under this Deed are to be taken into consideration in determining a Development Contribution under s7.11 of the Act to the Development to the extent provided for in Item 7 in Schedule 1.

Part 2 – Development Contributions

8 Provision of Development Contributions

8.1 The Developer is to make Development Contributions to the Council in accordance with Schedule 1, any other provision of this Deed relating to the making of Development Contributions and otherwise to the satisfaction of the Council.

8.2 The Council is to apply each Development Contribution made by the Developer under this Deed towards the public purpose for which it is made and otherwise in accordance with this Deed.

9 Payment of Monetary Development Contributions

9.1 The Developer is to pay to the Council the Monetary Contribution in the manner and at the time or times specified in Schedule 1.

9.2 A Monetary Contribution is made for the purposes of this Deed when the Council receives the full amount of the contribution payable under this Deed in cash or by unendorsed bank cheque or by the deposit by means of electronic funds transfer of cleared funds into a bank account nominated by the Council.

10 Maintenance of Sandham Road

10.1 A dilapidation survey of Sandham Road from the intersection with Bells Line of Road to the Land, must be carried out and provided to Council prior to the commencement of works under any development consent granted in relation to the Development.

10.2 The Developer must Maintain the part of Sandham Road between Bells Line of Road and the Land for the life of the Development, to at least the standard reported in the dilapidation survey provided under clause 10.1 of this Deed.

10.3 Annual inspections of the part of Sandham Road from Bells Line of Road to the Land must be conducted by a representative of the Developer with a Council officer and traffic engineer engaged by the Developer at its cost present, to identify any Maintenance required to be carried out.

10.4 Any Maintenance agreed between the representative of the Developer, the Council officer and the traffic engineer as being required, must be carried out within a reasonable time period relevant to the required Maintenance Work.

Part 3 – Dispute Resolution

11 Dispute resolution – expert determination

11.1 This clause applies to a Dispute between any of the Parties to this Deed concerning a matter arising in connection with this Deed that can be determined by an appropriately qualified expert if:

- 11.1.1 the Parties to the Dispute agree that it can be so determined, or
- 11.1.2 the Chief Executive Officer of the professional body that represents persons who appear to have the relevant expertise to determine the Dispute gives a written opinion that the Dispute can be determined by a member of that body.

11.2 A Dispute to which this clause applies is taken to arise if one Party gives another Party a notice in writing specifying particulars of the Dispute.

11.3 If a notice is given under clause 11.2, the Parties are to meet within 14 days of the notice in an attempt to resolve the Dispute.

11.4 If the Dispute is not resolved within a further 28 days, the Dispute is to be referred to the President of the NSW Law Society to appoint an expert for expert determination.

11.5 The expert determination is binding on the Parties except in the case of fraud or misfeasance by the expert.

11.6 Each Party is to bear its own costs arising from or in connection with the appointment of the expert and the expert determination.

11.7 The Parties are to share equally the costs of the President, the expert, and the expert determination.

12 Dispute Resolution - mediation

12.1 This clause applies to any Dispute arising in connection with this Deed other than a Dispute to which clause 11 applies.

12.2 Such a Dispute is taken to arise if one Party gives another Party a notice in writing specifying particulars of the Dispute.

12.3 If a notice is given under clause 12.2, the Parties are to meet within 14 days of the notice in an attempt to resolve the Dispute.

12.4 If the Dispute is not resolved within a further 28 days, the Parties are to mediate the Dispute in accordance with the Mediation Rules of the Law Society of New South Wales published from time to time and are to request the President of the Law Society to select a mediator.

12.5 If the Dispute is not resolved by mediation within a further 28 days, or such longer period as may be necessary to allow any mediation process which has been commenced to be completed, then the Parties may exercise their legal rights in relation to the Dispute, including by the commencement of legal proceedings in a court of competent jurisdiction in New South Wales.

12.6 Each Party is to bear its own costs arising from or in connection with the appointment of a mediator and the mediation.

12.7 The Parties are to share equally the costs of the President, the mediator, and the mediation.

Part 4 - Enforcement

13 Breach of obligations

13.1 If the Council reasonably considers that the Developer is in breach of any obligation under this Deed, it may give a written notice to the Developer:

  13.1.1 specifying the nature and extent of the breach,

  13.1.2 requiring the Developer to:

    (a) rectify the breach if it reasonably considers it is capable of rectification, or

(b) pay compensation to the reasonable satisfaction of the Council in lieu of rectifying the breach if it reasonably considers the breach is not capable of rectification,

13.1.3 specifying the period within which the breach is to be rectified or compensation paid, being a period that is reasonable in the circumstances.

13.2 Any costs incurred by the Council in remedying a breach in accordance with clause **Error! Reference source not found.** may be recovered by the Council as a debt due in a court of competent jurisdiction.

13.3 For the purpose of clause 13.2, the Council's costs of remedying a breach the subject of a notice given under clause 13.1 include, but are not limited to:

13.3.1 the costs of the Council's employees, agents and contractors reasonably incurred for that purpose,

13.3.2 all fees and charges necessarily or reasonably incurred by the Council in remedying the breach, and

13.3.3 all legal costs and expenses reasonably incurred by the Council, by reason of the breach.

13.4 Nothing in this clause 13 prevents the Council from exercising any rights it may have at law or in equity in relation to a breach of this Deed by the Developer, including but not limited to seeking relief in an appropriate court.

14 Enforcement in a court of competent jurisdiction

14.1 Without limiting any other provision of this Deed, the Parties may enforce this Deed in any court of competent jurisdiction.

14.2 For the avoidance of doubt, nothing in this Deed prevents:

14.2.1 a Party from bringing proceedings in the Land and Environment Court to enforce any aspect of this Deed or any matter to which this Deed relates, or

14.2.2 the Council from exercising any function under the Act or any other Act or law relating to the enforcement of any aspect of this Deed or any matter to which this Deed relates.

Part 5 – Registration & Restriction on Dealings

15 Registration of this Deed

15.1 The Parties agree to register this Deed for the purposes of s7.6(1) of the Act.

15.2 Not later than 10 Business Days after the commencement of this Deed, the Developer is to deliver to the Council in registrable form:

15.2.1 an instrument requesting registration of this Deed on the title to the Land duly executed by the Developer, and

15.2.2 the written irrevocable consent of each person referred to in s7.6(1) of the Act to that registration.

15.3 This Deed is to be lodged for registration within 21 days from the date of execution of the Deed. The Developer is to do such other things as are reasonably necessary to enable registration of this Deed to occur.

15.4 The Parties are to do such things as are reasonably necessary to remove any notation relating to this Deed from the title to the Land once the Developer has completed its obligations under this Deed to the reasonable satisfaction of the Council or this Deed is terminated or otherwise comes to an end for any other reason.

16 Restriction on dealings

16.1 The Developer is not to:

16.1.1 sell or transfer the Land, or

16.1.2 assign the Developer's rights or obligations under this Deed, or novate this Deed,

to any person unless:

16.1.3 the Developer has, at no cost to the Council, first procured the execution by the person to whom the Land or part is to be sold or transferred or the Developer's rights or obligations under this Deed are to be assigned or novated, of a deed in favour of the Council on terms reasonably satisfactory to the Council, and

16.1.4 the Council has given written notice to the Developer stating that it reasonably considers that the purchaser, transferee, assignee or novatee, is reasonably capable of performing its obligations under this Deed, and

16.1.5 the Developer is not in breach of this Deed, and

16.1.6 the Council otherwise consents to the transfer, assignment or novation, such consent not to be unreasonably withheld.

16.2 Subject to clause 16.3, the Developer acknowledges and agrees that it remains liable to fully perform its obligations under this Deed unless and until it has complied with its obligations under clause 16.1.

16.3 Clause 16.1 does not apply in relation to any sale or transfer of the Land if this Deed is registered on the title to the Land at the time of the sale.

Part 6 – Risk and Release

17 Risk

17.1 The Developer performs this Deed at its own risk and its own cost.

18 Release

18.1 The Developer releases the Council from any Claim it may have against the Council arising in connection with the performance of the Developer's obligations under this Deed except if, and to the extent that, the Claim arises because of the Council's negligence or default.

Part 7 – Other Provisions

19 Review of Deed

19.1 The Parties agree to review this Deed every year, and otherwise if either party is of the opinion that any change of circumstance has occurred, or is imminent, that materially affects the operation of this Deed.

19.2 For the purposes of clause 19.1, the relevant changes include (but are not limited to) any change to a law that restricts or prohibits or enables the Council or any other planning Authority to restrict or prohibit any aspect of the Development.

19.3 For the purposes of addressing any matter arising from a review of this Deed referred to in clause 19.1, the Parties are to use all reasonable endeavours to agree on and implement appropriate amendments to this Deed.

19.4 If this Deed becomes illegal, unenforceable or invalid as a result of any change to a law, the Parties agree to do all things necessary to ensure that an enforceable agreement of the same or similar effect to this Deed is entered into.

19.5 A failure by a Party to agree to take action requested by the other Party as a consequence of a review referred to in clause 19.1 (but not 19.4) is not a Dispute for the purposes of this Deed and is not a breach of this Deed.

20 Notices

20.1 Any notice, consent, information, application or request that is to or may be given or made to a Party under this Deed is only given or made if it is in writing and sent in one of the following ways:

- 20.1.1 delivered or posted to that Party at its address set out in the Summary Sheet, or
- 20.1.2 emailed to that Party at its email address set out in the Summary Sheet.

20.2 If a Party gives the other Party 3 business days' notice of a change of its address or email, any notice, consent, information, application or request is only given or made by that other Party if it is delivered, posted or emailed to the latest address.

20.3 Any notice, consent, information, application or request is to be treated as given or made if it is:

20.3.1 delivered, when it is left at the relevant address,

20.3.2 sent by post, 2 business days after it is posted, or

20.3.3 sent by email and the sender does not receive a delivery failure message from the sender's internet service provider within a period of 24 hours of the email being sent.

20.4 If any notice, consent, information, application or request is delivered, or an error free transmission report in relation to it is received, on a day that is not a business day, or if on a business day, after 5pm on that day in the place of the Party to whom it is sent, it is to be treated as having been given or made at the beginning of the next business day.

21 Approvals and Consent

21.1 Except as otherwise set out in this Deed, and subject to any statutory obligations, a Party may give or withhold an approval or consent to be given under this Deed in that Party's absolute discretion and subject to any conditions determined by the Party.

21.2 A Party is not obliged to give its reasons for giving or withholding consent or for giving consent subject to conditions.

22 Costs

22.1 The Developer is to pay to the Council the Council's costs of preparing, negotiating, executing and stamping this Deed, and any document related to this Deed up to an amount of $5,000, within 7 days of a written demand by the Council for such payment.

22.2 The Developer is also to pay to the Council the Council's reasonable costs of enforcing this Deed within 7 days of a written demand by the Council for such payment.

23 Entire Deed

23.1 This Deed contains everything to which the Parties have agreed in relation to the matters it deals with.

23.2 No Party can rely on an earlier document, or anything said or done by another Party, or by a director, officer, agent or employee of that Party, before this Deed was executed, except as permitted by law.

24 Further Acts

24.1 Each Party must promptly execute all documents and do all things that another Party from time to time reasonably requests to effect, perfect or complete this Deed and all transactions incidental to it.

25 Governing Law and Jurisdiction

25.1 This Deed is governed by the law of New South Wales.

25.2 The Parties submit to the non-exclusive jurisdiction of its courts and courts of appeal from them.

25.3 The Parties are not to object to the exercise of jurisdiction by those courts on any basis.

26 Joint and Individual Liability and Benefits

26.1 Except as otherwise set out in this Deed:

26.1.1 any agreement, covenant, representation or warranty under this Deed by 2 or more persons binds them jointly and each of them individually, and

26.1.2 any benefit in favour of 2 or more persons is for the benefit of them jointly and each of them individually.

27 No Fetter

27.1 Nothing in this Deed shall be construed as requiring Council to do anything that would cause it to be in breach of any of its obligations at law, and without limitation, nothing shall be construed as limiting or fettering in any way the exercise of any statutory discretion or duty.

28 Illegality

28.1 If this Deed or any part of it becomes illegal, unenforceable or invalid as a result of any change to a law, the Parties are to co-operate and do all things necessary to ensure that an enforceable agreement of the same or similar effect to this Deed is entered into.

29 Severability

29.1 If a clause or part of a clause of this Deed can be read in a way that makes it illegal, unenforceable or invalid, but can also be read in a way that makes it legal, enforceable and valid, it must be read in the latter way.

29.2 If any clause or part of a clause is illegal, unenforceable or invalid, that clause or part is to be treated as removed from this Deed, but the rest of this Deed is not affected.

30 Amendment

30.1 No amendment of this Deed will be of any force or effect unless it is in writing and signed by the Parties to this Deed in accordance with clause 25C of the Regulation.

31 Waiver

31.1 The fact that a Party fails to do, or delays in doing, something the Party is entitled to do under this Deed, does not amount to a waiver of any obligation of, or breach of obligation by, another Party.

31.2 A waiver by a Party is only effective if it:

31.2.1 is in writing,

31.2.2 is addressed to the Party whose obligation or breach of obligation is the subject of the waiver,

31.2.3 specifies the obligation or breach of obligation the subject of the waiver and the conditions, if any, of the waiver,

31.2.4 is signed and dated by the Party giving the waiver.

31.3 Without limitation, a waiver may be expressed to be conditional on the happening of an event, including the doing of a thing by the Party to whom the waiver is given.

31.4 A waiver by a Party is only effective in relation to the particular obligation or breach in respect of which it is given, and is not to be taken as an implied waiver of any other obligation or breach or as an implied waiver of that obligation or breach in relation to any other occasion.

31.5 For the purposes of this Deed, an obligation or breach of obligation the subject of a waiver is taken not to have been imposed on, or required to be complied with by, the Party to whom the waiver is given.

32 GST

32.1 In this clause:

Adjustment Note, **Consideration**, **GST**, **GST Group**, **Margin Scheme**, **Money, Supply** and **Tax Invoice** have the meaning given by the GST Law.

GST Amount means in relation to a Taxable Supply the amount of GST payable in respect of the Taxable Supply.

GST Law has the meaning given by the *A New Tax System (Goods and Services Tax) Act 1999* (Cth).

Input Tax Credit has the meaning given by the GST Law and a reference to an Input Tax Credit entitlement of a party includes an Input Tax Credit for an acquisition made by that party but to which another member of the same GST Group is entitled under the GST Law.

Taxable Supply has the meaning given by the GST Law excluding (except where expressly agreed otherwise) a supply in respect of which the supplier chooses to apply the Margin Scheme in working out the amount of GST on that supply.

32.2 Subject to clause 32.4, if GST is payable on a Taxable Supply made under, by reference to or in connection with this Deed, the Party providing the Consideration for that Taxable Supply must also pay the GST Amount as additional Consideration.

32.3 Clause 32.2 does not apply to the extent that the Consideration for the Taxable Supply is expressly stated in this Deed to be GST inclusive.

32.4 No additional amount shall be payable by the Council under clause 32.2 unless, and only to the extent that, the Council (acting reasonably and in accordance with the GST Law) determines that it is entitled to an Input Tax Credit for its acquisition of the Taxable Supply giving rise to the liability to pay GST.

32.5 If there are Supplies for Consideration which is not Consideration expressed as an amount of Money under this Deed by one Party to the other Party that are not subject to Division 82 of the *A New Tax System (Goods and Services Tax) Act 1999*, the Parties agree:

32.5.1 to negotiate in good faith to agree the GST inclusive market value of those Supplies prior to issuing Tax Invoices in respect of those Supplies;

32.5.2 that any amounts payable by the Parties in accordance with clause 32.2 (as limited by clause 32.4) to each other in respect of those Supplies will be set off against each other to the extent that they are equivalent in amount.

32.6 No payment of any amount pursuant to this clause 32, and no payment of the GST Amount where the Consideration for the Taxable Supply is expressly agreed to be GST inclusive, is required until the supplier has provided a Tax Invoice or Adjustment Note as the case may be to the recipient.

32.7 Any reference in the calculation of Consideration or of any indemnity, reimbursement or similar amount to a cost, expense or other liability incurred by a party, must exclude the amount of any Input Tax Credit entitlement of that party in relation to the relevant cost, expense or other liability.

32.8 This clause continues to apply after expiration or termination of this Deed.

33 Explanatory Note

33.1 The Appendix contains the Explanatory Note relating to this Deed required by clause 25E of the Regulation.

33.2 Pursuant to clause 25E(7) of the Regulation, the Parties agree that the Explanatory Note is not to be used to assist in construing this Planning Deed.

Schedule 1

(Clause 8)

Development Contributions

Column 1 Item/ Contribution	Column 2 Public Purpose	Column 3 Manner & Extent	Column 4 Timing
A. Monetary Contributions			
1.$140,000 (one hundred and forty thousand dollars) including GST	1. The following road upgrade works to Sandham Road, Dargan in the locations shown in the photos included in Schedule 2: (a) widening of Sandham Road in select locations along the existing sealed section to provide passing bays which will allow safe passing between a truck-and-dog and a car and would also address the use of Sandham Road by non-quarry trucks and school buses; (b) length of the widening is be dependent on the existing road features and would be a minimum of 30 metres long (20 metres plus basic tapes) as summarised in Schedule 3. 2. Safety upgrade of the approximately 1250 m2 long sealed section of Sandham Road, Dargan comprising of warning signage and guide posts.	Payable as a lump sum	Payable upon execution of the Deed.

Schedule 2

Upgrade Works

Location ID1

GTAconsultants

Location ID2

Location ID3

Location ID4

GTAconsultants

Location ID5

GTAconsultants

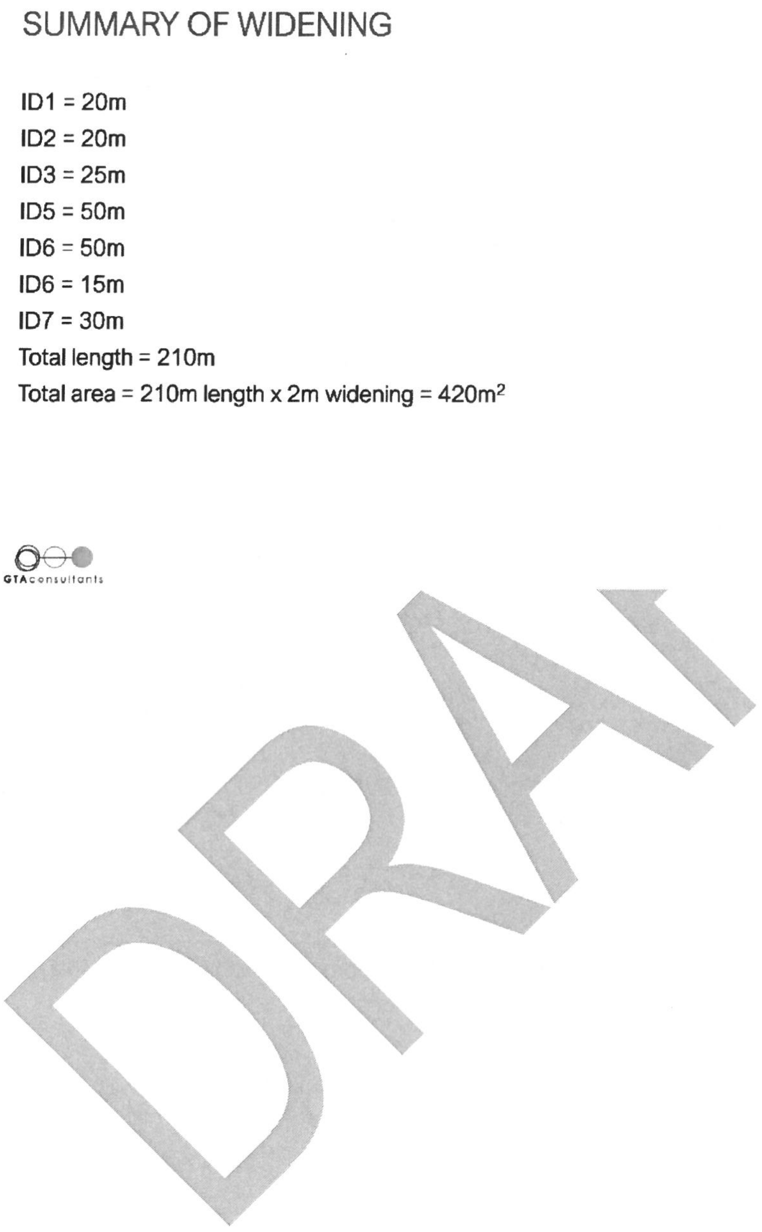
Location ID6

Location ID7

Note: 2 options, widen one side only

Schedule 3

Summary of Widening



SUMMARY OF WIDENING

ID1 = 20m
ID2 = 20m
ID3 = 25m
ID5 = 50m
ID6 = 50m
ID6 = 15m
ID7 = 30m
Total length = 210m
Total area = 210m length x 2m widening = 420m²

GTAconsultants

Execution

Executed as a Deed

Dated:

Executed on behalf of the Council

General Manager	**Witness**
Mayor	**Witness**

Executed on behalf of the Developer in accordance with s127(1) of the Corporations Act (Cth) 2001

Name/Position

Name/Position

Executed on behalf of the Land Owner in accordance with s127(1) of the Corporations Act (Cth) 2001

Name/Position

Name/Position

Appendix

(Clause 33)

Environmental Planning and Assessment Regulation 2000

(Clause 25E)

Explanatory Note

Draft Planning Agreement

Under s7.4 of the *Environmental Planning and Assessment Act 1979*

Parties

Lithgow City Council ABN 59 986 092 492 of 180 Mort Street, Lithgow NSW 2790

(Council)

and

Bell Quarry Rehabilitation Project Pty Ltd ACN 64 614 764 144 of Level 1, Suite 1, 181 Macquarie Street, Parramatta NSW 2150

(Developer)

Chalouhi Rural Pty Ltd [insert details]

(Landowner)

Description of the Land to which the Draft Planning Agreement Applies

The Draft Planning Agreement applies to Lot 23 in Deposited Plan 751631, Sandham Road, Dargan NSW 2786 being the land shown shaded in red in the plan below.

[Plan to be inserted]

Description of Proposed Development

The Draft Planning Agreement is in connection with the proposed rehabilitation of the Land through the importation of clean fill.

Description of Development Contributions

Under the Draft Planning Agreement, the Developer is to pay a monetary Development Contribution to the Council in the amount of $140,000 excluding GST to be applied towards the upgrade of parts of Sandham Road, Dargan within the Council's local government area as set out below:

(a) widening of Sandham Road in select locations along the existing sealed section to provide passing bays which will allow safe passing between a truck-and-dog and a car and would also address the use of Sandham Road by non-quarry trucks and school buses;

(b) length of the widening is be dependent on the existing road features and would be a minimum of 30 metres long (20 metres plus basic tapes); and

(c) Safety upgrade of the approximately 1250 m2 long sealed section of Sandham Road, Dargan comprising of warning signage and guide posts.

Summary of Objectives, Nature and Effect of the Draft Planning Agreement

Objective, Nature and Effect of Draft Planning Agreement

The Draft Planning Agreement is a planning agreement under s7.4 of the EPA Act. It is a voluntary agreement, under which the Developer makes Development Contributions (as defined in clause 1.1 of the Draft Planning Agreement) for public purposes (as defined in s 7.4(2) of the EPA Act).

The objectives of the Draft Planning Agreement are to provide funding for the upgrade of Sandham Road as set out in the 'Description of Development Contributions'. The Draft Planning Agreement:

- requires the Developer to make monetary development contributions,
- does not exclude the application of s 7.11, s7.12 and 7.24 of the EPA Act to the Development,
- is to be registered on the title to the Land,
- imposes restrictions on the Developer transferring the Land or part of the Land or assigning an interest under the Agreement prior to registration of the planning agreement on the title to the land,
- provides a dispute resolution method where a dispute arises under the agreement, being mediation and expert determination,
- provides that the agreement is governed by the law of New South Wales,

Assessment of the Merits of the Draft Planning Agreement

How the Draft Planning Agreement Promotes the Public Interest

The Draft Planning Agreement will provide Council with funding to be applied towards upgrade of Sandham Road as described under 'Description of Development Contributions'.

The Draft Planning Agreement:

- promotes the objects of the EPA Act set out in sections 1.3 (c) and (j); and
- enables the funding and provision of public improvements for the public benefit and to address demand arising from the development of the Land.

The Draft Planning Agreement also promotes the following guiding principles for local councils as set out in s8A of the *Local Government Act 1993* by:

- providing an example of Council working with others, being the Developer, to secure appropriate services for local community needs,
- promoting active engagement with local communities by being required to be publicly notified in accordance with the *Environmental Planning and Assessment Regulation 2000*,
- promoting Council's long-term strategic planning on behalf of the local community.

Whether the Draft Planning Agreement Conforms with the Authority's Capital Works Program

Yes. The Drafting Planning Agreement conforms with Council's Capital Works Program.

Whether the Draft Planning Agreement specifies that certain requirements must be complied with before a construction certificate, occupation certificate or subdivision certificate is issued

Yes. This Draft Planning Agreement specifies that the Developer must pay monetary contributions upon execution of the Deed.

Bell Quarry Rehabilitation Project

Supplementary Environmental Impact Statement

Bell Quarry Rehabilitation Project

19 November 2021

Submission of Supplementary EIS

Prepared under the Environmental Planning and Assessment Act 1979, Section 4.10

Environmental Assessment prepared by	**Name:**	Karl Rosen	Anthony Dixon
	Qualification:	Bachelor of Science (hons I) Applied Physical Geography	Bachelor of Chemical Engineering (hons), Master of Environmental Engineering and Master of Groundwater Management
	Address:	GHD Pty Ltd L15, 133 Castlereagh Street Sydney NSW 2000	GHD Pty Ltd L15, 133 Castlereagh Street Sydney NSW 2000
	In respect of:	Bell Quarry Rehabilitation Project as described in this Supplementary EIS	
Development Application	**Applicant's name:**	Bell Quarry Rehabilitation Project Pty Ltd	
	Applicant's address:	Level 1, Suite 1, 181 Macquarie Street Parramatta NSW 2150	
	Land to be developed:	The Project is to be carried out within the former Bell Quarry located on Sandham Road as shown in the Supplementary Environmental Impact Statement	
	Lot no, DP/MPS, vol/fol, etc.	DP 751631	
Environmental Impact Statement	A Supplementary Environmental Impact Statement is attached.		
Certificate	I certify that I have prepared the contents of this Supplementary Environmental Impact Statement and to the best of my knowledge: – It is in accordance with the requirements of Schedule 2 of the Environmental Planning and Assessment Regulation. – It contains all available information that is relevant to the amendments to the original DA as described in the Environmental Impact Statement of the development; and – That the information contained in the Supplementary Environmental Impact Statement is neither false nor misleading.		
	Signature:	Karl Rosen	a. Dixon
	Name:	Karl Rosen	Anthony Dixon
	Date:	19/11/2021	19/11/2021

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Sydney, New South Wales 2000, Australia
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Project number	12541317

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Revision	Author	Reviewer		Approved for issue		
		Name	Signature	Name	Signature	Date
1	Karl Rosen	A Dixon	a. Dixon	A Dixon	a. Dixon	19/11/2021

→ **The Power of Commitment**

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1. Introduction

1.1 Background

Bell Quarry Rehabilitation Project Pty Ltd (the Applicant) seeks to rehabilitate the Bell Quarry site, located on Sandham Road at Newnes Junction, approximately ten kilometres east of Lithgow in NSW. The development application seeks (DA) to achieve the final rehabilitated landform via importation of emplacement material sourced from Sydney and the local regional area which meets:

- the definition of virgin excavated natural material (VENM) as defined by the *Protection of the Environment Act, 1997* (POEO Act) from time to time
- the criteria of excavated natural material (ENM) as set out in the Excavated Natural Material Order and Exemption 2014 issued by the Environmental Protection Authority under clause 93 of the Protection of the Environmental Operations (Waste) Regulation 2014; or
- an exemption granted by the Environment Protection Authority (EPA) pursuant to clauses 91 and 92 of the Protection of the Environmental Operations (Waste) Regulation 2014) and which specifically relates to the site (comparable material).

The DA (294/18) is Designated Development and is also defined as Regional Development under clause 7, Schedule 7 of the State Environmental Planning Policy (State and Regional Development) 2011 (SRD SEPP). The DA was notified and assessed by Lithgow City Council (Council), and subject to consent by the Western Regional Planning Panel (WRPP).

An Environmental Impact Statement (EIS) was prepared by GHD Pty Ltd (GHD) to support the DA and submitted to Council in October 2018. The DA and EIS were placed on exhibition for a 60-day period from 19 January to 20 March 2019. A Response to Submissions (RtS) Report was prepared by GHD in June 2019 to address the issues raised in submissions during exhibition and additional responses were provided to Council in October and November 2019.

The WRPP refused the DA on 6 April 2020 following a public panel meeting. The primary reasons for the refusal were based around the potential for adverse environmental impacts upon the downstream receiving environment in the Greater Blue Mountains World Heritage Area and disruption to the amenity of the local community.

Amendments to the development are proposed to address the primary reasons for refusal by the WRPP, with environmental considerations arising from the amended project outlined in this Supplementary EIS. An outline of how the Secretary's Environmental Assessment Requirements (SEARs) for the project have been addressed and a summary of the issues raised as part of Council's response to contentions in EIS and indication as to where they have been addressed as part of this Supplementary EIS is also included in Appendix A.

1.2 Project overview

The development application seeks to achieve the final rehabilitated landform via importation of VENM, ENM and comparable material sourced from projects across Sydney and the local regional area (the Project). The Project aligns with NSW Government's key policy priority actions to increase recycling and reuse of materials and limiting the need for new landfills and reduce landfill disposal.

The key objectives for the Project continue to include:

- Rehabilitate the site to a condition closely representing the pre-quarry original landform and that of the adjoining Blue Mountains National Park.
- Rehabilitation of areas of National Park land adjoining the site to comply with the Blue Mountains National Park Plan of Management.
- Maximise resource recovery through diversion of VENM/ENM and comparable materials away from landfill for beneficial reuse for site rehabilitation.
- Undertake the rehabilitation works to be sympathetic to the surrounding land-use and environmental setting.
- Provide ongoing local employment opportunities.

- Revegetate the site with locally endemic species to provide effective integration with the surrounding landscape.

The rehabilitation process will involve:

- Importation of approximately 1 million m^3 of VENM, ENM and comparable material.
- Vehicle haulage at a rate of up to 140,000 tonnes per annum (tpa).
- Staged emplacement and compaction of soil material within the existing quarry voids.
- Shaping of fill to closely represent the pre-quarry landform and to allow surface water drainage across the final landform.
- Development of a water management system including management plans to control surface water discharges throughout the rehabilitation program and from the final landform.
- Revegetation of the site with locally endemic species to provide effective integration with the surrounding landscape.
- Ongoing monitoring and maintenance for life of Project and minimum two years post completion.

1.3 Project amendments

A summary of proposed modifications to the original DA include:

- Defining the acceptance criteria for the site to be limited to VENM, and ENM or material that meets an exemption pursuant to clauses 91 and 92 of the Protection of the Environmental Operations (Waste) Regulation 2014.
- Implementation of a revised water management system incorporating:
  - Inclusion of an engineered barrier (liner) in the base, sidewalls, and cap to create a barrier to groundwater flow and infiltration of rainfall / surface water into the emplaced material.
  - Groundwater diversion system to promote groundwater movement down-gradient of the basal liner.
  - Management of surface of water flows in three separate streams including:
    - Clean surface water from upstream catchment areas will be conveyed through/around the site to prevent interaction with site operations.
    - Sediment laden run-off from disturbed areas comprising naturally occurring site soils will be treated in sediment basins prior to release to receiving waters.
    - Contact water comprising any surface water flows that have come in contact with emplacement material will be captured in a contact water pond for reuse via on-site irrigation to prevent discharge of surface water from the site.
  - The water management system includes a contingency option for installation of a water treatment plant to be triggered based upon storage levels in a contact water pond to ensure any contact water or leachate required to be released from the site is treated to background water quality prior to discharge.
- Updated staging plan to reflect the revised surface water management system with the following features:
  - Use of the existing eastern void as a contact water pond – contact water pond will be lined with geomembrane (or equivalent).
  - Modification to the site entrance during Stage 1 emplacement activities to facilitate internalisation of haulage activities and revegetation works.
  - A temporary clean water diversion system (headwall and diversion channel) will be constructed to the west of the site to allow diversion of upstream catchment around active emplacement areas.
  - Confirmation that the existing sediment basin / constructed wetland immediately downstream from the site does not form part of the water management system proposed as part of the proposed development.
  - Implementation of filling stages has been re-ordered to facilitate surface water flows and internalisation of the site access during Stage 1 of the development.
  - Final landform footprint has been altered to accommodate site access road and use of eastern void as a contact pond. The footprint remains entirely within the footprint previously assessed and there is no change to the proposed maximum height of the final landform.
- Provision of a more detailed revegetation and vegetation management plan for the site.

- Implementation of a vegetation management plan along the eastern and southern boundary of the site to rehabilitate National Parks and Wildlife Service (NPWS) land adjoining the site previously impacted by site operations.
- integration of the *Roads Act 1993* (Roads Act) approvals.
- an offer of a planning agreement to contribute to the costs of identified upgrade works to Sandham Road.

1.4 Purpose of this report

This Supplementary EIS has been prepared to respond to the contentions in the Appeal and to consider potential environmental impacts arising from the amendments to the project.

An overview of the key changes from the original development application are outlined in this report.

Key issues raised in submissions and reasons for refusal primarily related to the potential for environmental impacts arising from the development to the adjoining environmentally sensitive areas of the Blue Mountains National Park. Additional hydrological, contact water, leachate, groundwater, and biodiversity investigations have been completed to review the EIS assessment, which have resulted in the amendments proposed in this report. The specialist investigations are included as appendices to this report with findings of the assessment included in Section 3.

2. Amendments to Project and Supplementary Information

2.1 Overview

The Supplementary EIS modifies the original DA to rehabilitate a former Bell Quarry site, located on Sandham Road in Newnes Junction approximately 10 kilometres east of Lithgow in NSW as shown on .

Modifications to the original DA relate to definition of the acceptance criteria for emplacement material to be accepted at the site to increase certainty about the nature of the waste to be emplaced on site and modifications to the proposed water management system and emplacement cell staging to reflect the revised water management system. Relocation of the site access road and a Vegetation Management Plan have been prepared to address boundary irregularities with the adjoining NSW National Parks estate and to facilitate the closure and rehabilitation in of previously disturbed National Park land in accordance with the Blue Mountains National Park Plan of Management. The Applicant has also offered to enter into a planning agreement to contribute to minor upgrade works which have been identified to improve the flow of traffic and safety of haulage vehicles utilising Sandham Road and to undertake routine maintenance of a specified portion of the unsealed section of Sandham Road.

An overview of how each component of the original DA is proposed to be amended by the Supplementary EIS is outlined in with an updated description of the development included in the following section.

Table 2.1 Amendments proposed as part of Supplementary EIS

Original DA (294/18)	Supplementary EIS
Acceptance criteria at the site limited to VENM, ENM and other clean fill material	Acceptance material at the site limited to VENM, ENM or comparable material that meets an exemption sought and granted by the EPA pursuant to clauses 91 and 92 of the Protection of the Environmental Operations (Waste) Regulation 2014. 'Clean fill' has been deleted and will not be received unless it meets these requirements.
Emplacement material proposed to be placed directly within the quarry voids and on areas previous quarried with no liner or artificial barrier.	– All areas proposed to be filled will be lined with High Density Polyethylene (HDPE) geomembrane (or equivalent) on the base and clay liner on the sidewalls where they are adjacent to the natural substrate (i.e., in the pits). – The basal lining of each stage includes a geonet drainage geocomposite (or equivalent) and leachate riser to allow extraction of leachate (if required). – Groundwater diversion system to promote groundwater movement down-gradient of the basal barrier layer. – The contact water dam will be lined with a geomembrane (or equivalent). – Areas proposed to be filled will be capped with Linear Low-Density Polyethylene (LLDPE) geomembrane (or equivalent), overlaid with a subsurface drainage system and revegetated.
Surface water management system and site water balance based around mixing of contact water from emplaced material with clean catchment run-off to ensure water quality leaving the site met Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2000) ambient water concentrations guideline values for environments of high conservation value.	– Water quality criteria has been revised and tightened as a result of which the surface water management system is now based upon separation of natural catchment flows and contact water to meet the objective of neutral or beneficial effect (NorBE) for the catchment. – All contact water will be captured in the lined contact water pond for reuse in active filling areas to prevent discharge of potentially polluted water from the site. – Water balance modelling indicates all contact water will be retained within the site under historical and at least 99.5% of the potential future climate scenarios using best estimate assumptions.

Original DA (294/18)	Supplementary EIS
	– The DA includes a contingency option for a water treatment plant to be installed at the site in the unlikely event that storage levels in the contact water pond reach 45%. – The water treatment plant (if required) \will ensure any contact water (or leachate) discharged from the site is treated to background water quality to meet the NORBE standard.
Emplacement activities proposed to be completed in a series of six stages through importation of approximately 1.2 million cubic metres of emplacement material. Excavation of topsoil from the former Stage 1 area for retention and use in rehabilitation activities.	– The amount of fill has been reduced by approximately 200,000 m^3 to enable environmentally positive changes to the operation and management of the project. Emplacement activities to be completed in a series of four stages with total emplacement volume of approximately 1 million cubic metres. – Emplacement stages have been re-ordered to facilitate management of surface water flows and internalisation of the site access during Stage 1 of the development. – Excavation of approximately 60,000 m^3 of material within the footprint of the northern stage. This material will be progressively won as needed for intermediate cover and for supply of a minimum 600 mm revegetation layer as part of the rehabilitated surface (cap). A stockpile of this material which will fluctuate in size and will be placed in the northeast corner of the site (with erosion and sediment control measures) for intermediate cover (if needed) and capping purposes. – A temporary clean water diversion system will be constructed to direct water from the west of the site. The diversion drain will cause clean water to enter further south of the site, over the filled Stage 1 intermediate batter. The water will then flow immediately through the site over surfaces rehabilitated with site won material. – The upstream diversion system will be decommissioned and rehabilitated at the end of Stage 3C and the upgradient catchment runoff will be redirected to approximately its pre-quarry flow line, with stormwater passing through the site over rehabilitated surfaces without being impacted by site operations. – The existing eastern void will be used as a contact water pond throughout emplacement operations. This pond will be lined with geomembrane (or equivalent). – Confirmation that the existing sediment basin / constructed wetland immediately downstream from the site does not form part of the water management system proposed as part of the proposed development. – Final landform footprint has been altered to accommodate the site access road and use of eastern void as a contact water storage. The footprint remains entirely within the footprint previously assessed and there is no change to the proposed maximum height of the final landform. – The total filling volume including retention of the eastern void has been reduced to approximately 1 million cubic metres. – Filling of the contact water pond (eastern void) will be considered in the future based upon ongoing monitoring of the performance of the overall rehabilitation project and development of a system for management of contact water during the completion of the filling operations. The filling of the contact water pond does not form part of the Amended Project presented in this report and would be subject to a modification to consent or new DA.
Use of existing haulage route into the quarry for placement of fill material within the quarry void for the duration of the project.	– A new site access road has been included in the design to be developed during the Stage 1 emplacement activities. – The existing haulage route is proposed to be utilised under a licence from NPWS to facilitate site access to fill the southern void to a level to allow construction of new road and revegetate the adjoining NPWS land as Stage 1A of the emplacement activities. It will then be revegetated in

Original DA (294/18)	Supplementary EIS
	accordance with the Vegetation Management Plan. This ensures that it meets the obligations of the park manager under the Blue Mountains National Park Plan of Management.
Progressive revegetation of final landform with locally endemic species to provide effective control or erosion and integration with the surrounding landscape.	– Progressive revegetation of the final landform will continue as part of the site ongoing site development process. – A Vegetation Management Plan has also been prepared to revegetate and manage an approximate 40 m buffer of land on the eastern and southern boundaries of the site to rehabilitate portions of the site that had been previously impacted by quarry operations.
	– Integration of Roads Act approvals and an offer of a planning agreement to contribute to the costs of identified upgrade works to Sandham Road. – Safety improvements to Sandham Road by minor road widening works at seven locations to provide additional passing opportunities and pull over bays for haulage vehicles travelling along Sandham Road.

Further details of activities associated with the projectand the rationale for proposed changes, are provided in Section 2.2, with detailed staging plans for emplacement activities included in the Environmental Management Plan to guide the implementation of the Amended Project is included in Appendix B.

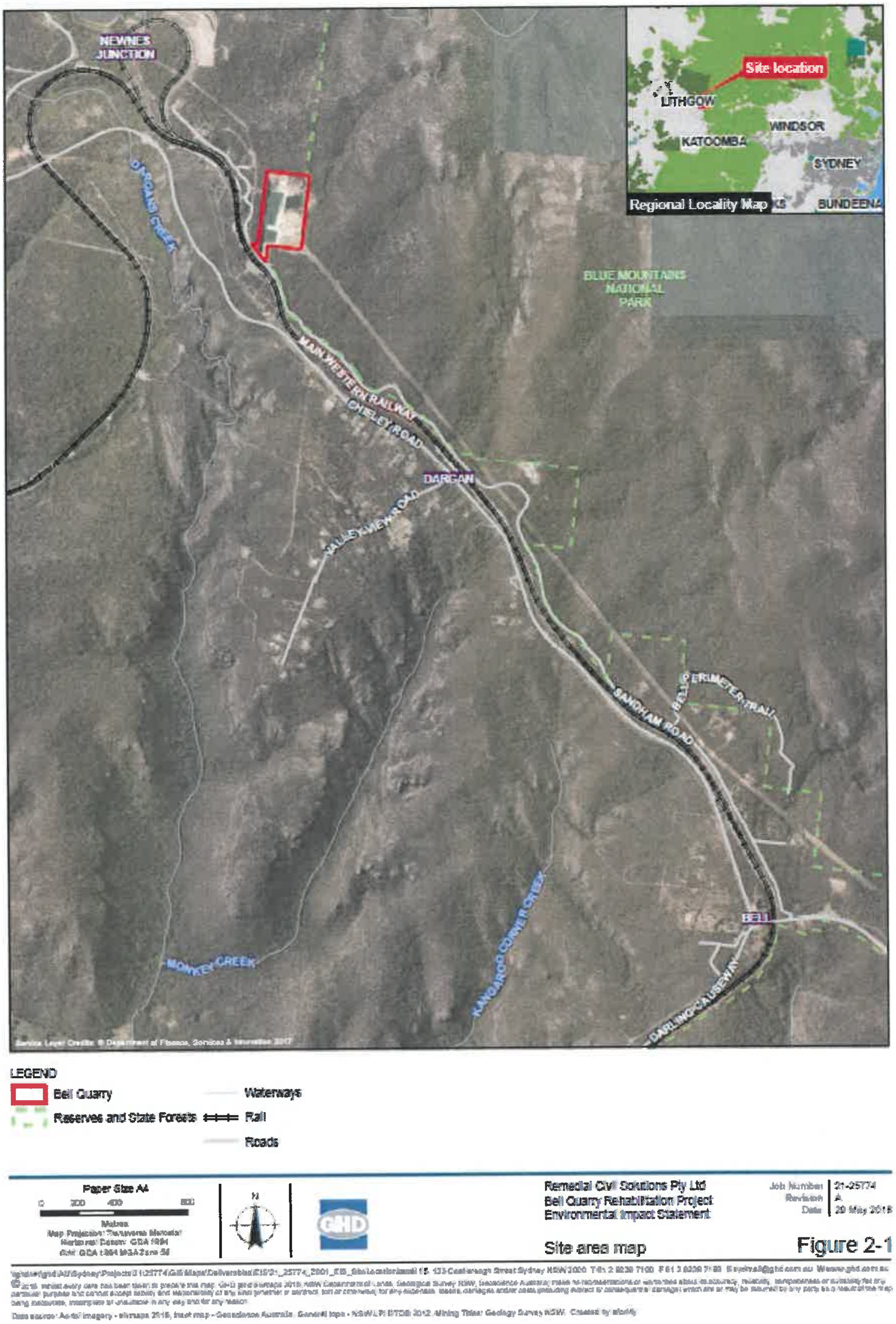

Figure 2.1 *Site Area Map*

2.2 Project activities

2.2.1 Fill importation

Acceptance Criteria

Rehabilitation of the final landform to be achieved via importation of material sourced across Sydney and the local regional area which meets:

1. the definition of VENM as defined by the *Protection of the Environment Operations Act 1997* (PoEO Act) from time to time.
2. the criteria of ENM as set out in the Excavated Natural Material Order and Exemption 2014 (ENM Order) issued by the Environmental Protection Authority (EPA) under clause 93 of the Protection of the Environmental Operations (Waste) Regulation 2014.
3. an exemption granted by the Environment Protection Authority pursuant to clauses 91 and 92 of the Protection of the Environmental Operations (Waste) Regulation 2014 and which specifically relates to the site (Comparable Material).

The PoEO Act defines VENM as 'natural' material (such as clay, gravel, sand, soil, or rock fines):

a. that has been excavated or quarried from areas that are not contaminated with manufactured chemicals, or with process residues, as a result of industrial, commercial, mining or agricultural activities, and
b. that does not contain any sulfidic ores or soils or any other waste.

ENM refers naturally occurring rock and soil (including but not limited to materials such as sandstone, shale, clay and soil) that has:

a. been excavated from the ground, and
b. contains at least 98% (by weight) natural material, and
c. does not meet the definition of Virgin Excavated Natural Material in the Act.

Excavated natural material does not include material located in a hotspot; that has been processed; or that contains asbestos, Acid Sulfate Soils (ASS), Potential Acid Sulfate Soils (PASS) or sulfidic ores.

Limiting concentrations for ENM in accordance with the ENM Order is included in .

Table 2.2 Limiting concentrations in ENM as per the ENM order (EPA 2014b)

Chemicals and other attributes	Maximum average concentration for characterisation (mg/kg 'dry weight' unless otherwise specified)	Absolute maximum concentration (mg/kg 'dry weight' unless otherwise specified)
1. Mercury	0.5	1.0
2. Cadmium	0.5	1.0
3. Lead	50	100
4. Arsenic	20	40
5. Chromium (total)	75	150
6. Copper	100	200
7. Nickel	30	60
8. Zinc	150	300
9. Electrical Conductivity	1.5 dS/m	3 dS/m
10. pH *	5 to 9 pH units	4.5 to 10 pH units
11. Total PAHs	20	40
12. Benzo(a)pyrene	0.5	1.0
13. Benzene	NA	0.5
14. Toluene	NA	65
15. Ethyl-benzene	NA	25
16. Xylene	NA	15
17. TPH C10-C36	250	500
18. Rubber, plastic, bitumen, paper, cloth, paint and wood	0.05 %	0.10 %

* The ranges given for pH are for the minimum and maximum acceptable pH values in the excavated natural material.

The Project has been amended to remove the use of the term "clean fill" to clarify it is intended that any emplacement material would fall within any exemptions regulated by sections 91 and 92 of the Protection of the Environmental Operations (Waste) Regulation 2014 and which specifically relate to the Land.

Haulage

Haulage of emplacement material to the site will remain in accordance with the development described in the EIS and subsequent submission responses.

The Project involves importation of fill material at a maximum rate of 140,000 tpa, using truck and trailer combinations of up to 42.5 tonne capacity. This fill material will be sourced from projects throughout the local region, Greater Sydney area and the Central West Slopes and Plains. It is noted that significant tunnelling works are proposed as part of the Great Western Highway upgrade and the Project may provide a valuable opportunity for reuse of excess material in the local area if it meets waste receipt criteria.

Transport routes to the site will depend upon the origin of the fill material and will vary over the life of the Project. The use of the following regional transport routes are likely to be:

- Material sourced from Sydney's western, southern and south-western suburbs will be transported via the Great Western Highway to Mount Victoria and Darling Causeway to Bell.
- Material sourced from Sydney's northern and north-western suburbs would use the Bells Line of Road to Bell.
- Material sourced the Central Western Slopes and Plains to the west of the site would utilise Chifley Road (Bells Line of Road) between Lithgow and Bell.
- Material sourced from the upgrade to the Great Western Highway would be transferred locally via the Great Western Highway to Mount Victoria and Darling Causeway to Bell.

Access to the quarry via the Sandham Road from Bells Line of Road as shown on . Sandham Road passes through the village of Bell and runs parallel to arterial road Chifley Road on the western side of the Main Western Railway Line and follows a north-western alignment to the access point to the quarry. An average of 37 haulage vehicle movements per day are predicted to occur along Sandham Road as a result of haulage activities for the Project.

To ensure the haulage for the rehabilitation works are equivalent in scale to the former quarry operations approved under the existing consent benefitting the site, it is proposed to limit haulage to a maximum rate of 140,000 tpa. It is estimated that haulage will occur for around 250 days per year accounting for wet days and reduced haulage on weekends with an average transport capacity of 30 tonne. The resulting traffic generated based on this assumption is an average of 19 truck deliveries per day (37 heavy vehicle movements) which is equivalent in scale to the extractive operations approved under the existing consent.

Due to the nature and scale of the proposed operations, it was recognised that haulage to site may occur in campaigns corresponding to generation of excess VENM and ENM from construction projects throughout the region. This has the potential to double the haulage movements for a restricted period of time and generate up to 38 truck deliveries or 74 vehicle movements per day. Any temporary increase in haulage during campaign operations would be followed by a period of reduced haulage to maintain the capacity of the site to accept a maximum of 140,000 tpa.

To ensure a conservative assessment, two traffic generation scenarios were considered as part of the traffic impact assessment for the EIS:

- An average haulage – 19 truck deliveries or 37 heavy vehicle movements per day; and
- A worst-case haulage - 38 truck deliveries - 74 heavy vehicle movements per day.

The predicted peak hour traffic generation for each scenario considered in the EIS is included in .

Table 2.3 Predicted peak hour traffic generation

Traffic Scenario	Light Vehicles (veh/h)		Heavy Vehicles (veh/h)		Total vehicles (veh/h)	
	Inbound	Outbound	Inbound	Outbound	Inbound	Outbound
Average Haulage	2	2	2	2	4	4
Worst Case Haulage	2	2	4	4	6	6

The Applicant is committed to develop a driver code of conduct as part of a Traffic Management Plan for the Project, to guide transport operations on all public roads including Sandham Road. This will include specific requirements such as limiting the speed limit to 40 km/hr for all trucks on Sandham Road and incorporate a haulage route complaint management system.

Additionally, the Applicant makes an offer to enter into a planning agreement under Section 7.4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) making provision for a monetary contribution to the relevant local government authorities for identified works to upgrade sections of Sandham Road. The Applicant is also willing to maintain the unsealed portion of Sandham Road after weather events or annual inspections in liaison with Council to maintain the road surface.

Seven locations have been identified for widening of Sandham Road to reduce conflict with road users and to accommodate two way passing of haulage vehicles.

2.2.2 Emplacement activities

2.2.2.1 Overview

The emplacement activities will be largely as described in the original DA and located within the disturbance footprint of the former Bell Quarry. Key changes in relation to the emplacement activities are described below:

- The proposed fill staging has been altered to reflect the revised surface water management system.
- The footprint of the landform has been amended but remains fully within the footprint included in the original DA and the maximum height of the final landform has not been altered.
- The eastern void is to be retained throughout the filling of the first 4 stages to allow for storage of contact water prior to disposal via irrigation (or, in the unlikely event a treatment plant is required, via treat and release).
- The fill footprint and final landform in the southern void have been adjusted to provide an alternative access which is developed as part of the filling of Stage 1.
- All areas proposed to be filled will be lined with HDPE geomembrane (or equivalent) on the base and clay on the sidewalls where they are adjacent to the natural substrate (i.e., in the pits).
- The basal lining of each stage includes a geonet drainage geocomposite (or equivalent) and riser to allow extraction of leachate (if required).
- Groundwater diversion system to promote groundwater movement down-gradient of the basal liner.
- A temporary clean water diversion system will be constructed to the west of the site to allow diversion of upstream catchment around active emplacement areas.
- The contact water dam will be lined with a HDPE geomembrane (or equivalent).
- Areas proposed to be filled will be capped with LLDPE geomembrane (or equivalent), overlaid with a subsurface drainage system, and revegetated.
  - Areas of the site have been identified for excavation works to supply site won material for site intermediate capping and a minimum of 600 mm of final capping materials.
- Excavation areas are within the extents of the proposed filling works and includes an area in the northern portion of the site as described in the original DA and a former deposition area in the eastern portion of the site.
- A stockpile of site won material is to be placed in the northeast corner of the site (for the later stages use).
- A potential future final filling stage involves filling the contact water dam at the conclusion of proposed emplacement activities and will be subject to a future application or modification to consent under Section 4.55 of the EP&A Act should development consent be granted by the Land and Environment Court. The future application would be based on an assessment of the facility performance over the first 4 stages and design of a water management system for contact water during the filling of the contact water pond. The assessment would quantify whether all or part of the contact water pond can be removed, and the final landform adjusted to suit.

2.2.2.2 Work stages

A detailed description of Project activities for each work stage and staging plans are included in the Environmental Management Plan included in Appendix B. A summary of staged quantities included in and an overview of emplacement activities for each stage is provided below.

Table 2.4 *Staged quantities and areas (subject to detailed design)*

	Excavation[1] (m^3)	Volume[2] (m^3)	Base lining area** (m^2)	Sidewalll lining area** (m^2)	Active filling area* (m^2)	New intermediate cover area** (m^2)	Final cap area** (m^2)
Stage 1A		104,300	4,100	11,740	12,400	-	-
Stage 1B		115,800	-	4,500	12,400	7,390	5840
Stage 2		48,800	11,800	-	12,560	1,820	11,880
Stage 3a		89,850	10,500	3,600	17,900[3]	4,400[5]	0
Stage 3b		244,200	-	10,450	16,700[5]	8,870[5]	11,690
Stage 3c		25,800	-	-	7,660	-	8,150
Stage 3d		169,050	-	8,160	6,500	4,340	10,150
Stage 4	Up to 60,500	255,250	3,800	13,500	15,180[5]	-	22,230
Total	***60,500***	***1,053,050***	***30,200***	***51,950***	-	***26,820***	***69,930***

* plan area

** slope area

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[1] Excavation represents the stage/area where the excavation is achieved. It does not represent the timing of excavation works. All other values in this table assume that this excavation work is undertaken as required.

[2] Volume represents volume from existing surface or design excavation surface to top of final cap. Stage fill capacities must also consider airspace lost to lining, cover and capping works.

[3] Where the entire stage catchment area is greater than 1.3 ha, filling works will be staged and intermediate cover used to maintain an actual contact water area of less than 1.3 ha at any time. Additional intermediate cover material may be required to achieve this requirement. Additional onsite soil generation has been included for this purpose.

STAGE ONE

VOLUME: 220,100 m³

Fill southern void:

- Dewater the southern void in accordance with EMP and site specific water management plan
- Construct lining system

During filling

- Collect contact water and pump to contact water pond for storage and disposal
- Install intermediate capping progressively on the northern intermediate batter
- Install final capping progressively on areas that reach final surface levels
- Direct sediment laden water from intermediate cap to temporary pond. Treat before discharge
- Develop site access around the south eastern area

EXISTING SURFACE
DESIGN CONTOURS
CATCHMENT AREAS
CLEAN WATER FLOW
SEDIMENT LADEN FLOW
ACTIVE FILLING AREA
REHABILITATED AREA
AMENITIES AREA
ACCESS ROAD

STAGE TWO

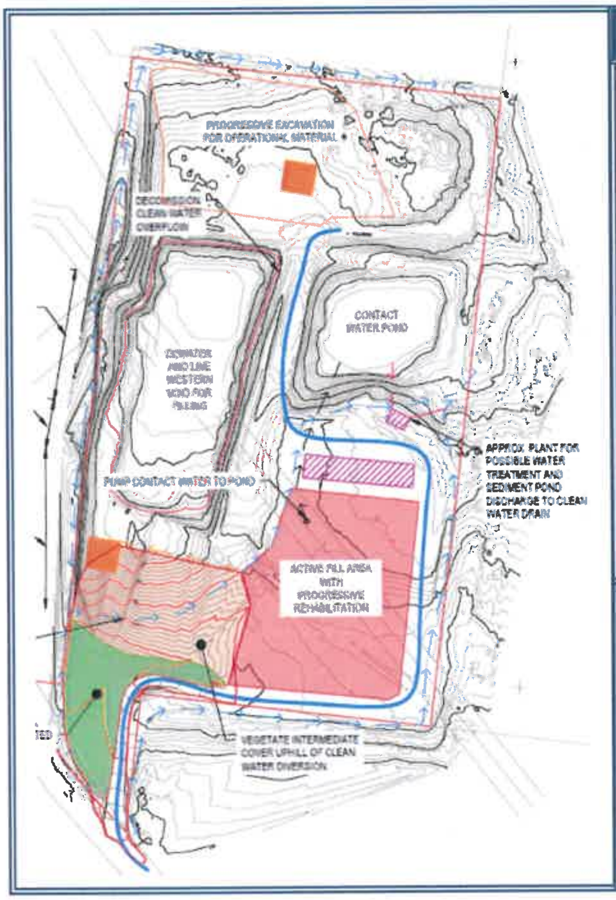
VOLUME: 48,800 m³

Fill southern void:

- Dewater the southern void in accordance with EMP and site specific water management plan
- Construct lining system

During filling

- During the filling works in south eastern area, contact water collected and drain/pumped to contact water pond.
- Intermediate capping progressively installed on western intermediate batter
- Direct sediment laden water from intermediate cap areas to temporary pond for treatment before discharge
- Construct temporary clean water diversion system for water from west of the site
- Dewater the western void, for Stage 3 filling



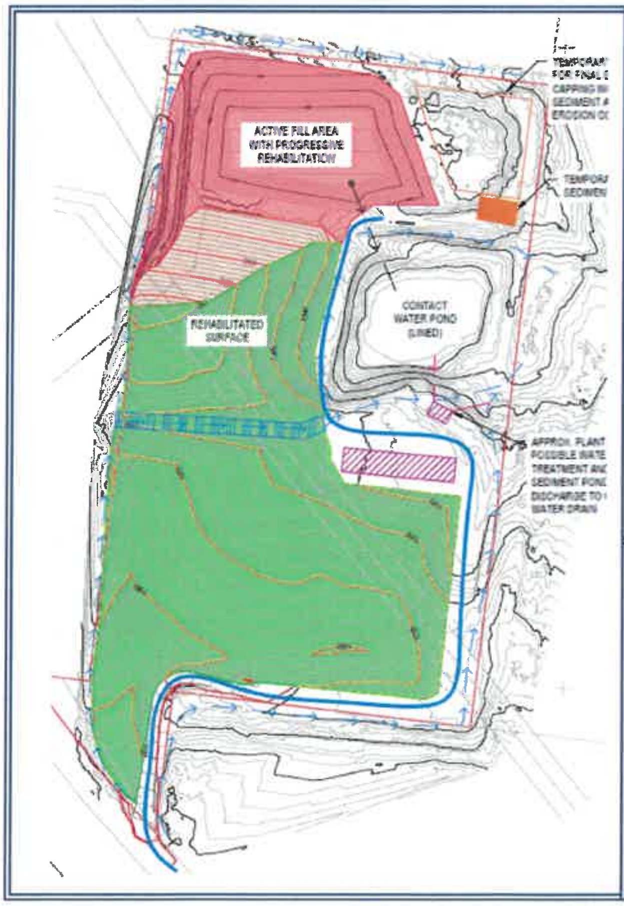
EXISTING SURFACE
DESIGN CONTOURS
CLEAN WATER FLOW
SEDIMENT LADEN FLOW
CONTACT WATER (PIPE)
TREATMENT WATER (PIPE)
REHABILITATED AREA
INTERMEDIATE COVER AREA
ACTIVE FILLING AREA
AMENITIES AREA
ACCESS ROAD

STAGE THREE

VOLUME: (Shown on diagrams)

- Construct lining system in in preparation for Stage 3 filling.
- Western void filled in four stages:
  A – Entire void area filled to approx. RL1032
  B – fill the southern section of the void to develop the final landform levels
  C – Once the final clean water drainage pathway is developed, fill over the temporary clean water drain and over the remaining Stage 1 and Stage 2 intermediate batters.
  D – Lastly, fill the northern section of the void.
- Intermediate capping installed progressively on intermediate batters. Final capping installed progressively on areas that reach final surface levels
- Temporary sediment pond in northern part of site. Stage 1 temporary pond removed.

═ EXISTING SURFACE
═ DESIGN CONTOURS
→ — CLEAN WATER FLOW
→ — SEDIMENT LADEN FLOW
→ — CONTACT WATER (PIPE)
→ — TREATMENT WATER (PIPE)
🟩 REHABILITATED AREA
▭ INTERMEDIATE COVER AREA
🟥 ACTIVE FILLING AREA
▨ AMENITIES AREA
━ ACCESS ROAD

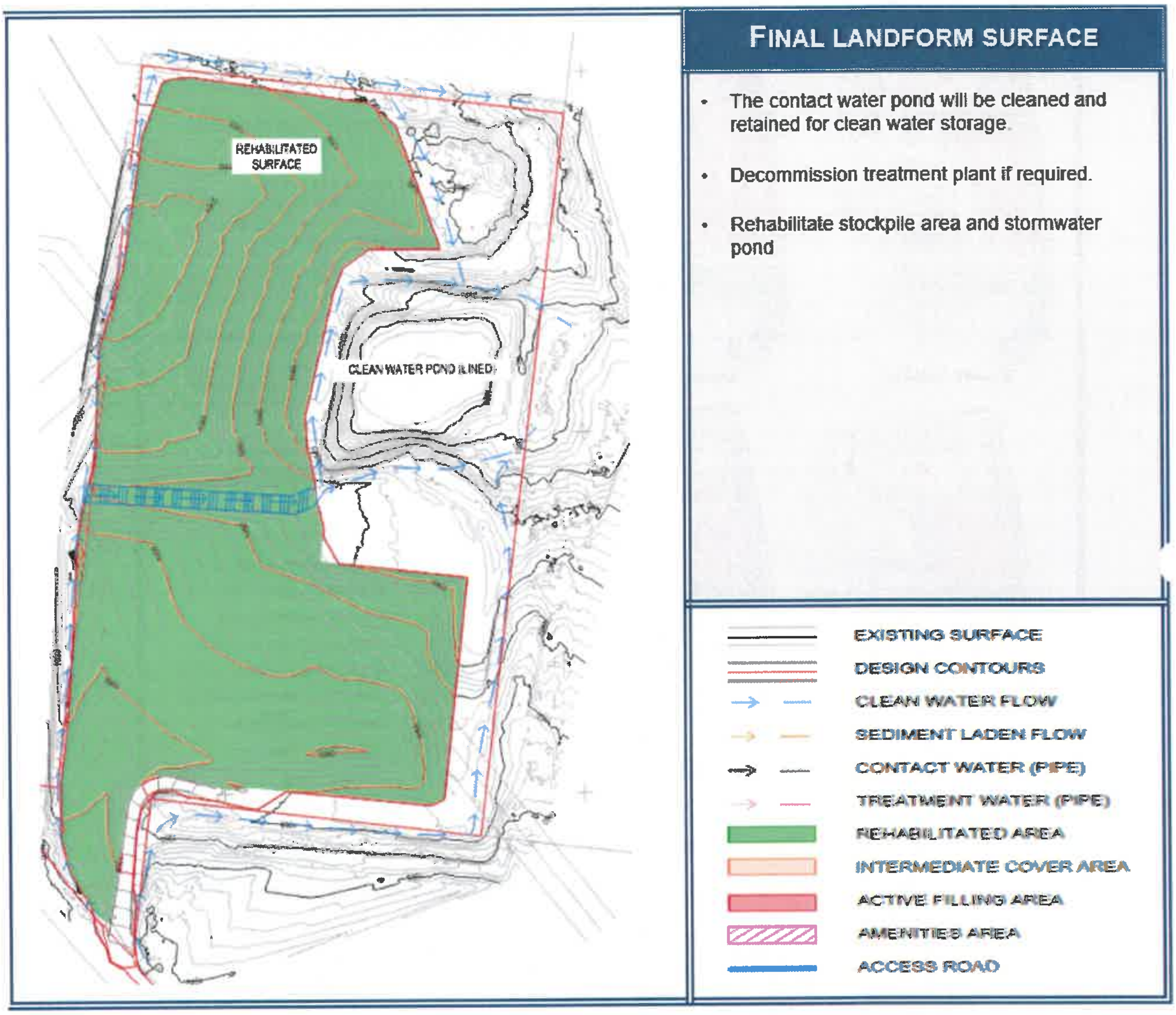


STAGE FOUR

VOLUME: 255,250 m³

- Fill northern area. During filling
  - Undertake filling works to ensure contact water area of less than 1.3 ha is maintained by temporary bunding or similar
  - Collect contact water and pump to contact water pond for storage and disposal
  - Install final capping progressively on areas that reach final surface levels
  - Maintain temporary sediment and erosion controls around cover material stockpile area
  - The temporary sediment pond adjacent to the cover material stockpile will be utilised or temporary ponds established in the operational areas as required

═ EXISTING SURFACE
═ DESIGN CONTOURS
→ — CLEAN WATER FLOW
→ — SEDIMENT LADEN FLOW
→ — CONTACT WATER (PIPE)
→ — TREATMENT WATER (PIPE)
🟩 REHABILITATED AREA
▭ INTERMEDIATE COVER AREA
🟥 ACTIVE FILLING AREA
▨ AMENITIES AREA
━ ACCESS ROAD



- The contact water pond will be cleaned and retained for clean water storage.
- Decommission treatment plant if required.
- Rehabilitate stockpile area and stormwater pond

Figure 2.2 Indicative Staging plans

Site establishment works

Before filling occurs, site establishment works are required to prepare the site for filling works. This will involve the following:

- Dewatering of the southern and western voids to separate the water between the voids. A bund will be created, if needed, to ensure future separation and completely dewater the southern void.
- A geomembrane (or equivalent) lining system will be installed in contact water pond after it is dewatered.
- The southern void will be dewatered, and a geomembrane (or equivalent) lining system installed in preparation for Stage 1 filling of the southern void. The liner would be installed above any site won material placed within Stage 1.
- The water in the western void will be drawn down and an overflow channel installed to allow clean water to drain directly offsite by gravity (bypassing the eastern void).

Stage 1

Stage 1 involves filling of the southern void in two stages:

- Stage 1A – initially fill against the southern and eastern batters to develop a new site access road which is within the site boundary.
- Stage 1B – fill the remaining available capacity in the Stage 1 area.

During filling:

- Contact water will be collected and pumped to the contact water pond for storage and disposal.
- Where filling is being undertaken above surrounding ground level, a soil bund will be constructed at the perimeter of each lift to prevent run off and a low point created to collect contact water.
- Intermediate capping will be installed progressively on the northern intermediate batter as each lift is placed.
- Final capping will be installed progressively on areas final surface areas as each lift is placed.
- Sediment laden water will be directed from the intermediate cap areas to the temporary pond (developed (developed when filling proceeds above ground) for settlement before discharge.
- South-eastern area will be lined in preparation for Stage 2 filling works.
- Site access around the south-eastern area will be developed to allow filling in Stage 2 area.

Stage 2

Stage 2 involves filling of the south-eastern area. During filling:

- Contact water will be collected and pumped / directed to the contact water pond for storage and disposal.
- Where filling is being undertaken above surrounding ground level, a soil bund will be constructed at the perimeter of the active fill area to prevent run off and a low point created to collect contact water.
- Intermediate capping will be installed progressively on the western intermediate batter.
- Final capping will be installed progressively on areas as they reach final surface levels.
- Sediment laden water will be directed from the intermediate cap areas to the temporary pond (developed in preliminary works) for settlement before discharge.

A temporary clean water diversion system will be constructed to direct water from the west of the site. The diversion drain will cause clean water to enter further south of the site, over the now-filled Stage 1 intermediate batter. The water will then flow through the site and directly offsite. It is expected that the diversion system will require:

- Construction of a shallow open channel on north side of existing entry, flowing south, nominally within 5-10 metres of the crest of the void.
- Construction of a headwall and upstream pond, nominally within 20-30 metres of the crest of the void.
- Construction of a deep open channel to the south of the existing entry, flowing south, nominally within 20-30 metres of the crest of the void.
- Construction of open channel on the Stage 1 batter and across the site to allow discharge of clean water directly offsite.
- Vegetation of all areas of intermediate batter draining into this diversion structure to control erosion.

The western void will be dewatered, the clean water overflow will be decommissioned, and a lining system will be installed in preparation for Stage 3 filling.

Stage 3

Stage 3 involves fill the western void in four stages:

- Stage 3A – the entire void area to be filled to approximately RL1032 m.
- Stage 3B – the southern section of the void will be filled to final landform levels to allow clean water drainage over the rehabilitated surface.
- Stage 3C – once the final clean water drainage pathway over the rehabilitated surface has been established, decommission the temporary clean water diversion drain over the Stage 1 batter and fill the remaining Stage 1 and Stage 2 intermediate batters.
- Stage 3D – northern section of the void will be filled in.

During filling:

- Filling works will be undertaken to ensure a contact water area of less than 1.3 hectares is maintained.
- Contact water will be collected and pumped to the contact water pond for storage and disposal.

- Where filling is being undertaken above surrounding ground level, a soil bund will be constructed at the perimeter of the active fill area to prevent run off and a low point created to collect contact water.
- Intermediate capping will be installed progressively on the intermediate batters.
- Final capping will be installed progressively on areas that reach final surface levels.
- A temporary sediment pond will be developed in the northern part of site and the Stage 1 temporary pond will be removed when required.
- Sediment laden water will be directed and pumped from intermediate capping areas to the temporary pond for settlement before discharge.
- Additional excavation will be undertaken, as required, between the Stage 3 and Stage 4 areas.
- Lining system will be constructed in the northern area in preparation for Stage 4 filling.
- Temporary cover material stockpile area will be developed in the north-east, including required sediment and erosion controls.

Stage 4

Stage 4 involves filling the northern area. During filling:

- Filling works will be undertaken to ensure a contact water area of less than 1.3 hectares is maintained.
- Contact water will be collected and pumped to the contact water pond for storage and disposal.
- Where filling is being undertaken above surrounding ground level, a soil bund will be constructed at the perimeter of the active fill area to prevent run off and a low point created to collect contact water.
- Final capping will be installed progressively on areas that reach final surface levels.
- Temporary sediment and erosion controls will be maintained around the cover material stockpile area.

If Stage 5 is developed for filling, Stage 4 works will also include:

- Cleaning and dewatering of the contact water pond and development of alternative contact water management measures, as required.
- Lining of the Stage 5 area in preparation for filling.

No consent is sought in this DA for the works described in the dot points directly above.

Stage 5 (potential)

A potential final filling stage, Stage 5, will be subject to a further development application or modification. It modification would be based on an assessment of the facility performance over the first 4 stages in relation to water management. The assessment would quantify whether all or part of the contact water pond can be removed, and the final landform adjusted to suit. If developed for filling:

- Filling works will be undertaken to ensure a contact water area of less than 1.3 hectares (or as otherwise determined) is maintained.
- Contact water will be collected and pumped to the contact water pond for storage and disposal.
- Where filling is being undertaken above surrounding ground level, a soil bund will be constructed at the perimeter of the active fill area to prevent run off and a low point created to collect contact water.
- Final capping will be installed progressively on areas that reach final surface levels.

Temporary sediment and erosion controls will be maintained around the cover material stockpile area.Final rehabilitation surface

At the conclusion of site filling, the contact water pond (if remaining) will be dewatered and cleaned, and the liner retained and would be a clean water pond.

This clean water pond would only receive direct rainfall and would include an overflow location, show it overflow.

2.2.2.3 Soil placement

VENM/ENM/comparable material will be placed within the former quarry void according to the proposed rehabilitation strategy. The placement procedure addresses potential impacts to the environment and required environmental performance outcomes. Soil placement procedures include the following:

- An active placement area will be established in accordance with the proposed staging plan.
- Soil will be delivered to the placement area by trucks. The unloaded soil will be spread out by bulldozer and compacted by roller.
- Designated vehicle wash down areas will be set up to prevent tracking of placement material outside of the active emplacement areas. This will also include cattle grates at entry and exit points of the site.
- Soil will be placed in lifts and compacted to 95% standard maximum dry density. Compaction testing will confirm that average compaction is being achieved. The lift height would be developed as part of the detailed design to allow for sufficient area for operations and placement of the capping material.
- The horizontal soil lifts will be graded to allow for free draining of surface water and to avoid localised ponding.
- The sidewall liner system will be inspected prior to placement of soil and after any rainfall event for any indications of damage such as scouring, tears or punctures. Soil placed against the side wall liner system will be pushed against the wall and the compaction limited to avoid damage to the liner system.
- Interim soil batters will be limited to 1(vertical) in 2 (horizontal) and final batters will be per the landform design.
- Intermediate cover material will be placed on all batters that do not form part of the final landform and will comprise site won material. Where possible the intermediate cover material will be partially stripped back and reused prior to placement of further VENM/ENM material.
- The final landform will be progressively capped to ensure stability of the emplacement areas and control erosion.

2.2.2.4 Excavation

Excavation works have been included to provide soil materials for operational uses, including:

- Intermediate cover.
- Final capping and rehabilitation works.

The proposed extents of excavation are wholly within the proposed fill boundary and located within areas proposed to be filled during Stage 2 (if required) and Stage 4. The preliminary design of the excavation surfaces has allowed for:

- Excavation batters of 1 (vertical) in 2 (horizontal).
- Minimum base dimension is around 35 metres to allow for vehicle movements within the base of the voids.

Access into these excavations would need will be considered as part of the development of these voids.

These areas are known to have been previously quarried, and rock materials may be found within the proposed excavation footprint. Historical documents show that the intention was to excavate the quarry to RL1018 m. The base of the current water-filled voids is around RL1023 m. The lowest points of these excavation areas are RL1035 m and RL1027 m. Where rock walls are located around the perimeter of these excavations the batters may be able to be made steeper to follow the steeper rock surface. Appropriate erosion and sediment controls will be installed as part of excavation works.

2.2.2.5 Works outside of site boundary

A detailed survey of the site boundary was undertaken during the preparation of the EIS. The disturbance footprint of the previous extractive operations has extended beyond the surveyed site boundary at two locations, as detailed below, which is likely to be a function of the accuracy of survey data at the time of establishment of the former quarry.

First:

(a) the edge of the main quarry void along the western boundary extends as a thin strip of approximately two metres onto the land legally described as Lot 7031 in Deposited Plan 1066257 which is Crown Land, and

(b) part of an unmade paper road comprised in certificate of title Volume 1956 Folio 183

as shown in below:

Figure 2.3 ***Aerial taken from six-maps showing the part of the Western Boundary of the main void which extends beyond the site boundary***

It is also noted that establishment of a temporary clean water diversion system will need to be developed in this lot and Lot 7032 in Deposited Plan 1066257 to divert clean water away from active emplacement cell during Stage 2 of the proposed development. The indicative footprint of the water diversion system is shown on .

Secondly:

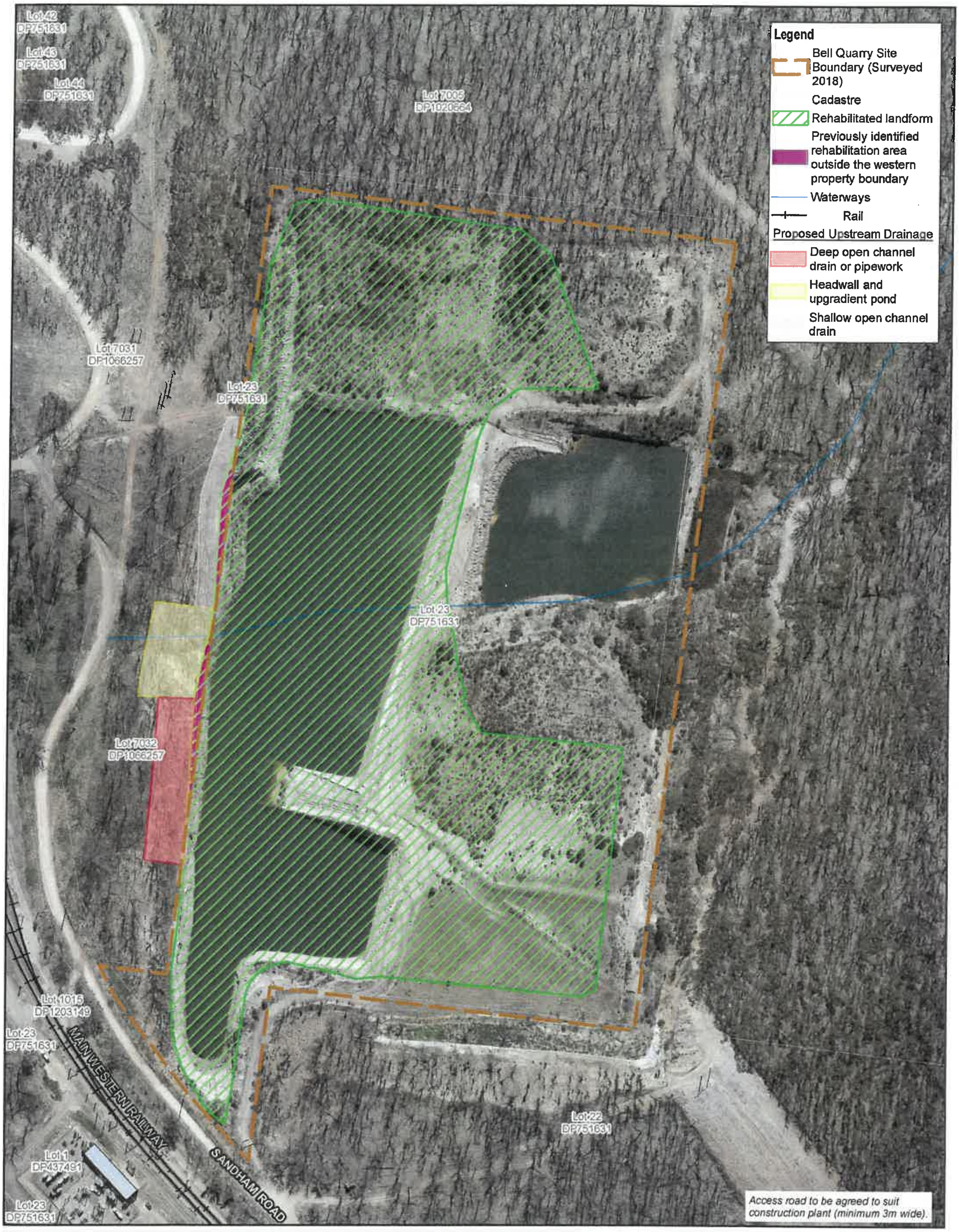
(a) the existing haul road at the entrance to the site partially located over Lot 22 in Deposited Plan 751631 and which is owned by Crown Lands and managed by NPWS; and

(b) a small portion of the existing western void which bisects a section of land within the Blue Mountains National Park.

The Applicant is committed to rehabilitating the site that has been affected by the extraction of materials at the former quarry and therefore emplacement activities will be undertaken within the existing disturbance footprint of the quarry to ensure this.

It will be necessary to fill marginally beyond the surveyed boundary on the western edge of the site to provide effective stability and stormwater management for the final landform.

The Applicant proposes to adjust the site entrance and haul road at the entrance to the site during Stage 1A of the Project. The haul road currently skirts around the edge of the southern void which comprises an approximate 30 metre near vertical drop. An overview of the proposed new haulage road within the site is provided in



Access road to be agreed to suit construction plant (minimum 3m wide).

Paper Size ISO A4

0 10 20 30 40

Meters

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Bell Quarry Rehabilitation Project Pty Ltd
Bell Quarry Appeal

Project No. **12541317**
Revision No. **C**
Date **10/11/2021**

Upstream Diversion Works

FIGURE 2.4

\\ghdnet\GHD\AU\Sydney\Projects\21\12541317\GIS\Maps\Deliverables\21_12541317_003_CappingProfile_.mxd

Data source: Groundwater monitoring locations: Martens; . Created by: tedarley

Figure 2.5 *New access road to be established on the edge of the existing void (once filled)*

The road will be established near the end of the proposed filling of Stage 1A and will result in a slight change in final landform and reduction in filling volume to accommodate the road design.

An indication of the revised final landform overlayed above an existing aerial is included in and indicates how the road cannot be installed until the completion of filling the southern void in Stage 1A of the proposed emplacement sequence due to the steepness of the existing land's surface and close proximity to the quarry walls. The filling of Stage 1A is predicted to be complete within around 12 months from commencement.

Figure 2.6 *Revised Final Landform*

The existing access road and adjacent disturbed land will be rehabilitated as part of the proposed Vegetation Management Plan, and the fence line adjusted to reflect the updated boundary survey of the site. The rehabilitation of the existing haulage route is consistent with the requirement to undertake rehabilitation within a 20-metre strip of the adjoining Blue Mountains National Park within the existing quarry operation consent.

The western boundary of the site will be adjusted following the completion of filling of the main void during Stage 3 of the proposed development. The temporary water diversion system will be decommissioned, and the area rehabilitated.

The Applicant acknowledges that:

1. filling part of the site which traverses Lot 7032 in Deposited Plan 1066257 requires owner's consent pursuant to clause 49 of the Environmental Planning and Assessment Regulation 2000 (EP&A Regulations); and
2. filling of the part of the 'public road' which traverses the main void on its western boundary, and which is comprised in certificate of title Volume 1956 Folio 183 will require an approval under Section 138 of the Roads Act.

With respect to point 1 above, it is noted that owner's consent was provided by Department of Industry - Crown Lands and Water, Orange by letter dated 18 March 2019.

With respect to point 2 above, the Applicant will amend the development application to be assessed as integrated development pursuant to Section 138 of the Roads Act.

Landowner consent has also been provided by NPWS subject to acceptable offsite environmental outcomes being achieved for the Project.

2.2.3 Water management

2.2.3.1 Overview

Management of surface water and groundwater resources across the quarry site will be of high importance throughout the Project life.

A revised surface water management system has been developed involving management of surface water within the site in three separate streams:

- Water from upstream catchment (off-site) areas: This water shall be conveyed through/around the site without interaction with site waters wherever practicable, with direct discharge to the downstream receiving system. Where mixing of upstream and site waters is unavoidable, (for example, a cascade of upstream waters currently enters the western void of the site) the upstream waters shall mix only with sediment-laden water (not contact water). Where this mixing occurs the sediment laden water management approach shall include the volumetric contribution of the upstream waters.
- Sediment laden water: This is runoff from areas where disturbed, non-vegetated soil is present but does not consist of foreign imported fill material. In these areas runoff is to be managed in accordance with *Managing Urban Stormwater: Soils and Construction Volume 1, Landcom 2004 and Volume 2, DECC 2008*. The requirements within the documents that apply to a "sensitive" receiving environment would be adopted.
- Contact water: This water comprises any surface water that has interacted with emplacement material and will be captured in a contact water pond for reuse via on-site irrigation to prevent discharge of surface water from the site. There will be no discharges of surface contact waters would occur other than when treated to background water quality conditions (if this were required).

The revised assessment has adopted an elevated assessment criteria for the works based upon achieving a neutral or beneficial effect, based upon the State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011 as well as the corresponding WaterNSW guideline *Neutral or Beneficial Effect on Water Quality Assessment Guideline.*

It is noted the site is not located within Sydney's drinking water catchment, however the neutral or beneficial effect (NorBE) approach has been applied to the proposed development to achieve the highest level of protection given the sensitivities of receiving waters in the Wollongambe River catchment and the Greater Blue Mountains World Heritage Area.

A NorBE on water quality is satisfied if the development:

a. has no identifiable potential impact on water quality, or

b. will contain any water quality impact on the development site and prevent it from reaching any watercourse, waterbody or drainage depression on the site.

Dewatering works will occur predominantly during the initial site establishment works phase as described in section 2.2.2.2. This water t

Furthermore, the water quality in quarry voids is generally within ANZG criteria for slightly to moderately disturbed freshwater ecosystems. The water quality is broadly described as fresh with a low pH and low concentrations for most water quality parameters considered. Nutrient content is generally low, although higher nitrogen levels were found in the quarry ponds and the upstream gauge site. These do not appear to have impacted water quality within the swamp (Martens and Associates 2021).

The project has been designed such that contact water will not enter the areas being dewatered. The only source of surface water which may enter the areas being dewatered are from upstream of the site and potentially runoff from site soils.

2.2.3.2 Final cover and liner system

The Amended Projectincludes an engineered barrier (liner) system in the base, sidewalls, and cap to create a barrier to groundwater flow and infiltration of rainfall / surface water into the emplaced material. The profile of the final cover and basal and side wall liners are described below:

– Final cover profile (top to bottom):
  - Revegetation layer suitable for the establishment and long-term viability of vegetation.
  - Subsurface drainage layer to ensure stability of the revegetation layer and minimise infiltration.
  - Geosynthetic barrier system (or equivalent) that will minimise infiltration to as low as reasonably practicable and prevent 'bath tubbing' (excessively elevated leachate levels) above the basal liner.
  - Seal bearing layer to support the geosynthetic barrier layer.

– Basal and sidewall liner profile (top to bottom):
  - Compacted clay sidewall barrier progressively placed in lifts to minimise the horizontal seepage of leachate out of the fill and seepage of groundwater into the fill.
  - Geonet drainage geocomposite (or equivalent) to minimise damage of the basal liner barrier system and allow monitoring of leachate in the fill.
  - Geosynthetic basal barrier layer to form a barrier between the placed fill and the groundwater, soil and substrata and minimise seepage to as low as reasonably practicable.
  - Seal bearing layer to support the geosynthetic barrier layer.
  - Groundwater diversion system to promote groundwater movement down-gradient of the lined emplacement.

A construction quality assurance (CQA) Plan for the liner system will be developed that outlines the material specifications, installation and testing requirements.

Individual components of each of these systems are summarised in and are described below.

Table 2.5 Preliminary liner and capping specification

Name	Layer Type	Thickness (mm)	Notes
Revegetation layer	Soil for vegetation	600	Site won or imported material with a similar geochemistry to the surrounding landscape.
Subsurface drainage layer	Geonet drainage geocomposite	To be determined as part of detailed design	Designed to prevent saturation of the revegetation layer and minimise infiltration into the fill.
Final cover barrier layer	Textured LLDPE Geomembrane (or equivalent)	2	Manufactured in accordance with GRI - GM17 Standard Specification for "Test Methods, Test Properties and Testing Frequency for Linear Low-Density Polyethylene (LLDPE) Smooth and Textured Geomembranes" (Geosynthetic Institute, 2019).
Seal bearing layer / intermediate cover layer	Cohesive soil material	300	Site won or imported material with a similar geochemistry to the surrounding landscape, made up of fine-grained material or if coarse material with a protection geotextile.
Fill	VENM, ENM or material in accordance with a specific resource recovery order/exemption that is applicable to the site	Variable	Imported material.
Sidewall barrier layer	Compacted clay material	500	Permeability of less than 10^{-9} m/s.
Subsurface drainage layer	Geonet drainage geocomposite (or equivalent)	To be determined as part of detailed design	Designed to protect the liner and allow extraction of leachate to prevent saturation of the fill causing bath-tubbing during operation and to allow the extraction of leachate if needed.
Basal barrier layer	HDPE Geomembrane (or equivalent)	2	Manufactured in accordance with GRI - GM13 Standard Specification for "Test Methods, Test Properties and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes" (Geosynthetic Research Institute, 2003).
Seal bearing layer	Cohesive soil material	300	Compacted site won or imported material with a similar geochemistry to the surrounding landscape.
Groundwater depressurisation layer	Free draining material	300	Free draining site won or imported material with a similar geochemistry to the surrounding landscape.

2.2.3.3 Groundwater diversion system

A groundwater diversion system will be included in the design of the basal lining in the pits to minimise the possibility of liner uplift and allow the flow of groundwater beneath and around the liner. The system will consist of a minimum of 300 mm of free draining site won or imported material with a similar geochemistry to the surrounding landscape. During detailed design of the basal liner the risk of liner uplift will be assessed and, if required, a sump and riser installed to allow depressurisation of the liner.

2.2.3.4 Leachate levels

Numerical groundwater modelling was performed by Martens and Associates (2021).

The modelling established that, taking into consideration groundwater inflow and outflow, infiltration from the cap and seepage through the liner, over the long term, leachate levels are expected to rise and equalise with the surrounding groundwater table level (approximately 1037.5 mAHD).

The basal drainage layer at the base of the quarry void would allow monitoring of leachate in the fill. Monitoring of leachate levels at the riser will be undertaken to confirm that leachate is not accumulating/increasing within the quarry void creating a bathtub effect. As the site is being progressively capped and revegetated this issue will be able to be monitored during site operations and remedial action taken if required.

2.2.3.5 Irrigation management

Contact water will result from runoff from active emplacement areas and minor quantities from any vehicle washdown. All contact water will be contained within the site or treated and discharged at background water quality conditions (if the treatment plant is required). Irrigation of contact water will only be applied within the contact water catchment.

Contact water will be contained by installation of diversion bunds and drained to the contact water storage. The accumulated contact water will be collected for irrigation within the emplacement area by:

- Tanker through application to the active placement area for dust suppression and moisture conditioning to achieve target compaction rates.
- Mobile sprinklers that will be located within the emplacement area outside of haulage routes.

The operation of the sprinklers will consider irrigation demand, wind speed and prevailing wind direction and elevation with the aim to prevent spray drift outside of the emplacement areas or exposure to workers. Irrigation activities will not take place during wet weather periods or during high wind speed condition depending on the elevation of the emplacement area. The mobile sprinklers will be sited within the emplacement area based on fill moisture monitoring by conductivity meter. The irrigation rate will be developed to minimise runoff, and to not exceed the capacity of the fill to absorb the contact water.

A surface water and groundwater monitoring program will be implemented which will be designed to detect any migration of contact water from the site. An outline of the monitoring program is included in the Revised Water Resources Assessment.

2.2.3.6 Water Treatment Plant operation

As part of the precautionary approach, the Amended Project includes a contingency option for a water treatment plant to be installed at the site if storage levels in the contact water pond reach 45% or if required to treat leachate. If required, the water treatment plant will be located in approximately the central portion of the site as shown in the staging plans. The general treatment process for the plant will involve:

- Pump system to remove water from the pond storage to the reverse osmosis (RO) treatment process.
- Ultrafiltration (UF) pre-treatment – for the removal of suspended solids, algae and any other potential issues to the membrane.
- Cartridge filtration (CF) – used as a polishing step and as a failsafe to protect the RO membrane from any unexpected solids breakthroughs.
- Anti-scalant (AS) dosing – for removal of scaling and fouling from the membranes.
- RO membrane – for removal of problematic analytes within the water. Vendors estimated RO recovery would be approximately 70% (i.e., 70% of the feed water would report to the treated water stream and 30% of the feed water would report to waste).
- Calcite filter or chemical dosing – likely to be required for remineralisation of permeate.
- Associated instrumentation for control and operation of the system.

Concentrated brine will be generated as a by-product of the water treatment plant. The brine will be stabilised prior to on-site disposal by mixing with soil material to maintain a closed circuit with the emplaced materials. Alternative off-site reuse options would be explored should the treatment plant be commissioned.

The soil and brine will be mixed within a lined skip bin such that the resulting consistency is generally capable of being picked up by a spade or shovel. The brine will be pumped directly to the skip bin and soil blended in using an excavator. The mixing area will be bunded to contain any leaks or contact water runoff. The mixed batches will not be stored for extended periods of time. Alternatively, the brine may be pumped directly to the relevant stage and mixed and placed in situ.

The brine mix will be disposed of within the quarry void via the trench and fill method. The spadable material will be unloaded from the skip bin/s and covered with site won soil immediately after placement. The quantity and disposal area location will be recorded. Disposal of stabilised brine will not take place during or immediately following wet weather to control the risk of runoff from the placement area.

2.2.4 Revegetation

The final landform would be progressively revegetated with locally endemic species which will control erosion and integrate the surrounding landscape. Rehabilitation activities aim to progressively provide a landform vegetated by locally occurring grasses, shrubs and trees representative of the native plant community type adjoining the site (PCT 1248 Sydney Peppermint – Silvertop Ash heathy open forest).

Vegetation would be selected by the project ecologists in consultation with the NPWS and a list of species suitable for use in the revegetation works is included in Appendix F.

A vegetation management plan has also been prepared to revegetate and manage an approximate 40 metre buffer of land on the eastern and southern boundaries of the site to rehabilitate portions of the site that had been previously impacted by quarry operations and is included in Appendix C.

Appendix C also includes an Ecological Monitoring Plan which applies to the whole project.

2.3 Project resources

2.3.1 Equipment

Anticipated plant and equipment to be used for the Project is largely consistent with the development described in the EIS and shown in .

Table 2.6 Anticipated plant and equipment

Project Activity	Equipment	Plant
Imported material		Up to 42.5 tonne truck and trailer haulage vehicles
Emplacement activities	Generator, site office / amenities building spill kits, refuelling/spill bunds,	1 grader, 1 tipper truck, 1 dozer, 2 front end loaders, Roller, Fuel delivery truck, water truck
Water management system	Submersible and centrifugal pumps	Contingency water treatment plant (if required)
Revegetation activities	Mechanical and electrical equipment,	Hydro-seeding (and planting of tubestock)

2.3.2 Workforce

The workforce required to operate the site is anticipated to be 4 – 6 employees in addition to haulage drivers as described in the EIS.

2.3.3 Operational hours

Operation hours for the proposed rehabilitation works will be in accordance with as described in the EIS. Rehabilitation activities and haulage to the site will be restricted to the hour of 7.00 am to 6.00 pm Monday to Friday and 7.00 am to 1.00 pm on Saturdays. Minor site preparation activities involving the use of a grader and roller to prepare the site for haulage vehicles is proposed between 6.00 am and 7.00 am Monday to Saturday.

Table 2.7 *Operating hours*

Activity	Day of week	Time	Assessment period
Rehabilitation related activities and transport of materials	Monday-Friday	7:00 am to 6:00 pm	Day
	Saturday	7:00 am to 1:00 pm	Day
	Sunday and Public Holidays	None	-
Preparation of ground on-site for haul trucks	Monday-Friday	6:00 am to 7:00 am	Night
	Saturday	6:00 am to 7:00 am	Night
	Sunday and Public Holidays	None	-

3. Environmental considerations

3.1 Emplacement material

3.1.1 Acceptance criteria

Rehabilitation of the final landform to be achieved via importation of material sourced across Sydney and the local regional area which meets:

1. the definition of VENM as defined by the PoEO Act from time to time.
2. the criteria of ENM as set out in the Excavated Natural Material Order and Exemption 2014 issued by the Environmental Protection Authority under clause 93 of the Protection of the Environmental Operations (Waste) Regulation 2014.
3. an exemption granted by the Environment Protection Authority pursuant to clauses 91 and 92 of the Protection of the Environmental Operations (Waste) Regulation 2014 and which specifically relates to the site (Comparable Material).

The original DA has been amended to remove "clean fill".

The term "clean fill" was initially adopted as part of the original DA as it is included in clause 121(3) of the State Environmental Planning Policy (Infrastructure) 2007 (Infrastructure SEPP).

The Infrastructure SEPP recognises the enhanced rehabilitation outcomes that can be achieved through importation of specified fill to sites previously disturbed by extractive operations. The Project is consistent with the aims and objectives of the policy and will allow for recycling and beneficial reuse of fill material.

For the purpose of this DA all fill material will meet the definition of either VENM, ENM or an exemption granted by the EPA specifically related to the site pursuant to clauses 91 and 92 of the Protection of the Environmental Operations (Waste) Regulation 2014.

It is noted that there is currently no site-specific resource recovery order and associated exemption applicable for the site and any future exemption would need to be directly authorised by the EPA. The option provides flexibility to accommodate other potentially exempt material if directly approved by the EPA and would be subject to an application made addressing the requirements in the Guidelines on Resource Recovery Orders and Exemptions (for the land application for waste material as fill) (EPA 2017), and any other requirements stipulated by the EPA. No material will be applied to the site that does comprise either VENM, ENM or comparable material that is specifically authorised by a site-specific resource recovery order and exemption which specially relates to the land pursuant to clauses 91 and 92 of the Protection of the Environmental Operations (Waste) Regulation 2014.

3.1.2 Waste classes and risk of environmental harm

It is important to dispel the perception that the material sought to be received at the site poses the same risks of causing an environmental impact compared to general solid waste permitted at landfills licensed by the EPA.

Emplacement material permitted to be accepted at the site is materially different to waste that has been generated at a site where potentially contaminating activities have or are occurring, and which would be required to be classified in accordance with the NSW EPA Waste Classification Guidelines (NSW EPA, 2014a) and transferred to landfill licensed to accept the classified waste.

VENM, ENM and comparable material permitted under a specific resource recovery order and associated exemption when applied to land are exempt from the licensing requirements under the PoEO Act. These licensing exemptions reflect the intrinsic lower risk of environmental impact that these material types present when applied to land compared to other waste classified such as general solid waste, special waste and restricted waste.

As described above, VENM is material not contaminated with any man-made substances and does not contain sulphidic (acid forming) material or any other waste. The ENM Order states that ENM must comprise at least 98% natural material and other limiting criteria as discussed below. An application for comparable material in the form of a specific resource recovery order and associated exemption must demonstrate as a minimum that the material:

- is fit for purpose in its proposed use
- poses minimal risk of harm to the environment or human health; and
- is not intended to be land applied as a means of disposal (i.e., a landfilling activity).

The ENM Order outlines the maximum concentrations of substances and other attributes for acceptable ENM material, whilst the NSW EPA Waste Classification guidelines (NSW EPA, 2014) identifies the maximum contaminant concentrations for general solid waste permitted at landfills licensed by the EPA.

Emplacement material to be accepted at the site (VENM, ENM and comparable material) present a lower risk of causing an environmental impact at the site than waste that is disposed of at a licensed general solid waste landfill facility.

Table 3.1 *Comparison of criteria in the ENM order (NSW EPA, 2014b) and the NSW EPA Waste Classification Guidelines (NSW EPA, 2014a)*

Substance	NSW EPA ENM order		NSW EPA Waste Classification Guidelines	General solid waste criteria in relation to absolute maximum ENM concentration
	Maximum average concentration for characterisation (mg/kg 'dry weight' unless otherwise specified)	Absolute maximum concentration (mg/kg 'dry weight' unless otherwise specified)	Maximum values of specific contaminant concentration for classification without TCLP General solid waste (mg/kg)	
Mercury	0.5	1	4	4 x larger
Cadmium	0.5	1	20	20 x larger
Lead	50	100	100	Same value
Arsenic	20	40	100	2.5 x larger
Chromium (total)	75	150	100[4]	0.66 x smaller*
Copper	100	200	No value specified	-
Nickel	30	60	40	0.66 x smaller*
Zinc	150	300	No value specified	-
Electrical conductivity	1.5 dS/m	3 dS/m	No value specified	-
pH	5 to 9 [5]	4.5 to 10[6]	No value specified	-
Total Polycyclic Aromatic hydrocarbons	20	40	200	5 x larger
Benzo(a)pyrene	0.5	1	0.8	0.8 x smaller*
Benzene	NA	0.5	10	20 x larger
Toluene	NA	65	288	4.4 x larger
Ethyl-benzene	NA	25	600	24 x larger
Xylene	NA	15	1,000	66.7 x larger
Total Petroleum Hydrocarbons $C_{10} - C_{36}$	250	500	10,000	20 x larger
Rubber, plastic, bitumen, paper, cloth, paint and wood	0.05%	0.10%	No value specified	-

* Maximum average concentrations are lower than for general solid waste

For the substances that are present in both the Order and Guidelines, the maximum concentrations for all substances in the NSW EPA Waste Classification Guidelines (based on the specific contaminant concentrations) are greater than the maximum average concentrations presented in the ENM Order.

There are, however, three substances which have a higher absolute maximum concentration in the ENM Order compared to the maximum values in the NSW EPA Waste Classification Guidelines for general solid waste. This occurs for Nickel, Benzo(a)pyrene and chromium. However, on average, the concentrations of all three of these substances are still less than those for general solid waste.

The VENM, and ENM sought to be accepted at the site will be required to meet the definition of VENM in the POEO Act and the criteria outlined in the ENM Order, respectively. Any comparable material will be required to

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[4] Cr(VI)

[5] The ranges given for pH are for the minimum and maximum acceptable pH values in the excavated natural material

[6] The ranges given for pH are for the minimum and maximum acceptable pH values in the excavated natural material

obtain a specific resource recovery order and exemption from the EPA by demonstrating that it poses minimal risk of harm to the environment or human health and address other criteria stipulated by the EPA.

These waste types (VENM, ENM and comparable material) present a lower risk of causing an environmental impact at the site than waste that is able to be accepted at a licensed general solid waste landfill facility.

Furthermore, additional mitigation measures, monitoring and if needed adaptive controls are proposed for the Project to ensure that the risk of environmental impact is negligible. These are described in detail throughout the Revised Water Resources Assessment (GHD 2021) (Appendix E) and Environmental Management Plan (GHD 2021) (Appendix B).

3.1.3 Requirement for an Environment Protection Licence

The PoEO Act provides for an integrated system of licensing and contains a core list of activities requiring an EPL from the EPA. These activities are called 'scheduled activities' and are listed in Schedule 1 of the PoEO Act. Application of waste to land is considered to be a scheduled activity in accordance with Clause 39 of Schedule 1 of the PoEO Act.

However, whilst the emplacement materials defined as waste under the PoEO Act, they are specifically exempt from licensing for application of waste to land under Clause 39 of Schedule 1 of the PoEO Act. The relevant clauses include:

- Clause 39 2(e) of Schedule 1 for VENM.
- the ENM Exemption 2014 and subject to its requirements turns off the licensing requirements under Clause 39 of Schedule 1.
- the details of any specific resource recovery exemption, if granted by the EPA pursuant to clauses 91 and 92 of the Protection of the Environmental Operations (Waste) Regulation 2014.

The Project meets all requirements for application of VENM and ENM exempt from licencing provisions under Clause 39 of Schedule 1 of the PoEO Act. Any other comparable material will only be permitted to the applied to the site if specifically authorised by the EPA through application of a site-specific resource recovery exemption which will also be licence exempt.

Further, the integrated provisions under the EP&A Act are elective in that the applicant is not obliged to have an application for a licence under the PoEO Act assessed at the time of assessment of the DA. An application for a licence under the PoEO Act can be made by the applicant separately to the DA, if required.[7]

It is acknowledged that under section 120 of the PoEO Act, a person who pollutes waters is guilty of an offence and that sections 121 and 122 of the PoEO Act provides a defence against prosecution under section 120 where the pollution was regulated by a licence or regulation that was complied with fully.

The definition of water pollution in the PoEO Act sets out general and specific circumstances that constitute water pollution. At its broadest, this means a prohibition on placing anything in waters that changes their chemical, biological or physical nature or is of a prescribed nature, description or class that does not comply with any standard prescribed in respect of the matter.

The "*EPA's Licencing Fact Sheet – Using environment protection licensing to control water pollution*" states that the EPA does not use licencing to regulate every potential pollutant that could be contained in a discharge such as:

- Those pollutants with little or no potential to be present at levels that pose a reasonable risk of harm to health or the environment.

The EPAs licencing fact sheet also includes a range of matters for considerations in exercising its licencing functions including:

- the pollution that will be caused and its impact on the environment.
- practical measures that can be taken to prevent, control, abate or mitigate the pollution and protect the environment from harm.
- the environmental values of water affected by the proposed discharge.

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[7] See *Maule v Liporoni & Anor* [2002] NSWLEC 25

- practical measures that can be taken to restore or maintain those values.

A revised surface water management systemto is proposed to ensure that all surface water released from the site drains only from naturally occurring soils within the catchment or is treated to standard to meet background water quality concentrations. The amended project will achieve a neutral or beneficial effect on the catchment and does not warrant an application for a licence under the PoEO Act.

3.2 Water Resources

3.2.1 Introduction

Management of water released from the site to the sensitive receiving waters in the Greater Blue Mountains National Park has been a key issue considered throughout the development of the Project. The potential for impacts associated with surface water releases and leachate generated by the Project to impact upon an unnamed tributary of the Wollongambe River and a connected hanging swamp located were primary reasons raised in the refusal of the DA by the WRPP in April 2020.

A number of investigations have been completed since the refusal to better characterise the receiving water environment and associated hanging swamp and to develop a revised water management system to ensure the proposed development achieves a neutral or beneficial effect on the catchment.

3.2.2 Existing hydrology characterisation

Surface water hydrology

Martens and Associates (2021) have undertaken detailed site based hydrological investigations to provide an improved understanding of the existing hydrological environment, with a particular focus on the swamp located approximately 200 metres downslope from the site. The assessment also considers hydrological conditions prior to commencement of the quarrying operations at the site and forecasts hydrological conditions after the proposed final landform is established. A summary of the key findings of the Martens and Associates (2021) study is outlined below, and a full copy of the assessment is provided in Appendix D.

The hanging swamp downslope of the site is characterised by the watercourse running through swamp with the catchment originating upstream from the quarry. The watercourse has a poorly defined channel with flows infiltrating into the ground and resurfacing at regular intervals upstream from the swamp. The existing quarry voids capture surface flows from upslope and direct these to the existing overflow point comprising a constructed wetland downstream of the site.

Two stream gauges were set up at the upslope and downslope ends of the hanging swamp to determine flows and assess likely changes to hydrological conditions likely to be realised through filling of the quarry voids and the final rehabilitated landform. The flow regime in the local catchment is characterised as follows:

- Flows to the hanging swamp appear to be directly related to incidence of local rainfall (i.e., flows appear to rely on surface flows from rainfall as opposed to base flows from groundwater).
- Local catchments have a relative rapid response with flows commencing not long after commencement of precipitation. This may be explained by the relatively shallow sandy catchment soils and frequent bedrock outcropping leading to runoff occurring relatively quickly following precipitation.
- Smaller flows upslope of the existing voids is captured by the voids, with overflows being directed to the hanging swamp downslope.
- Water levels in the voids are influenced largely by groundwater inflows and evaporation.
- Flows tend to be relatively minor (of the order of < 5 L/s) for most of the monitoring period, with the average flow rate skewed by less frequent flow events (median flows much less than average flows).

Development of a calibrated MUSIC (Model for Urban Stormwater Improvement Conceptualisation) model was undertaken determine pre-quarry hydrological conditions and likely impacts upon the catchment from long term quarrying operations.

The modelling results show lower flows appear to be more frequent for pre-quarry conditions when compared to existing conditions, although total daily volumes are comparable for the downstream gauge and higher for the upstream gauge. This is reasonably expected given the excavation of the quarry voids which would be expected to remove lower flows from the system and overflow larger volumes during higher flow conditions.

Modelling of the final landform surface indicates flows into the swamp will be similar to existing hydrological conditions, with mid-range flows more representative of pre-quarry conditions. The modelling demonstrates that the proposed final surface will not detrimentally impact on the surface hydrological regime in the downstream swamp and closure of the upper void will go some way towards remediating historical changes in flow regime caused through development of the quarry.

Water quality

Water quality monitoring was also undertaken as part of the Martens and Associates (2021) investigations and found the following:

- Water quality of overflows from the quarry voids is generally of relatively good quality when compared with trigger values given in the National Water Quality Management Strategy (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*.
- Nutrient, heavy metal and hydrocarbon concentrations in surface discharges from the site are low, indicating that the existing quarry and associated accesses are not significantly impacting on surface water quality downstream at the hanging swamp.
- Surface water is generally slightly acidic, most likely as a result of local geology.

Hydrogeology

The Martens and Associates (2021) investigations included continuous groundwater monitoring at eight wells surrounding the site including shallow and deep wells installed in the vicinity of the downstream hanging swamp to understand the interaction between the shallow, perched aquifer, and the deeper sandstone aquifer. On the basis of investigations, a conceptual hydrogeological model for the downstream swamp was prepared with a commentary on the findings provided below:

- Groundwater within the swamp develops in response to direct rainfall and surface inflows arriving from the catchment which are developed both within the site but also within adjoining valley areas.
- As surface water inflows enter the swamp, these spread out and typically flow in an un-channelised manner over the swamp surface where due to the high sand content of swamp soils, there is a high degree of infiltration.
- Infiltrated surface water causes a perched water table to develop which sits over the underlying sandstone bedrock. This water table is ephemeral and has the capacity to recharge the underlying permanent water table.
- Perched water within the swamp exits at the downstream portion of the swamp into a narrow-formed channel.
- The swamp surface does not appear to have been the subject of any current significant erosion, although there is evidence that historical erosive events have occurred.

The following implications arise out of the investigation findings:

- Groundwater flows from the filled quarry voids is not likely to contribute to groundwater flows within the swamp because these are controlled by surface water inflows and direct rainfall.
- Perched groundwater that occurs within the swamp will at times recharge deeper groundwater.
- Surface flows discharged from the site during filling operations and following completion of the final landform will likely enter the swamp area and contribute to the hydrology and water chemistry of the perched water table.

Groundwater modelling indicates that groundwater flow is generally downwards and that the existing quarry voids have significantly altered groundwater levels by lowering the groundwater table by up to 5 metres in the quarry voids and increasing groundwater levels elsewhere by 1 to 2 metres.

Dewatering and filling of the main void at the quarry is expected to lower groundwater levels in the sandstone aquifer beneath the hanging swamp by around 0.5 metres compared to existing conditions and shows that the groundwater levels of the final rehabilitated landform are closest to the pre-quarry conditions as the drawdown extents at the quarry are the smallest. Groundwater levels in the sandstone aquifer will remain beneath the swamp and there will be no connection between groundwater flows from the quarry to the swamp.

The groundwater quality monitoring found that:

- Nitrogen observations are generally higher in the deep wells compared to the shallow wells mostly due to elevated total nitrogen and NOx readings in MB03.
- Total phosphorous observations are higher in the shallow wells compared to the deep wells.
- Heavy metals are generally higher in the shallow groundwater wells than in the deeper groundwater wells.
- Total recoverable hydrocarbons (TRHs) were all below the detection limit except for at MW201 where they were observed on four occasions.

3.2.3 Surface water management system

Introduction

A revised water management system has been developed for the site as described in Section 2.2.3. The management system involves separation of surface water flows to ensure that all surface water released from the site drains only from naturally occurring soils within the catchment or is treated to standard to meet background water quality concentrations. A detailed assessment of potential impacts to surface water resources is presented in the Revised Water Resources Assessment included in Appendix E with a summary of the findings outlined below.

The system has been designed to achieve the adopted elevated assessment criteria based on the State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011 as well as the corresponding WaterNSW guideline *Neutral or Beneficial Effect (NorBE) on Water Quality Assessment Guideline*. The NorBE approach has been applied to the proposed development to achieve the highest level of protection given the sensitivities of receiving waters in the Wollongambe River catchment and the Greater Blue Mountains World Heritage area, although it is noted the site does not fall within Sydney's Drinking Water catchment area.

The assessment criteria is derived based on the following definition from the guideline:

A neutral or beneficial effect on water quality is satisfied if the development:

a. has no identifiable potential impact on water quality, or
b. will contain any water quality impact on the development site and prevent it from reaching any watercourse, waterbody, or drainage depression on the site.

A detailed surface monitoring program has been developed to be implemented throughout site operations to demonstrate how the management of surface water flows in the site achieve NorBE as described below.

Upstream catchment

Upstream catchment flows will be transferred directly through or around the site, without any mixing with contact water from active operational emplacement areas. Where mixing of upstream and site waters is unavoidable (eg. a cascade of upstream waters currently enters the western void of the site) the upstream waters shall mix only with run-off from existing site soils or rehabilitated surfaces with a site won capping material.

Transfer of upstream flows directly through the site will reduce the storage of water within the existing voids during extended dry periods. This will reduce potential stress the downstream receiving waters and sensitive ecological receptors and more closely replicate the natural base flow conditions to support the downstream hanging swamp.

Where the upstream water does not come into contact with any site waters it is anticipated to *have no identifiable potential impact on water quality* and as such satisfy the NorBE criteria adopted for the site.

The initial quarry dewatering works will be undertaken in a manner to ensure that the flow rate does not exceed the guidance provided by Martens and Associates (2021). This will ensure that the dewatering works would not cause any detrimental impact on the geomorphology of the downstream swamp (for example, not create a 'nick point').

The water quality that will be released from dewatering the quarry void from the site establishment phase will be of the same quality as exists in the ponds and that is discharged currently. Martens and Associates (2021) have identified that the quality of the water in the voids has not impacted the water quality within the swamp.

Therefore, dewatering of the quarry voids prior to operations will satisfy NorBE criteria adopted for the site.

Existing site soils

Sediment laden water has been characterised as run-off originating from areas where disturbed, non-vegetated soil is present, but does not consist of imported fill material or run-off from active emplacement areas. For naturally occurring site soils, runoff is to be managed in accordance with *Managing Urban Stormwater: Soils and Construction Volume 1, Landcom 2004 and Volume 2, DECC 2008* as applicable to a "sensitive" receiving environment. The guidelines are considered current recommended practices (CRPs) endorsed by WaterNSW and are applicable to be applied to site to achieve NorBE.

During the quarry dewatering works occurring during the site operations, the only potential source of water than may influence its water quality is runoff from the site's soils and potentially introducing suspended solids. The total suspended solids concentration of this water will be adjusted as needed to meet the guidance WaterNSW current recommended practice and will satisfy NorBE criteria adopted for the site.

Contact Water

A key change adopted as part of the revised water management system is to ensure that all contact water draining from operational areas will be captured in a contact water pond for reuse via on-site irrigation in the active emplacement cell.

A water balance has been prepared and indicates all contact water can be retained on site for the life of the project under best estimate assumptions emplacement operations when assessed against historical and potential future climate scenarios. Containment of contact water on site will meet the NorBE criteria of preventing any potentially impacted water from reaching receiving waters and assist with site operations through dust suppression and compaction and ensure all emplacement material is retained entirely within the site. Contingency for the provision of a water treatment plant has also been included as part of the proposed development if best estimate assumptions for site water use are not realised. The water treatment plant will be triggered if the contact water pond reaches 45% capacity to provide time for commissioning and treatment of water in the contact water pond prior to release from the site. This will ensure that any releases from the site are treated to meet background water quality standards and result in no identifiable impact upon water quality.

Containment of contact water within site operations or treatment to meet background water quality will meet the NorBE assessment criteria adopted for the Project.

Management approach

The water management system as depicted in the staging plans is designed to control surface flows and erosion risks within the site.

A Soil and Water Management Plan will be developed prior to the commencement of any soil disturbance or wate management works. This would be developed in accordance with the WaterNSW CRP *Managing Urban Stormwater: Soils and Construction Volume 1, Landcom 2004 and Volume 2, DECC 2008*. It should be noted that the key basis of this plan (and therefore the feasibility of appropriately implementing it) has been confirmed through development of the Revised Water Resources Assessment (GHD 2021). This includes:

- Confirming the appropriate separation of water types (e.g. clean, contact, sediment-laden) during the different stages of the project
- The sizing and inclusion of sediment basins in accordance with the WaterNSW CRP based on the contributing sediment-laden catchment areas for each stage
- Review of the receiving water quality and imposing of the required discharge standard for sediment laden water
- Inclusion of contingency measures in the event of initial sediment laden water quality treatment not satisfying the discharge criteria
- Identifying that the dewatering would be undertaken at a rate that is within the general existing range of downstream flow rates (Martens and Associates 2021).

3.2.4 Groundwater

The amended project includes the adoption of a lining system within the emplacement cell and contact water dam. All areas proposed to be filled will be lined with a geomembrane on the base and clay liner on the sidewalls where they are adjacent to the natural substrate within the pits. The final rehabilitated surface will also be capped with geomembrane, overlaid with a subsurface drainage system and revegetated.

A detailed assessment of the potential impacts to groundwater is presented in the Revised Water Resources Assessment included in Appendix E with a summary of the findings outlined below.

The adoption of a lining system within the emplacement cell will also limit the potential for leachate within the emplacement cell to impact upon local or regional groundwater systems. The limited potential for seepage through the lined emplacement cell will result in less than a 0.2% contribution to groundwater volume at the assessed closest discharge point to surface waters downslope of the hanging swamp, with the remaining 99.81 per cent comprised of background/catchment groundwater. It is noted that the Martens and Associates (2021) assessment has demonstrated that there is no direct connection between groundwater flows from the quarry site and the downstream hanging swamp. The adoption of the closest potential discharge point immediately downstream of the swamp is conservative and is likely to underestimate mixing and attenuation factors within the bedrock aquifer.

The mixing percentages were used to back calculate site-specific target levels for leachate from the fill material within the quarry void. The leachate target levels were conservatively calculated based upon predicted seepage rates and the attenuation capacity within the aquifer prior to the nearest potential discharge point to receiving waters downstream from the swamp. The target levels for leachate generated within the site provides an indication of likely acceptable leachate concentrations that could be developed within the cell and still result in a neutral or beneficial effect upon receiving waters in the catchment.

The site-specific target levels were then compared to estimates for likely leachate generation based upon ASLP testing of select range of indicative soils in the Sydney basin and theoretical soil partitioning values for estimating the potential transfer of inorganic and organic substances in soils into the liquid state using US EPA developed partitioning equations (GHD, 2018).

The ASLP tests considered a range of typical geologies and soil types and involves tumbling the soil/rock sample with water for 18 hours to generate the maximum potential leachability from the samples. The soil-water partition equation (USEPA 1996) was calculated for using the maximum average concentrations (or the absolute maximum concentrations, where no maximum average concentration exists) in the ENM Order which sets the acceptance criteria for emplacement material at the site. The partitioning equations used median values adopted in the EIS to provide another estimate potential leachability that could be generated within the emplacement cell.

All ASLP test results were below the site-specific target levels with the exception of one analyte which is considered as a function of the level of reporting in the laboratory analysis and assumptions adopted in the modelling rather than a realised potential for exceedance.

The soil partitioning results for ENM suggest there is some risk for material to generate leachate. The soil partitioning results for the analytes identified to have residual risks are considered to be highly conservative relative to the ASLP results or representative of contaminated sites, which are not reflective of the VENM and ENM soils proposed to be brought to site. While there may be localised incidence of higher leachable concentrations, when considered from a bulk filling perspective it is expected that concentrations on average would be well below the leachate monitoring criteria adopted for the site as demonstrated by the results of the ASLP analysis.

A monitoring program has been developed to monitor for and respond to the emergence of impacts associated with these analytes and provide an early warning system before any emerging groundwater impacts could arise from the site operations.

Adoption of the liner system to minimise the potential seepage of leachate from the site and a monitoring program with a targeted action response plan will ensure that the operations pose minimal risk to receiving waters and meet the NorBE criteria adopted for the Project.

3.3 Biodiversity

3.3.1 Introduction

A detailed biodiversity assessment was undertaken to consider the potential impact of the project on ecological values of the study area as part of the EIS. The assessment found that the majority of the rehabilitation activities would be undertaken in disturbed areas within the quarry footprint and that direct impacts would be limited to clearance of a total of 0.13 ha of remnant vegetation and 2.48 ha of planted native vegetation.

The assessment included consideration of the downstream swamp which was identified as representative of Prickly Tea-tree – sedge wet heath swamp below the quarry discharge location as a Newnes Plateau Shrub Swamp (Endangered Ecological Community (EEC) under the *Biodiversity Conservation Act 2016* (BC Act)*)* and Temperate Highland Peat Swamps on Sandstone (EEC under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)).

Consideration of potential for indirect impacts upon the ecological communities within the swamp was undertaken based upon the interpretation of the results of the Water Resources Assessment included in the EIS and concluded there was no potential for significant impacts.

However, the potential for impacts to the swamp associated with altered hydrology and water quality were outlined as a key issue in the refusal of the DA by WRPP in April 2020.

Further ecological investigations have been undertaken by Cumberland Ecology and are reported in Appendix F. The study includes field assessments undertaken following 2019 bushfires and includes consideration of the impacts associated with the amended project presented in the report and the updated hydrology and water resources assessments.

3.3.2 Supplementary analysis

The revised assessment has confirmed the swamp vegetation includes a *Leptospermum*-dominated southern extent and a sedge dominated northern extent and conforms to plant community type (PCT) 1078 Prickly Tea-tree - sedge wet heath on sandstone plateaux, central and southern Sydney Basin Bioregion. This PCT conforms to the Newnes Plateau Shrub Swamp Threatened Ecological Community (TEC) is listed as an EEC under the BC Act and the EPBC Act.

The assessment confirms that the Project will not have potential to directly impact upon the swamp, however indirect impacts associated with an altered hydrological regime may potentially influence the swamp. The Martens and Associates (2021) assessment has confirmed that groundwater flow from the quarry is not likely to contribute to groundwater flows within the swamp. The perched water table at the swamp is fed by surface water flows and rainfall which contributes to the water chemistry within the swamp, which will at times recharge the deeper groundwater systems.

The report outlines that the primary hydrological pathway for impacting the swamp would be the release of uncontrolled flows from the filling operations area. This can be readily managed through the implementation of the revised water management strategy through capture and treatment of any contact water prior to release, reuse of water for dust suppression and irrigation within the active emplacement areas, minimisation of surface water inflows to the void area, and controlled management of site discharges.

At the completion of the Project, there will be return to a hydrological regime co-existent with conditions prior to quarrying operations. This is seen of benefit to the swamp as it ameliorates the historical impacts currently realised at the site as a result of the historical quarrying operations.

The revised water management at the site and the final developed landform will also reduce the storage of low catchment flows within the quarry voids and reduce the stress on the downstream swamp. This is important in ameliorating the potential effects of human induced climate change which is considered the greatest long-term threat to the swamp vegetation.

The Project will reduce the storage of water within the existing voids during extended dry periods. This will reduce potential stress the downstream receiving waters and sensitive ecological receptors and more closely replicate the natural base flow conditions to support the downstream hanging swamp.

Cumberland Ecology have also included a Vegetation Management Plan for the site and portion of land on the adjoining NPWS estate as included in Appendix C.

3.4 Traffic

A detailed Traffic Impact Assessment was prepared as part of the original EIS in accordance with the Roads and Maritime inputs to the Secretary's Environmental Assessment Requirements (SEARs) and RTA's *Guide to Traffic Generating Development* 2002.

The assessment included a haulage analysis based upon the traffic predicted to be generated by the project including detailed modelling undertaken at the intersections likely to be most affected by the proposed development including the intersection of Sandham Road and Bells Line of Road and the intersection of Bells Line of Road and Darling Causeway.

The intersection modelling indicated there would be no change to the level of service of the most affected intersections with the average delay increasing by less than two seconds during AM and PM peak periods. The proposed haulage is not anticipated to impact upon the safety and capacity of the road network.

The haulage traffic represents a relatively small proportional increase to background traffic on the wider regional road network which comprise designated heavy vehicle routes utilising major state and arterial roads. The average percentage increase of between 1 and 3% in comparison to existing vehicle numbers is not expected to impact upon the safety of capacity of the road network. A maximum of four truck deliveries per hour under the Worst Case Haulage scenario will not result in surge or pulse effects on the road network.

The Applicant committed to develop a driver code of conduct as part of a Traffic Management Plan for the Project, to guide transport operations on all public roads including Sandham Road. This will include specific requirements such as limiting the speed limit to 40 km/hr for all trucks on Sandham Road and incorporate a haulage route complaint management system.

There is no change to the haulage operations described in the original EIS as outlined in Section 2.2.1.

An independent review of the findings of the original traffic assessment has been undertaken by GTA Traffic Consultants. The review supported the findings of the original assessment and highlighted that traffic generated by the proposed development will have a negligible impact upon the function of the surrounding road network.

The assessment highlighted that whilst some sections of Sandham Road were narrow, the low traffic volumes associated with the proposed development did not warrant wholesale upgrade of the road. Seven locations have been identified along Sandham Road to provide opportunities for minor shoulder widening or localised widening for the creation of passing bays to improve the two way flow of traffic as shown in Appendix G.

3.5 Noise

A detailed noise impact assessment was undertaken as part of the original EIS in accordance with EPA policies and guidelines. The modelling indicated compliance at all nearby receivers for both emplacement activities within the quarry site and use of Sandham Road as a haulage route.

The Supplementary EIS modifies the staging plan presented in the EIS and the final landform has been altered to accommodate the new site access road and the use of the eastern void as a contact water pond. It is noted that the footprint remains entirely within the footprint previously assessed as part of the noise impact assessment and there is no change to the maximum height of the final landform or equipment used as part of the filling operations.

It is noted that the noise modelling included scenarios for mobile equipment such as the grader, dozer, loaders and roller/compactor operating at the base of each cell at the commencement of filling of each stage and at the highest point on the excavation face as each stage approaches the final landform.

The final landform surface represents the worst-case scenario for noise propagation at each stage and the revised staging and landform will continue to fall within the extent of impacts predicted as part of the original noise assessment.

It is noted that the worst-case scenario noise generation from the site was during filling in Stage 1 as a result of proximity to the nearest sensitive receiver located to the north-west of the site. The worst-case scenario will now be experienced during Stage 4 of the revised staging and be consistent with the model predictions included in the EIS.

An additional diesel generator may be required if the water treatment plant is commissioned at the site. The noise impact assessment included a generator for operating of the water pump with a sound power level of 89 dBA. This is well below all other modelled sources (between 13 dBA and 21 dBA lower) and would not likely have any contribution to noise levels experienced at offsite receptors.

The water treatment plant and associated generator would be located at a distance further away from the nearest sensitive receivers than other louder noise sources and would be unlikely to contribute to overall noise levels generated at the site.

3.6 Other environmental matters

The revisions to the project proposed as part of the Supplementary EIS are not considered to have potential to alter the findings of the original EIS. All assessment outcomes will continue to comply with relevant assessment criteria and fall within the extent of impacts predicted in the original EIS.

4. Conclusion

The Supplementary EIS has been prepared to describe the amendments proposed to the Bell Quarry Rehabilitation Project. The Project will remain largely consistent with original DA and involves rehabilitating a former Bell Quarry site to achieve the final rehabilitated landform via importation of VENM, ENM and comparable material (that meets an exemption pursuant to clauses 91 and 92 of the Protection of the Environmental Operations (Waste) Regulation 2014). The emplacement material will sourced from projects across Sydney and the local regional area and transported to the site at up to 140,000 tpa which is the equivalent scale of the extraction operations previously undertaken at the site.

Modifications to the original DA relate to definition of the acceptance criteria for emplacement material to be accepted at the site and modifications to the proposed water management system and emplacement cell staging to reflect the revised water management system. Relocation of the site access road and a vegetation management plan have been prepared to address boundary irregularities with the adjoining NSW National Parks estate. The applicant is also willing to enter into a planning agreement to contribute to minor upgrade works which have been identified to improve the flow of traffic and safety of haulage vehicles utilising Sandham Road and to undertake maintenance of the unsealed section of Sandham Road.

The Supplementary EIS proposes a revised surface water management system which will ensure that all surface water released from the site drains only from naturally occurring soils within the catchment or is treated to standard to meet background water quality concentrations. All contact water draining from operational areas will be captured in a contact water pond for reuse in the active emplacement cell. A water treatment plant has been included as a contingency to be triggered in the unlikely event that discharge of contact water is required to ensure water quality continues to reflect background water quality.

The Supplementary EIS also includes the adoption of a lining system within the emplacement cell and contact water dam and the final rehabilitated surface will be capped and revegetated. The proposed lining system will greatly reduce the potential for any seepage of leachate generated within the emplacement cell to impact upon the local or regional groundwater systems.

Site based hydrological investigations of groundwater flows from the filled quarry voids is not likely to contribute to groundwater flows within the swamp and that the rehabilitation project will return both the surface and groundwater environments to be more representative of the original catchment conditions prior to the commencement of quarrying operations. This is considered to be of benefit to the ecological health of the downstream swamp and provide additional resilience to drought conditions or human induced climate change.

The remainder of environmental impacts are considered to comply with relevant assessment criteria and fall within the extent of impacts predicted in the original EIS. The benefits of the Project include:

- Beneficial reuse of emplacement materials and reduced landfill disposal
- Revegetated landform more closely matching the adjoining national park
- Revegetation of land adjoining the site that has been impacted by historical quarrying operations
- Return of surface water and groundwater regimes closer to original catchment conditions to provide additional resilience to the receiving waters and downstream swamp.

Overall, the Project is considered to provide a beneficial outcome for site and is recommended to be approved.

Appendices

Appendix A

SEARs compliance and Response to contentions in EIS

Supplementary EIS compliance with SEARs

Category	Secretary's requirements	Where addressed in EIS	Supplementary EIS
General	– EIS must meet the minimum form and content requirements in clauses 6 and 7 of Schedule 2 of the Environmental Planning and Assessment Regulation 2000	Throughout	As per original EIS and as supplemented by this assessment for amendments to the project
	– assess all potential impacts of the proposed development on the existing environment (including cumulative impacts if necessary) and develop appropriate measures to avoid, minimise, mitigate and/or manage these potential impacts.	Chapter 7 to 14	
Planning	assess the Project against the relevant environmental planning instruments, including but not limited to: – State Environmental Planning Policy (Infrastructure) 2007; – State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007; – State Environmental Planning Policy No. 33 Hazardous and Offensive Development; – State Environmental Planning Policy No. 55 Remediation of Land; – Lithgow Local Environmental Plan 2014; and – relevant development control plans and section 94 plans.	Chapter 5	As per original EIS
Strategic context	– a detailed justification for the Project and suitability of the site for the development	Chapter 16	As per original EIS and as supplemented by this assessment for amendments to the project
	– a demonstration that the Project is consistent with all relevant planning strategies, environmental planning instruments, development control plans (DCPs), or justification for any inconsistencies – a list of any approvals that must be obtained under any other Act or law before the development may lawfully be carried out.	Chapter 5	
Consultation	– consult the relevant local, State and Commonwealth government authorities, service providers and community groups, and address any issues they may raise in the EIS. In particular, you should consult with the: • Environment Protection Authority; • Office of Environment and Heritage; • Department of Primary Industries; • Roads and Maritime Services; • Water NSW; • NSW National Parks and Wildlife Services; • Lithgow City Council; • holder of Mining Lease 1654 and Mineral Exploration Licence 7674 (Kaolin Pty Ltd); • holder of Coal Authorisation 307 (Hartley Vale Coal Pty Ltd); • holder of Mining Lease 1583 (Coalex Pty Ltd); and • the surrounding landowners and occupiers that are likely to be impacted by the proposal. – details of the consultation carried out and issues raised must be included in the EIS.	Chapter 6	As per original EIS
Waste management	– details of the type, quantity and classification of waste to be received at the site	Chapters 4 and 14	Section 2.2, Section 3.1 and Appendix B

Category	Secretary's requirements	Where addressed in EIS	Supplementary EIS
	– details of the resource outputs and any additional processes for residual waste – details of how the proposal would meet the EPAs Excavated Natural Material Order and Exemption 2014 if relevant – details of waste handling including, transport, identification, receipt, stockpiling and quality control – the measures that would be implemented to ensure that the proposed development is consistent with the aims, objectives and guidelines in the NSW Waste Avoidance and Resource Recovery Strategy 2014-21.		
Air quality	– a description of all potential sources of air and odour emissions – an air quality impact assessment in accordance with relevant Environment Protection Authority Guidelines – a description and appraisal of air quality impact mitigation and monitoring measures.	Chapter 10 and Appendix F	Section 3.6
Noise and vibration	– a description of all potential noise and vibration sources during construction and operation, including road traffic noise – a noise and vibration assessment in accordance with the relevant Environment Protection Authority Guidelines – a description and appraisal of noise and vibration mitigation and monitoring measures.	Chapter 11 and Appendix G	Section 3.5
Soil and water	– a description of local soils, topography, drainage and landscapes – an assessment of potential impacts on the quality and quantity of surface and groundwater resources – details of fill material to be imported to the site, including quantity and its waste classification – details of sediment and erosion controls – a detailed site water balance – details of the proposed stormwater and wastewater management systems (including sewage), water monitoring program and other measures to mitigate surface and groundwater impacts – a description and appraisal of impact mitigation and monitoring measures.	Chapter 7 Appendix C	Section 2,2 Section 3.2 Appendix D Appendix E
Traffic and transport	– details of road transport routes and access to the site – road traffic predictions for the development during construction and operation – assessment of impacts to the safety and function of the road network; and the details of any road upgrades required for the development.	Chapter 9 Appendix E	Section 3.4 Appendix G
Biodiversity	– accurate predictions of any vegetation clearing on site or for any road upgrades – a detailed assessment of the potential impacts on any threatened species, populations, endangered ecological communities or their habitats, groundwater dependent ecosystems and any potential for offset requirements – a detailed description of the measures to avoid, minimise, mitigate and offset biodiversity impacts.	Chapter 8 Appendix D	Section 3.3 Appendix C Appendix F
Visual	– an impact assessment at private receptors and public vantage points.	Chapter 14	As per original EIS

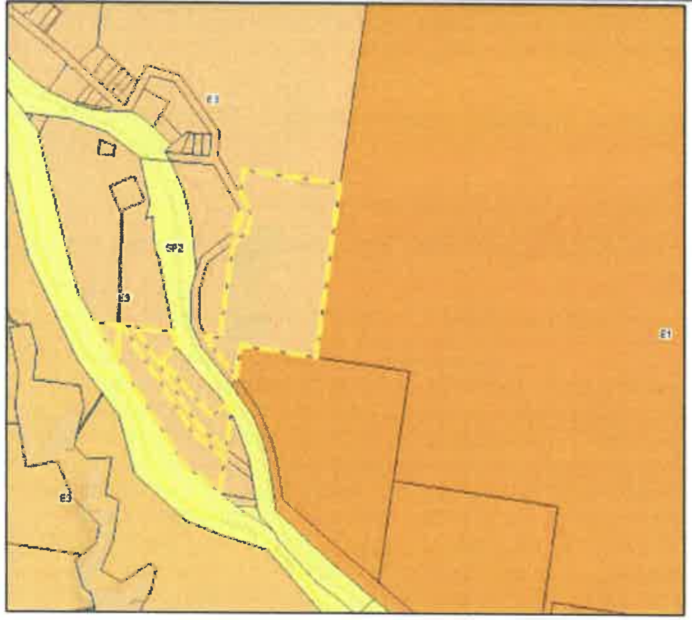
Statement of Facts and Contentions	Response	Supplementary Environmental Impact Statement reference
Part A – Statement of facts		
The Proposal 1. Development Application No. DA294/18 seeks to utilise the former Bell Quarry at Sandham Road, Dargan (Lot 23 DP 751631) to accommodate the importation of 1.2 million cubic metres (approximately 2.2 million tonnes) of fill over a 15 year and 9 month period and to rehabilitate the site to a final landform that reflects the original topography prior to quarrying. There are some minor encroachments of the proposed development onto adjoining lands to the west (Crown Land) and to the east (National Park).	As amended, the Development Application seeks consent to achieve the final rehabilitated landform via importation of approximately 1 million m^3 of emplacement material sourced from Sydney and the local regional area which meets: • the definition of virgin excavated natural material (VENM) as defined by the *Protection of the Environment Act, 1997* (POEO Act) from time to time the criteria of excavated natural material (ENM) as set out in the Excavated Natural Material Order and • Exemption 2014 issued by the Environmental Protection Authority under clause 93 of the Protection of the Environmental Operations (Waste) Regulation 2014; or • an exemption granted by the Environment Protection Authority (EPA) pursuant to clauses 91 and 92 of the Protection of the Environmental Operations (Waste) Regulation 2014) and which specifically relates to the site (Comparable Material) to achieve the final landform that reflects as close as practical the original topography prior to quarrying.	
2. The proposed development is defined as a waste or resource management facility.	In response to paragraph 2 of the SOFAC the applicant says that the proposed development can be characterised as a waste or resource management facility however the purpose of the proposed development is to rehabilitate the former quarry to a landform as close as possible to that which existed prior to quarrying operations.	Section 1.2
3. The proposed fill is to be comprised of both Virgin Excavated Natural Material (VENM) and Excavated Natural Material (ENM).	In response to paragraph 3, the applicant says that the development application originally sought consent to import Virgin Excavated Natural Material (**VENM**) and Excavated Natural Material (**ENM**) as well as other 'clean fill', this terminology was undefined. (3a) In response to concerns raised by the Council and the Environment Protection Authority (**EPA**) during the assessment phase of the development application as to what 'clean fill' comprised, the applicant now proposes amendments to clarify that the proposed fill will be limited to material sourced across Sydney and the local regional area which meets: – the definition of virgin excavated natural material (VENM) as defined by the POEO Act from time to time; – the criteria of excavated natural material (ENM) as set out in the Excavated Natural Material Order and Exemption 2014 issued by the Environmental Protection Authority under clause 93 of the	Section 2.2.1

Statement of Facts and Contentions	Response	Supplementary Environmental Impact Statement reference
	Protection of the Environmental Operations (Waste) Regulation 2014; or – an exemption granted by the Environment Protection Authority pursuant to clauses 91 and 92 of the Protection of the Environmental Operations (Waste) Regulation 2014) and which specifically relates to the Land.	
4. Fill brought to the site will be from various, currently unknown sources in Sydney and the Central West region of NSW. The haulage route will vary depending on the source of the fill.	Agreed.	
5. The development involves the haulage of up to 140,000 tonnes of material per annum. It is estimated that the development will generate an average of 37 heavy vehicle trips (74 heavy vehicle movements) per day.	Agreed.	
6. The development also involves the dewatering of the existing quarry voids and discharge of that water off site.	Agreed.	
7. The development is to be undertaken in 6 stages.	The Supplementary EIS is to be completed in 4 key stages.	Section 2.2.2
8. The development is Integrated Development as it requires an Environment Protection Licence under the Protection of the Environment Operations Act 1997.	The integrated development provisions of the *Environmental Planning and Assessment 1979* (**EPA Act**) are facilitative, they do not mandate that an application must be assessed as integrated. The applicant did not elect the development to be dealt with as integrated, otherwise than in relation to the *Water Management Act 2000.* 8(a) As part of the proposed amendments to the development application the applicant will seek to integrate s138 of the *Roads Act 1993* in relation to the part of Sandham Road that traverses the site. 8(b) The applicant rejects the assertion that the development requires an Environment Protection Licence under the *Protection of the Environment Operations Act 1997* (**POEO Act**) as the fill proposed to be imported is exempt from licensing for application of waste to land: a. under clause 39 of Schedule 1 to the POEO Act in respect of VENM: b. pursuant to *The Excavated Natural Material Exemption 2014* in respect of ENM; and c. pursuant to Part 9 of the *Protection of the Environment Operations (Waste) Regulation 2014* with respect to future fill material that may be imported.	
9. The development is Designated Development as the amount of fill exceeds the limits identified under clause 32, Schedule 3 of the Environmental Planning and Assessment Regulation 2000.	The development is Designated Development under Clause 32, Schedule 3 of the Environmental Planning and Assessment Regulation 2000 under Clause 32(d) as the site is located within 100 metres of the Blue Mountains National Park which is considered a sensitive	

Statement of Facts and Contentions	Response	Supplementary Environmental Impact Statement reference
	environmental area. The development comprises more than 100,000 tonnes of "clean fill" but is not likely to cause a significant impact on flooding or drainage.	
The Site Street Address: Sandham Road, Dargan Property Description: Lot 23 DP 751631		
10. The subject site consists of one lot with an approximate area of 14.29 hectares.	Agreed.	
11. That part of the site the subject of the proposed development is located to the east of the Main Western Railway Line and Bells Line of Road. This part of the site contains a number of quarry voids that are currently filled with water.	Agreed.	
12. Access to the site is via Sandham Road from its intersection with Bell's Line of Road. Part of the access road traverses Crown Land.	Agreed.	
The Locality		
13. To the east of the subject site is the Blue Mountains National Park. To the west is Crown Land and the Main Western Railway Line. To the south is land owned by Lithgow City Council. To the north is land associated with the Clarence Colliery.	The applicant agrees with paragraph 13 of the SOFAC except also says that part of Sandham Road also adjoins and traverses the site to the West and the site of the approved Newnes Kaolin project is located to the north	
14. Much of the surrounding land comprises areas of native vegetation.	In response to paragraph 14 of the SOFAC the applicant says the surveys provided in the Biodiversity Assessment as supplemented by additional information speak for themselves.	Section 3.3 and Appendix F
Statutory Controls ***Environmental Planning and Assessment Act 1979***		
15. The Western Joint Regional Planning Panel is the consent authority (Section 4.5)	Agreed.	
16. The development is designated development (Section 4.10)	Agreed.	
17. The development requires an environmental impact statement (Section 4.12)	Agreed.	
18. The development is to be assessed in accordance with the relevant matters for consideration (Section 4.15)	Agreed.	
19. The development is integrated development (Section 4.46)	In response to paragraph 19 the applicant reiterates that whether or not the development should be assessed as integrated development relies solely on whether the applicant has made the relevant election.	

Statement of Facts and Contentions	Response	Supplementary Environmental Impact Statement reference
	19(a) The applicant agrees with paragraph 19 of the SOFAC to the extent that an approval pursuant to section 138 of the *Roads Act 1993* is required to be obtained from Council.	
	19(b) The proposed development does not need to be licensed under the POEO Act.	Section 3.1.1
	19(c) The applicant will amend the development application to integrate s138 of the *Roads Act 1993* for the part of unmade Sandham Road which traverses the site and offsite works.	
20. The development is to be exhibited and notified (Schedule 1)	Agreed.	
Environmental Planning & Assessment Regulation 2000		
21. The proposal requires an environmental impact statement (Schedule 2)	Agreed.	
22. The proposal is designated development (Section 4 and Clause 32 of Schedule 3)	Agreed.	
Protection of the Environment Operations Act 1997		
23. An environmental protection licence is required for the regulation of water pollution from any non-scheduled activity (Section 43 (d))	The applicant does not agree with paragraph 23 of the SOFAC and repeats paragraph 3 of this document.	Section 3.1.3
Water Management Act 2000		
24. A controlled activity approval is required for any works within 40m of a watercourse (Section 91 (2))	Agreed.	
25. An aquifer interference approval is required for any aquifer interference activity (Section 91 (3))	Agreed.	
Crown Land Management Act 2016		
26. A licence is required to use Crown Land (Section 5.21)	The Applicant agrees with paragraph 26 of the SOFAC. The Applicant notes that the Office of Environment and Heritage including National Parks and Wildlife Services expressed support of *the rehabilitation of the areas of the park that have been impacted by the quarry's operations and the restoration of a stable landform* in a letter from Ms Samantha Wynn of the Office of Environment and Heritage dated 5 February 2020 and indicated a license will be granted.	
Threatened Species Conservation Act 1997 / Biodiversity Conservation Act 2006		
27. The Biodiversity Conservation (Savings and Transitional) Regulation 2017 is relevant as it excludes (under Part 7) the development application from the provisions under the Biodiversity Conservation Act 2016 which came into effect on 25 August 2017. Accordingly, the former sections 5A-5D of	Agreed.	

Statement of Facts and Contentions	Response	Supplementary Environmental Impact Statement reference
the Environmental Planning and Assessment Act 1979 continue to apply to the development application, including the factors and assessment guidelines referred to in the former section 5A of that Act (which must be taken into account in deciding whether there is likely to be a significant effect on threatened species, populations or ecological communities).		
28. A biodiversity conservation licence is required to damage habitat of threatened species (Section 2.11 of BC Act).	The applicant agrees with paragraph 28 of the SOFAC as a legal proposition. However, pursuant to clause 2.8 of the BCA Act a biodiversity conservation licence is not required where carrying out of development is in accordance with a development consent within the meaning of the EPA Act. Therefore, if development consent is granted to the DA, a biodiversity conservation licence will not be required. The Applicant disputes habitat of threatened species will be damaged.	
Lithgow Local Environmental Plan 2014 ("LLEP 2014")		
29. The site is situated within Zone E3 Environmental Management.	The applicant agrees with paragraph 29 of the SOFAC.	
30. An extract of the Land Zoning map referred to in Clause 2.2 of the LLEP 2014 with the subject site included is provided in Figure 2 below: An extract of the Land Zoning map referred to in Clause 2.2 of the LLEP 2014 with the subject site included is provided in Figure 2 below:	The applicant agrees that the extract of the zoning map in paragraph 30 is correct.	

Statement of Facts and Contentions	Response	Supplementary Environmental Impact Statement reference
 *Figure 2: Extract of Land Zoning Map (Source: eplanning spatial viewer).*		
31. The development is defined as a waste or resource management facility. This use is prohibited in the E3 Environmental Management Zone under LLEP 2014. However, the use is permitted with consent under State Environmental Planning Policy (Infrastructure) 2007.	In response to paragraph 31 of the SOFAC the applicant repeats paragraph 2 of this document. The applicant agrees that waste management facilities are prohibited in the E3 Environmental Management Zone under LLEP 2014 but are permissible with consent under *State Environmental Planning Policy (Infrastructure) 2007* (**ISEPP**).	
32. The following clauses of LLEP 2014 are relevant to the determination of the development application: a. Clause 7.1 Earthworks b. Clause 7.4 Terrestrial Biodiversity c. Clause 7.7 Sensitive Lands d. Clause 7.10 Essential Services	The applicant agrees with paragraph 32 of the SOFAC. It is noted that the site does not appear to be mapped a an environmentally sensitive area for Terrestrial Biodiversity, however comprehensive biodiversity assessments have been completed to satisfy this clause.	
State Environmental Planning Policy 44 – Koala Habitat Protection		
33. The subject land is potential koala habitat (clause 7)	The applicant rejects paragraph 33 of the SOFAC. SEPP 44 defines potential habitat as *"areas of native vegetation where the trees of the*	Section 3.3 and Appendix F

Statement of Facts and Contentions	Response	Supplementary Environmental Impact Statement reference
	types listed in Schedule 2 constitute at least 15% of the total number of trees in the upper or lower strata of the tree component". None of the eucalypts listed in Schedule 2 have been recorded within the Site by the authors of Appendix D to the EIS - Biodiversity Assessment prepared by GHD nor by the authors of the Supplementary Ecological Information prepared by Cumberland Ecology. Therefore, the Site does not contain potential koala habitat and SEPP 44 does not apply.	
34. The subject land is not core koala habitat (clause 8)	Agreed.	
State Environmental Planning Policy (Infrastructure) 2007		
35. Development for the purpose of the disposal of virgin excavated natural material (within the meaning of Schedule 1 to the Protection of the Environment Operations Act 1997) or clean fill, may be carried out by any person with consent on land on which development for the purpose of extractive industries may be carried out with consent under any environmental planning instrument. Clause 7(3) of State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007 provides for extractive industries to be carried out with development consent on land where agriculture is permitted with or without consent. Extensive agriculture is permitted without consent in the E3 Environmental Management zone under LLEP 2014. Therefore, a waste or resource management facility is permitted with consent.	Agreed.	
36. The development is traffic generating development (Clause 104 and Schedule 3)	Agreed.	
State Environmental Planning Policy (State and Regional Development) 2011		
37. The development is regional development (Clause 7 and Schedule 7)	Agreed.	
Actions of the Respondent		
38. On 27 November 2018, Development Application No. DA294/18 was lodged with the Respondent.	Agreed.	
39. The Western Joint Regional Planning Panel were advised on 29 November 2019 of the application being lodged as the Panel would be the determining authority	The applicant neither agrees nor disagrees with paragraph 39 of the SOFAC.	
40. The application did not include owner's consent in relation to the encroachments onto Crown Land and the Blue Mountains National Park. On 4 December 2019, Council wrote to the applicant requesting additional information, including owner's consent.	Agreed.	

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41. The application was referred on 9 January 2019 to: a. NSW Rural Fire Service b. Water NSW c. Natural Resources Access Regulator d. Roads and Maritime Services (now Transport for New South Wales (TfNSW)) e. Sydney Trains f. NSW Department of Planning (now Department of Planning, Infrastructure and Environment) g. Office of Environment and Heritage h. National Parks and Wildlife Service i. Endeavour Energy j. Environment Protection Authority k. Department of Planning – Resources & Energy l. Department of Primary Industries – Agriculture m. Department of Primary Industries – Fisheries & Aquaculture n. Department of Primary Industries – Lands o. Blue Mountains City Council p. Hawkesbury City Council q. NSW Local Land Services r. Bathurst Local Aboriginal Land Council s. Mingaan Aboriginal Corporation.	The applicant agrees that the application was referred to the agencies listed in paragraph 41 of the SOFAC however does not agree that all of the referrals were necessarily required.	
42. The application was notified to surrounding land owners on 16 January 2019. The closing date for submissions was 18 February 2019.	The applicant neither agrees or disagrees with paragraph 42 of the SOFAC.	
43. Council extended the exhibition period until 20 March 2019 and informed all agencies and notified surrounding land owners accordingly.	The applicant neither agrees or disagrees with paragraph 43 of the SOFAC	
44. Owner's consent from the Department of Industry – Crown Lands and Water was received by Council on 18 March 2019 (Note that owner's consent was valid for a period of 12 months if not acted upon and if not extended. It is not known if owner's consent has been extended and therefore it may have expired).	In response to paragraph 44 the applicant agrees that owner's consent from the Department of Industry - Crown Lands and Water was provided on 18 March 2019. The applicant does not agree that it is valid only for a period of 12 months.	
45. On 20 March 2019, Council received a letter from the NSW Environment Protection Authority (EPA) advising that they do not support the project and recommend that the development application be refused. Issues raised by the EPA included the following:	The EPA's objections have been considered and answered by the additional material in the Supplementary EIS..	

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a. Lack of clarification in the application as to the nature of the "clean fill" b. Environmental impacts of development have not been fully identified. c. The development poses an unacceptable water pollution risk to the Greater Blue Mountains World Heritage Area, including the Wollangambe River / Colo River. d. The application does not identify any water treatment of the existing water in the quarry voids, or of the leachates associated with filling the quarry voids with waste. e. The development presents a risk to two groundwater dependent ecosystems that are listed as endangered ecological communities downstream of the site and the application has not adequately assessed this risk.		
46. During the notification period, Council received 470 submissions (excluding duplicates) to the development application. Issues raised in submissions included the following: a. Adverse impact of the Greater Blue Mountains World Heritage Area; b. Impacts of the importation of the fill on groundwater; c. Impacts of dewatering on Blue Mountains National Park; d. Potential contamination of Wollangambe and Colo Rivers, including domestic water supply from Colo River; e. Spraying of water to mitigate dust and washdown of trucks will flow into Wollangambe River, part of the Hawkesbury-Nepean catchment; f. Loss of water source in quarry will increase bushfire risk for local communities and restrict RFS aircraft capabilities to fight local fires; g. Traffic impacts on Bells Line of Road and Great Western Highway, in particular in Mount Victoria from additional heavy truck movements; h. Existing condition and width of Sandham Road unable to safely accommodate heavy truck movements, particularly in respect to the school bus, pedestrians, cyclists and local resident vehicle movements and needs to be upgraded if the proposal is approved; i. Intersection of Sandham Road and Bells Line of Road has poor sight lines and needs to be improved; j. Potential for queuing of trucks in Sandham Road and Bells Line of Road prior to 7.00am opening of facility; k. Amenity impacts on Sandham Road residences with dust, noise and public safety; and l. Proposed development is not a continuation of the earlier development consent (108/94) as it has been abandoned upon satisfaction of	The applicant neither disagrees or agrees with paragraph 46 of the SOFAC.	

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condition 12 of that consent relating to the rehabilitation of the site and retained ponds as a water source for bush fire purposes.		
47. Council wrote to the applicant on 16 April 2019 outlining the concerns raised regarding the proposed development by the NSW EPA and the issues raised in submissions and requesting a response to these issues.	Agreed.	
48. The applicant prepared a Submissions Report and provided this to Council on 13 June 2019.	Agreed.	
49. The Submissions Report was forwarded by Council to the NSW EPA, Blue Mountains City Council and Hawkesbury Council on 3 July 2019.	The applicant neither disagrees or agrees with paragraph 49 of the SOFAC.	
50. The NSW EPA wrote to Council on 2 September 2019 maintaining their concerns regarding the proposed development. The EPA advised that: a. The Submissions Report does not provide the required high level of confidence that discharges related to the Project will not adversely impact the Wollangambe River and the Greater Blue Mountains World Heritage Area as minimal additional scientific information has been provided to establish the local water quality and local water quality criteria. b. Given the ecological sensitivity of the receiving environment, the EPA strongly recommends that local water quality and local water quality objectives are established consistent with the current ANZECC guidelines [2018] and contemporary guidance notes such as Deriving site-specific guideline values for physico-chemical parameters and toxicants (IESC, 2019).	The EPA's objections have been considered and answered by the additional material in the Supplementary EIS.	Section 3.2 and Appendix D
c. On 6 September 2019, Council wrote to the applicant requesting additional information.	Agreed.	
d. On 3 October 2019, a meeting was held between the applicant, the respondent and the NSW EPA regarding the proposed development.	Agreed.	
e. On 11 October 2019, the applicant responded to the request for additional information.	Agreed.	
f. Owner's consent from the National Parks and Wildlife Service was received by Council on 14 October 2019.	Agreed.	
51. The NSW EPA again wrote to Council on 15 October 2019 maintaining their objection to the development application. The EPA noted the following: a. The inherent difficulty in managing waste over the fifteen-year life of the project to ensure no contaminated waste is taken to the site	In response to paragraph 51 of the SOFAC, the applicant agrees that that a letter was provided by the EPA dated 15 October 2019.	

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b. Potential risks to surface and groundwater within the World Heritage Area downstream of the site c. Potential risk of erosion from discharges impacting on the receiving drainage line and an endangered ecological community located within the World Heritage Area d. No commitment to establishing a liner to reduce potential impacts to groundwater within the World Heritage Area e. Improvement to the aesthetic appeal of the site will only be achieved following the life of the project and an undefine regeneration period; and f. The environmental assessment does not demonstrate there will be an improved environmental outcome in the long term, when compared to the current stabilised site.		
52. The EPA also advised that: a. When assessing any proposal which involves the use of waste in accordance with the NSW resource recovery framework, the consent authority, like the EPA, must be satisfied it is a genuine re-use opportunity rather than simply a method of opportunistic waste disposal and does not cause harm to the environment or human health. b. Recently, the UNESCO World Heritage Committee (Forty-third session, 30 June to 10- July 2019) articulated concerns about mining projects and activities in the vicinity of the World Heritage Area which might cumulatively result in significant impact on the outstanding universal value of the World Heritage Area. The Committee specifically noted the World Heritage Area's increased vulnerability to edge effects as it does not have a formal buffer zone, and the need to assess the potential cumulative impacts of existing and planned mining projects in its vicinity. c. Having regard to the legitimacy of the Project under the NSW waste framework, the principles of ecologically sustainable development including the precautionary principle, and the sensitivity of the World Heritage Area including its vulnerability to edge effects, the EPA does not support the project and maintains its recommendation that the project be refused.	The EPA's objections have been considered and answered by the additional material in the Supplementary EIS..	
53. On 1 November 2019, the applicant provided additional information to Council. In the letter, the applicant offered to demonstrate further via additional studies that the predictions detailed in the EIS are achievable and that the Project would not result in an unacceptable impact on water quality and aquatic ecology of the receiving environment. It was proposed	In response to paragraph 53 of the SOFAC the applicant says that the letter dated 1 November 2019 did not provide additional information but rather responded to comments made by the EPA in its letter date 15 October 2019. The letter speaks for itself.	

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that these additional studies be undertaken as part of a deferred commencement consent under Section 4.16 (3) of the EP&A Act.		
54. On 1 November 2019, Council forwarded the applicant's response to the EPA for further comment.	The applicant neither agrees or disagrees with paragraph 54 of the SOFAC.	
55. On 14 November 2019, the applicant provided additional information to Council in response to issues raised by Transport for NSW.	Agreed.	
56. Copies of submissions received to the development application were provided to the Department of Planning, Industry and Environment (DPIE) on 14 November 2019.	The applicant neither agrees or disagrees with paragraph 56 of the SOFAC.	
57. DPIE advised Council in writing on 20 November 2019 to ensure that the concerns raised in submissions are adequately addressed before determining the development application.	The applicant neither agrees or disagrees with paragraph 57 of the SOFAC.	
58. On 13 December 2019, Council again requested any further comments from the EPA in response to the applicant's letter dated 1 November 2019.	The applicant neither agrees or disagrees with paragraph 58 of the SOFAC.	
59. The EPA wrote again to Council on 13 January 2020 maintaining its objection to the development and its recommendation that the application be refused.	Agreed.	
60. The development application was considered and determined by the Western Joint Regional Planning Panel on 6 April 2020. The determination was by way of refusal of the application for the following reasons: *1. The Environment Protection Authority has concluded that the SEARS (1105) requirements have not been satisfied and that the proposal will have unacceptable environmental impacts on the adjoining Blue Mountains National Park and the Wollangambe and Colo River systems.* *2. The Environment Protection Authority considers, based on its submissions to Council, that the proposal will have unacceptable environmental impacts on the Greater Blue Mountains World Heritage Area, arising from the following:* *i. it is likely that some of the soil leachates will adversely alter the natural characteristics and ionic balance of water draining into the Greater Blue Mountains World Heritage Area and the Colo River, Greater Blue Mountains World Heritage Area (GBMWHA).* *ii. proposed discharges into a tributary of the Wollangambe River were identified that would impact on a swamp located on the tributary approximately 200m downstream of where the discharge is proposed. The tributary (and its connected swamp) is proposed to receive pumped out water from the quarry pits, any leachate from the material that is emplaced*	Agreed.	

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in the pits and overland flow once the area is rehabilitated. The tributary and swamp are in the GBMWHA. *iii. The Biodiversity Impact Assessment identified the Prickly Tea-tree – sedge wet heath swamp below the quarry discharge location as a Newnes Plateau Shrub Swamp (EEC under the TSC Act) and Temperate Highland Peat Swamps on Sandstone (EEC under the EPBC Act).* *iv. The existence of the swamp in the headwaters of the drainage line downstream of Bell Quarry strongly suggests that there is a groundwater source which helps support/maintain the swamp in this location.* *v. The Water Resources Assessment Section of the EIS has not clearly defined the downstream swamp as a Groundwater Dependent Ecosystem (GDE); it has not assessed the level of groundwater dependence for the swamp and the likely pathways (e.g. disruption of groundwater connections, reduction in groundwater quality) by which the project might impact on the swamp; and it does not consider issues surrounding water discharge rates or their effect on geomorphic stability for the swamp. It has therefore not appropriately assessed the risk the project will have on the THPS swamp.* *vi. The dewatering of the quarry voids is likely to present a significant potential to destabilise sediments in the downstream swamp. If an erosional nick-point is established in the swamp, it could lead to the loss of the swamp in its entirety through erosion and gullying.* *3.The proposed development will not be consistent with the objectives of the E3 Environmental Management zone under the Lithgow LEP 2014 due to the adverse environmental impacts to the GBMWHA arising from the dewatering of the former quarry voids and importation of fill to the site as detailed by the EPA in its submissions, contrary to s4.15(1)(a)(i) of the Environmental Planning and Assessment Act 1979.* *4. The proposed development fails to satisfy the requirements of Clause 7.1 Earthworks (1) of the Lithgow LEP 2014 in that the proposal will have a detrimental impact on environmental functions and processes, contrary to s4.15(1)(a)(i) of the Environmental Planning and Assessment Act 1979.* *5. The proposed development fails to satisfy the provisions under Clause 7.1 Earthworks (3) (a), (c), (d), (e) and (g) of the Lithgow LEP 2014 given the adverse environmental impacts on the GBMWHA and the Wollangambe and Colo Rivers arising from the dewatering of the site and the importation of fill to the site, contrary to s4.15(1)(a)(i) of the Environmental Planning and Assessment Act 1979.* *6. The proposed development fails to satisfy the requirements of Clause 7.4 Terrestrial Biodiversity of the Lithgow LEP 2014 given the comprehensive assessment of likely environmental impacts of the*		

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proposed development detailed by the EPA in its submissions, contrary to 4.15(1)(a)(i) of the Environmental Planning and Assessment Act 1979. *7. The proposed development fails to satisfy the requirements under Clause 7.7 Sensitive Lands of the Lithgow LEP 2014 given the comprehensive assessment of likely environmental impacts of the proposed development detailed by the EPA in its submissions, contrary to s4.15(1)(a)(i) of the Environmental Planning and Assessment Act 1979.* *8. The proposed development will have unacceptable environmental and amenity impacts arising from the activity associated with the importation of fill to the former quarry site contrary to s4.15(1)(b) of the Environmental Planning and Assessment Act 1979.* *9. The scope of the likely adverse environmental impacts on the GBMWHA and Wollangambe and Colo Rivers arising from the proposed development indicates that the site is not suitable for the proposed use, contrary to s4.15(1)(c) of the Environmental Planning and Assessment Act 1979.* *10. The site is acknowledged as stable and its condition is manageable in its current form. As a result, the public interest justification of the proposal as a necessary rehabilitation project is not compelling.* *11. The notification of the Designated Development application attracted submissions from relevant Government agencies, local government, special interest groups and individuals. A total of 470 submissions of objection, excluding duplicates, were received by Council including 321 individual submissions and 149 form letters, expressing concerns in relation to:* *• Adverse environmental impacts on Greater Blue Mountains World Heritage Area.* *• Impacts of the importation of the fill on groundwater.* *• Impacts of dewatering on Blue Mountains National Park.* *• Potential contamination of Wollangambe and Colo Rivers, including domestic water supply from Colo River.* *• Spraying of water to mitigate dust and washdown of trucks will flow into Wollangambe River, part of the Hawkesbury-Nepean Catchment;* *• Loss of water source in quarry will increase bushfire risk for local communities and restrict RFS aircraft capabilities to fight local fires;* *• Traffic impacts on Bells Line of Road and Great Western Highway, in particular in Mt Victoria from additional heavy truck movements;* *• Existing condition and width of Sandham Road unable to safely accommodate heavy truck movements, particularly in respect to the school*		

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bus, pedestrians, cyclists and local resident vehicle movements and needs to be upgraded if the proposal is approved; • *Intersection of Sandham Road and Bells Line of Road has poor sight lines and needs to be improved;* • *Potential for queuing of trucks in Sandham Road and Bells Line of Road prior to 7.00am opening of facility; and* • *Amenity impacts on Sandham Road residences with dust, noise and public safety.* *In the circumstances it is considered that approval of the designated development application would not be in the public interest under s4.15(1)(e) of the Environmental Planning and Assessment Act 1979.*		
61. On 1 April 2021, the Applicant commenced proceedings in Class 1 of the Land and Environment Court's jurisdiction appealing against the Respondent's refusal of the development application. Council notified the Panel of the appeal on 16 April 2021, and was directed by the Panel on 13 May 2021 to: 1. *provide the Panel with the Council's SOFAC at least 7 days before it is to be filed with the Court. The Council is directed to identify in the draft SOFAC the steps taken by Council to notify the Panel of the appeal and any response from the Panel;* 2. *provide updates as to any directions, orders or judgments issued by the Court in the appeal proceedings within 7 days of the date of those directions, orders or judgments;* 3. *advise of any change in position from the SOFAC after it is filed and provide any draft Amended SOFAC to the Panel at least 7 days before filing if Council intends to file one;* 4. *4. provide a copy of any proposed in principle agreement between the parties following a conciliation conference within 3 days of the proposed agreement being reached and before any written agreement is executed.*	The applicant agrees with paragraph 61 of the SOFAC insofar as the Class 1 Appeal was filed on 1 April 2021. The Applicant has no knowledge of when the Panel was notified or its direction in relation to the proceedings.	
Part B - Contentions		
The Respondent contends that the Application should be refused on the following basis:-		
Unacceptable Environmental Impacts		
Contention 1: The Environment Protection Authority has concluded that the SEARs have not been satisfied and that the proposal will have unacceptable environmental impacts on the adjoining Blue Mountains National Park and the Wollangambe	The SEARS have been satisfied. The proposed development will not have unacceptable environmental impacts on the adjoining Blue Mountains National Park and the Wollangambe and Colo River Systems.	

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and Colo River systems. In the circumstances of the case, the Court should refuse the application because of this.		
Particulars i. That the SEARs have not been satisfied	The SEARS have been satisfied. Further and better particulars should be provided to specify the ways in which it is alleged that the SEARS have not been complied with.	
ii. ii. That the proposal will have unacceptable environmental impacts on the adjoining Blue Mountains National Park, the Greater Blue Mountains World Heritage Area and the Wollangambe and Colo Rivers systems through the dewatering process and the importation of fill over the life of the project and beyond; and	The proposed development will not have unacceptable environmental impacts on the adjoining Blue Mountains National Park, the Greater Blue Mountains World Heritage Area and the Wollangambe and Colo River systems through the dewatering process nor the importation of fill over the life of the project and beyond. The applicant has established by the additional surface and groundwater monitoring and analysis contained in the Revised Water Resources Assessment prepared by GHD and dated 18 November 2021, the Hydrology Report prepared by Martens & Associates and dated 19 November 2021 and the Supplementary Ecological Report prepared by Cumberland Ecology and dated 18 November 2021, that the proposed final landform will have a beneficial impact on surrounding land.	Section 3.2 and 3.3 Appendix D, E and F
iii. That the EPA will not provide an Environment Protection Licence for the discharging of water under section 43(d) of the Protection of the Environment Operations Act 1997 nor its General Terms of Approval required for the development under Division 4.8 of the EP&A Act.	An EPL is not required under s48 of the POEO Act as the fill proposed to be imported is exempt from licensing for application of waste to land: a. under clause 39 of Schedule 1 to the POEO Act in respect of VENM: b. pursuant to The Excavated Natural Material Exemption 2014 in respect of ENM; and c. pursuant to Part 9 of the Protection of the Environment Operations (Waste) Regulation 2014 with respect to future fill material that may be imported (iv) An EPL is not required under s43(d) of the POEO Act as the dewatering process, site operations and post closure will not change the water chemistry in the downstream waters including the swamp, creeks and rivers. d. For the reasons set out above, general terms of approval are not required from the Environment Protection Authority and in any event, the Court is not bound to refuse an application for development consent because an approval body has decided not to grant its approval.	Section 3.1.3
Contention 2: The Environment Protection Authority considers, based on its submissions to Council, that the proposal will have unacceptable environmental impacts on	The proposal will not have unacceptable impacts on the Greater Blue Mountains World Heritage Area.	

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the Greater Blue Mountains World Heritage Area. In the circumstances of the case, the Court should refuse the application because of this.		
Particulars i. It is likely that some of the soil leachates will adversely alter the natural characteristics and ionic balance of water draining into the Greater Blue Mountains World Heritage Area and the Colo River, Greater Blue Mountains World Heritage Area (GBMWHA).	The application is amended to incorporate a number of elements to prevent leachate entering groundwater or stormwater off-site. The entire emplacement area will be lined with an engineered barrier to separate leachate from groundwater. Any stormwater which contacts the exposed emplaced material be able to be contained and managed on site and should there be excess water it would be treated to prevent adverse impacts on any water eventually draining into the GMBWH or the Colo River. A construction, operations and post closure plan will detail the proposed controls and how they would be implemented in practice. In addition, modification to surface flows within the drainage line exiting the site will be minor and temporary. Following completion of rehabilitation there will be no adverse impacts on receiving environments caused by stormwater runoff Part of the alleged impacts are premised on an assumption of a hydraulic connectivity between the groundwater in the voids and the Newnes Plateau Shrub swamp located downstream of the site. Further data collection and monitoring data confirms that the swamp and groundwater from the quarry (before, during and after operations cease) are disconnected. Potential impacts on erosion of the downstream swamp from dewatering of the voids or from stormwater runoff from upgradient and clean areas will be minimised by erosion and sediment controls implemented as part of an operations management plan and protocols.	Section 3.2
ii. Proposed discharges into a tributary of the Wollangambe River were identified that would impact on a swamp located on the tributary approximately 200m downstream of where the discharge is proposed. The tributary (and its connected swamp) is proposed to receive pumped out water from the quarry pits, any leachate from the material that is emplaced in the pits and overland flow once the area is rehabilitated. The tributary and swamp are in the GBMWHA.	Any stormwater which contacts the exposed emplaced material be able to be contained and managed on site and should there be excess water it would be treated to prevent adverse impacts on any water eventually draining into the GMBWH or the Colo River. A construction, operations and post closure plan (updated EMP) will detail the proposed controls and how they would be implemented in practice. In addition, dewatering rates will be within the existing range of flow conditions. Following completion of rehabilitation, flows will be returned to as close as practical to pre-quarrying conditions. There will be no adverse impacts on the receiving environment caused by the quarry void dewatering activity. A Soil and Water Management Plan will be developed prior to the commencement of any soil disturbance or water management works. This would be developed in accordance with the WaterNSW current recommended practices (CRPs) *Managing Urban Stormwater: Soils and Construction Volume 1, Landcom 2004 and Volume 2, DECC 2008*. The	Section 2.2, 3.2 and 3.3

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	key basis of this plan (and therefore the feasibility of appropriately implementing it) has been confirmed through development of the site staging plans and Revised Water Resources Assessment (GHD 2021). Part of the alleged impacts are premised on an assumption of a hydraulic connectivity between the groundwater in the voids and the Newnes Plateau Shrub swamp located downstream of the site. Further data collection and monitoring data confirms that the swamp and groundwater from the quarry (before, during and after operations cease) are disconnected.	
iii. The Biodiversity Impact Assessment identified the Prickly Tea-tree – sedge wet heath swamp below the quarry discharge location as a Newnes Plateau Shrub Swamp (EEC under the TSC Act) and Temperate Highland Peat Swamps on Sandstone (EEC under the EPBC Act).		Section 3.3
iv. The existence of the swamp in the headwaters of the drainage line downstream of Bell Quarry strongly suggests that there is a groundwater source which helps support/maintain the swamp in this location.	Further data collection and monitoring data confirms that the swamp and groundwater from the quarry (before, during and after operations cease) are disconnected.	
v. The Water Resources Assessment Section of the EIS has not clearly defined the downstream swamp as a Groundwater Dependent Ecosystem (GDE); it has not assessed the level of groundwater dependence for the swamp and the likely pathways (e.g. disruption of groundwater connections, reduction in groundwater quality by which the project might impact on the swamp; and it does not consider issues surrounding water discharge rates or their effect on geomorphic stability for the swamp. It has therefore not appropriately assessed the risk the project will have on the THPS swamp.	The Water Resources Assessment in the EIS clearly identified the downstream swamp as a GDE and conservatively assessed the potential for a hydraulic connection. Further studies have confirmed there is no direct connection between the groundwater in the quarry voids and the swamp.	Section 3.3
vi. The dewatering of the quarry voids is likely to present a significant potential to destabilise sediments in the downstream swamp. If an erosional nick-point is established in the swamp, it could lead to the loss of the swamp in its entirety through erosion and gullying.	In addition, dewatering rates will be within the existing range of flow conditions. Following completion of rehabilitation, flows will be returned to as close as practical to pre-quarrying conditions. There will be no adverse impacts on the receiving environment caused by the quarry void dewatering activity.	Sections 2.2, 3.2 and 3.3
<u>Contention 3:</u> The scope of the likely adverse environmental impacts on the GHBMWHA and Wollangambe and Colo Rivers arising from the proposed development indicates that the site is not suitable for the proposed use, contrary to s.4.15(1)(c) of the EP&A Act.	a. The particulars of all other contentions are repeated here. b. The proposed development will not have any adverse environmental impacts on the GHBMWHA, Wollangambe or Colo Rivers. c. The site is suitable for the proposed development and will result in a final landform which better mimics the original landform and rectifies historical and current quarry impacts on surface and groundwater hydrology arising out of historical mining activities. The north eastern quarry void will be retained in the long term	Section 3.3

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	and would be available to provide a long term source of clean water.	
Contention 4: The site is acknowledged as stable and its condition is manageable in its current form. As a result, the public interest justification of the proposal as a necessary rehabilitation project is not compelling.	There is a public interest in restoring the site to a condition similar to its natural state and contributing to the sustainable disposal needs of Sydney over the next 15 years. The project will return the surface water and groundwater flows to be more representative of pre-quarry conditions and provide additional resilience to climate change and drought for the downstream swamp.	Section 3.4
Lithgow Local Environmental Plan 2014 Objectives of E3 Environmental Management Zone		
Contention 5: The proposed development will not be consistent with the objectives of the E3 Environmental Management zone under the Lithgow LEP 2014 due to the adverse environmental impacts to the GBMWHA arising from the dewatering of the former quarry voids and importation of fill to the site as detailed by the EPA in its submissions, contrary to s4.15(1)(a)(i) of the EP&A Act.	The proposed development is consistent with the objectives of the E3 Environmental Management zone under LLEP. a. The proposed development will not have adverse environmental impacts on to the GBMWHA arising from the dewatering of the former quarry voids or importation of fill to the site and the final form of the site following the rehabilitation will be beneficial to the surrounding environments. b. There is no requirement in the LLEP for the proposed development to be consistent with the zone objectives. Rather, pursuant to clause 2.3(2) the consent authority must have regard to the objectives.	
Particulars (a) The land is zoned E3 Environmental Management under Lithgow Local Environmental Plan (LEP) 2014. The objectives of the E3 zone are:- *"Zone E3 Environmental Management* *1. Objectives of zone* • *To protect, manage and restore areas with special ecological, scientific, cultural or aesthetic values.* • *To provide for a limited range of development that does not have an adverse effect on those values.* • *To facilitate the management of environmentally sensitive lands and riparian areas.* • *To protect and conserve the vegetation and escarpment landscape surrounding Lithgow.* • *To maintain or improve the water quality of receiving water catchments."*	c. The first objective of the E3 Environmental Management zone is irrelevant because the site does not have special ecological, scientific, cultural or aesthetic values. It is a modified landform that has been cleared of endemic vegetation. While 2.48 ha of planted vegetation and 0.13 ha of remnant vegetation will be temporarily removed with progressive revegetation the end result will be a substantial net increase in indigenous vegetation. To the extent that it is relevant, the project development meets the first objective as it seeks to 'restore' the site to its previous landform whilst retaining one of the three quarry voids in a stable form. d. For the reasons set out in (c) above, the second objective of the E3 Environmental Management zone is not relevant however to the extent that it is, the second objective is met as the proposed development will not have an adverse impact on any ecological, scientific, cultural or aesthetic values. e. The proposed development meets objective 3 of the E3 Environmental Management zone as it will facilitate the management of environmentally sensitive lands by restoring the site to a final land form consistent with the original land form	

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	which will be beneficial to receiving environments. The applicant will also offer to revegetate adjoining National Park land. f. With respect to objective 4 the proposed development provides a net increase in indigenous vegetation on the site and there is no impact on the escarpment landscape surrounding Lithgow. g. In relation to objective 5 of the E3 Environmental Management zone, the proposed development will not have adverse impacts on the water quality of receiving water catchments. Further, the end state of the site will restore flow regimes to as close as possible to site conditions existing prior to the quarrying operations.	
(b) Arising from the issues and concerns raised by the EPA in the four (4) submissions lodged with Council in response to the proposed development, it is considered that the proposed development will not be consistent with the objectives of the E3 Environmental Management zone under the Lithgow LEP 2014.	See response above.	
Clause 7.1 Earthworks		
Contention 6: The proposed development fails to satisfy the requirements of Clause 7.12 Earthworks (1) of the Lithgow LEP 2014 in that the proposal will have a detrimental impact on environmental functions and processes, contrary to s4.15(1)(a)(i) of the EP&A Act.	The proposed development meets the requirements of clause 7.1 of LLEP and will not have detrimental impacts on environmental functions and processes.	
Particulars (a) Clause 7.1(1) states:- "(1) The objective of this clause is to ensure that earthworks for which development consent is required will not have a detrimental impact on environmental functions and processes, neighbouring uses, cultural or heritage items or features of the surrounding land."	a. Present investigations and monitoring of the swamp in the Blue Mountains National Park indicate that: i. shallow groundwater within the soil profile above the rock surface is hydraulically separated from deeper ground water; ii. shallow groundwater within the swamp soils is supplied by direct rainfall and surface water inflows and not deeper groundwater; and therefore iii. the swamp is not hydraulically connected to the groundwater system. b. On the basis of the above and as the swamp does not appear to be hydraulically connected to the groundwater, there will be no impacts on groundwater dependent ecosystems. c. The proposed development has been appropriately designed to avoid and will not have any detrimental impacts on environmental functions and processes. All material to be emplaced at the site would be contained with an engineered	Section 3.3

Statement of Facts and Contentions	Response	Supplementary Environmental Impact Statement reference
	barrier to separate the material from the groundwater. The final landform will have beneficial impacts on the environmental functions and processes as it will restore the land to its more natural state.	
(b) The development proposes the importation of 1.2 million cubic metres of VENM and ENM fill material for the old quarry site over a period of 15 years. The proposed importation of fill is not expected to impact any heritage items, archaeological sites or heritage conservation areas, as the earthworks will be retained within the footprint of the former quarry works and where no heritage items are identified.	As amended, the Development Application proposes the importation of approximately 1 million m^3 of VENM, ENM and Comparable Material.	
(c) Submissions from the EPA, the Office of Environment & Heritage and others detailed later in the Assessment Report considered by the Panel in determining to refuse the application have raised significant concerns relating to unacceptable environmental impacts on groundwater dependent ecosystems downstream of the development site arising from the importation of the fill, and likely adverse impacts on the adjoining Blue Mountains National Park, Greater Blue Mountains World Heritage Area and Wollangambe and Colo Rivers. Accordingly, it is considered that the proposal fails to satisfy the requirements of Clause 7.1(1) in that the proposal will have a detrimental impact on environmental functions and processes.	See responses to contentions above.	Section 3.2 and 3.3 Appendix D, E and F
Contention 7: The proposed development fails to satisfy the provisions under Clause 7.1 Earthworks (3)(a), (c), (d), (e) and (g) of the Lithgow LEP 2014 given the adverse environmental impacts on the GBMWHA and the Wollangambe and Colo Rivers arising from the dewatering of the site and the importation of fill to the site, contrary to s4.15(1)(a)(i) of the EP&A Act.	See responses to contentions above The development application should be approved having regard to the matters listed in clause 7.1(3) of LLEP.	
Particulars (a) Clause 7.1(3) provides for the following: *"(3) In deciding whether to grant development consent for earthworks (or for development involving ancillary earthworks), the consent authority must consider the following matters:* *(a) the likely disruption of, or any detrimental effect on, drainage patterns and soil stability in the locality of the development,* *(b) the effect of the development on the likely future use or redevelopment of the land,* *(c) the quality of the fill or the soil to be excavated, or both,* *(d) the effect of the development on the existing and likely amenity of adjoining properties,*	a. The particulars of all other contentions are repeated here. b. Clause 7.1(3) does not prohibit the consent authority from granting consent to a development application that does not meet the requirements listed in that clause. Rather consideration of the matters in clause 7.1(3) are required. c. The applicant says that upon proper consideration of the matters in clause 7.1(3) the proposed development is acceptable. d. In particular: i. in relation to clause 7.1(3)(a) - the information filed in support of the application shows that there will be no disruption or detrimental impact on drainage patterns or soil stability in the locality of the development. Further modelling has been provided to confirm the information already provided	Section 3.2 and 3.3 Appendix D, E and F

Statement of Facts and Contentions	Response	Supplementary Environmental Impact Statement reference
(e) the source of any fill material and the destination of any excavated material, *(f) the likelihood of disturbing relics,* *(g) the proximity to, and potential for adverse impacts on, any waterway, drinking water catchment or environmentally sensitive area,* *(h) any appropriate measures proposed to avoid, minimise or mitigate the impacts of the development,* *(i) the proximity to, and potential for adverse impacts on, any heritage item, archaeological site or heritage conservation area."*	ii. In relation to clause 7.1(3)(d) the effect of the development in terms of earthworks will not have any detrimental impacts on the amenity of adjoining properties iii. In relation to clause 7.1(3)(e) the fill material is proposed to be sourced from projects in Sydney and the regional area and the fill meeting specified criteria. iv. In relation to clause 7.1(3)(g), whilst the site is in proximity to a waterway and environmentally sensitive area, the assessment and further reports, and information filed in support of the application evidences that there will be no adverse impacts on any receiving environment.	
(b) Based on the concerns raised in comprehensive submissions from the EPA and others, it is considered that the proposal, including the dewatering of the site, will fail to satisfy the requirements under Clause 7.1(3)(a), (c), (d), (e) and (g) of the Lithgow LEP 2014.		Section 3.2 and 3.3 Appendix D, E and F
Clause 7.4 Terrestrial Biodiversity		
Contention 8: The proposed development fails to satisfy the requirements of Clause 7.4 Terrestrial Biodiversity of the Lithgow LEP 2014 given the comprehensive assessment of likely environmental impacts of the proposed development detailed by the EPA in its submissions, contrary to s4.15(1)(a)(i) of the EP&A Act.	The proposed development satisfies clause 7.4 of LLEP	
Particulars (a) Clause 7.4 Terrestrial Biodiversity provides:- *"7.4 Terrestrial biodiversity* *(1) The objective of this clause is to maintain terrestrial biodiversity by:-* *(a) protecting native fauna and flora, and* *(b) protecting the ecological processes necessary for their continued existence, and* *(c) encouraging the conservation and recovery of native fauna and flora and their habitats.* *(2) This clause applies to land identified as ":biodiversity" on the Environmentally Sensitive Areas – Biodiversity Overlay Map.* *(3) In deciding whether to grant development consent for development on land to which this clause applies, the consent authority must consider:-* *(a) Whether the development is likely to have:-*	a. Clause 7.4 applies to land identified as "Biodiversity" on the Environmentally Sensitive Areas—Biodiversity Overlay Map. Most of Lot 23 that contains the quarry and parts of Sandham Road required for access is not mapped as Biodiversity on this map. Only a small portion in the North West corner is mapped and that area has been significantly impacted by previous quarrying activities. b. The rehabilitation of the site meets the objectives of clause 7.4 as it will encourage and result in a final landform more closely reflective of the natural landform. The proposed development will protect native fauna and flora, the ecological processes for their continued existence and will encourage recovery of native fauna and flora and their habitats by the revegetation of the site with native plant species representative of vegetation communities in the local area.	Section 3.3 and Appendix F

Statement of Facts and Contentions	Response	Supplementary Environmental Impact Statement reference
(i) any adverse impact on the condition, ecological value and significance of the fauna and flora on the land, and *(ii) any adverse impact on the importance of the vegetation on the land to the habitat and survival of native fauna, and* *(iii) any potential to fragment, disturb or diminish the biodiversity structure, function and composition of the land, and* *(iv) any adverse impact on the habitat elements providing connectivity on the land, and* *(b) any appropriate measures proposed to avoid, minimise or mitigate the impacts of the development.* *(4) Development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that:-* *(a) the development is designed, sited and will be managed to avoid any significant adverse environmental impact, or* *(b) if that impact cannot be reasonably avoided by adopting feasible alternatives – the development is designed, sited and will be managed to minimise that impact, or* *(c) if that impact cannot be minimised – the development will be managed to mitigate that impact."*	c. Clause 7.4(3) does not prohibit the consent authority from granting consent to a development application that does not meet the requirements listed in that clause. Rather consideration of the matters in clause 7.4(3) is required. d. Upon proper consideration of the matters in clause 7.4(3) the proposed development is acceptable. In particular: v. In relation to clause 7.4(3)(a)(i) the proposed development will not result in any adverse impacts on the condition, ecological value or significance of the fauna and flora on the land; vi. In relation to clause 7.4(3)(a)(ii) the proposed development will not result in any adverse impact on the importance of the vegetation on the land to the habitat and survival of native fauna. It is noted that the site is largely disturbed consisting of predominantly planted and sub-mature vegetation and only a small area of intact remnant vegetation. The proposed development will improve vegetation and terrestrial fauna habitats at the site. vii. In relation to clause 7.4(3)(a)(iii), the proposed development will not fragment, disturb or diminish the biodiversity structure, function or composition of the land but will rather, provide a significant improvement in relation to these matters. viii. In relation to clause 7.4(3)(iv) the proposed development will result in a landform that more closely resembles the natural or pre-quarrying conditions and therefore will in the long term improve the extent and connectivity of habitat in the locality ix. In relation to clause 7.4(3)(v), appropriate measures have been proposed to avoid, minimise or mitigate the impacts of the development. These are addressed in section 8.8.3 and section 15 of the EIS. The Additional mitigation measures will be undertaken in accordance with appropriate environmental management plans and a surface and stormwater management plan. e. In accordance with clause 7.4(4), the consent authority can be satisfied that the development has been designed, sited and will be managed to avoid significant adverse impacts on the environment.	
(b) The EIS states that a detailed assessment of impacts upon biodiversity values within the site and the adjoining Blue Mountains National Park has		

Statement of Facts and Contentions	Response	Supplementary Environmental Impact Statement reference
been undertaken. The majority of the site has been previously disturbed, with some areas of revegetation undertaken to assist with the stabilisation of soils and some limited remnant vegetation around the periphery of the site. A total of 2.48 hectares of planted vegetation and 0.13 hectares of remnant vegetation will be removed and reinstated with progressive revegetation undertaken over the 15 year life of the development.		
(c) A total of 105 flora species from 38 families, comprising 95 native and 10 exotic species were recorded within the study area encompassing the Project area within the existing quarry footprint and the surrounding bushland and drainage line flowing from the site.		
(d) A total of 55 native fauna species were positively recorded during the field survey, including 38 bird species, 4 terrestrial mammal species, 3 bat species, 7 reptiles species, 6 frog species and 6 dragonfly species.		
(e) Two additional bat species were possibly recorded using echolocation call analysis, including one threatened species, the Eastern Bentwing Bat (Miniopterus schreibersii oceanensis), but poor data quality and/or interspecific call similarities precluded reliable identification of this species. No introduced species were recorded during the survey.		
(f) Based on the comprehensive assessment of likely environmental impacts of the proposed development by the EPA dated 20 March 2019 and subsequent submissions, it is considered reasonable to accept that the proposal fails to satisfy the provisions under Clause 7.4 of the LEP.	The Biodiversity assessment in the EIS and the supplementary ecological assessment both conclude there is unlikely to be a significant impact upon biodiversity values	Section 3.3 and Appendix F
Clause 7.7 Sensitive Lands		
Contention 9: The proposed development fails to satisfy the requirements under Clause 7.7 Sensitive Lands of the Lithgow LEP 2014 given the comprehensive assessment of likely environmental impacts of the proposed development detailed by the EPA in its submissions, contrary to s4.15(1)(a)(i) of the EP&A Act.	The proposed development satisfies the requirements of clause 7.7 Sensitive Lands of LLEP.	
Particulars (a) Clause 7.7 Sensitive Lands provides: "*7.7 Sensitive lands* *(1) The objective of this clause is to protect, maintain and improve the diversity and stability of landscapes including the restriction of:* a. development on land generally unsuitable for development due to steep slopes or shallow soils, and b. development on land subject to salinity, and	a. This clause is intended to apply to naturally formed steep slopes or Karst landscapes, not man-made landscapes such as the subject site, notwithstanding it is considered that the to the extent the objectives are relevant, they are met. b. Mitigation strategies are proposed including sequencing, management plans (to be provided), erosion and sediment control and revegetation. c. The site is highly disturbed as a result of the many years of quarrying. Little intact native vegetation is present on the site.	Section 3.3

Statement of Facts and Contentions	Response	Supplementary Environmental Impact Statement reference
c. the removal of native vegetation, and d. development on land that is subject to regular or permanent inundation, and e. development on land that is within significant karst environments. *(2) This clause applies to land identified as "Sensitive Land Areas" on the Environmentally Sensitive Areas – Land Overlay Map.* *(3) Before determining a development application for development on land to which this clause applies, the consent authority must consider whether the development is likely to have any adverse impact on the following:* a. any land with slopes greater than 25%, (b. any land subject to high erosion potential, c. any land subject to salinity or impeded drainage, d. any land subject to regular or permanent inundation, e. any significant karst environment (including ecological, air quality and movement, water quality, biodiversity, geodiversity (geomorphical and geological), heritage, recreational and sociological values). *(4) Development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that:* a. the development is designed, sited and will be managed to avoid significant adverse environmental impact, or b. if that impact cannot be avoided – the development is designed, sited and will be managed to minimise that impact, or c. if that impact cannot be minimised – the development will be managed to mitigate that impact."	The proposed development includes reprofiling following emplacement of fill to create a more natural landform, and the revegetation of the final landform with locally endemic species to re-create the woodland to improve site biodiversity. Flows will return close to natural conditions (improved from existing conditions). d. The dewatering of the quarry voids will be progressive. Dewatering of the existing voids will be fluctuated and will typically be limited to 10 to 15% of the existing storm flows and will not impact upon downstream geomorphology. Restoring the landform to be representative of its original topography will return the site to more natural run-off and flow conditions at the conclusion of the project. e. In accordance with clause 7.7(4), the consent authority can be satisfied that the development has been designed, sited and will be managed to avoid significant adverse impacts on the development.	
(b) The proposal involves the removal of 2.48 hectares of planted vegetation, which formed the rehabilitation planting undertaken in 2014 arising from the consent conditions under Development Application 108/1994, and 0.13 hectares of remnant vegetation.	Rehabilitation of the site has not been undertaken strictly in accordance with the previous consent conditions and in particular, parts of the site which are outside the cadastral boundaries of the land remain disturbed. The OEH has indicated that it supports the rehabilitation of the site to a more stable which reflects pre-quarrying conditions.	
(c) The proposal seeks approval for the site, post importation of fill to be reinstated with progressive revegetation undertaken over the 15-year life of the development.		
(d) The dewatering of the quarry voids has been assessed by the EPA as having the potential to erode the existing intermittent watercourse and swamp located downstream of the site through increased water flows during the dewatering program planned over Stages 1 to 5 of the Project.	Dewatering will be managed and not cause downstream erosion.	

Statement of Facts and Contentions	Response	Supplementary Environmental Impact Statement reference
(e) Based on the comprehensive assessment of likely environmental impacts of the proposed development by the EPA dated 20 March 2019 and subsequent submissions, it is considered reasonable to accept that the proposal fails to satisfy the provisions under Clause 7.7 of the LEP.	The documents supporting the amended application conclude that the Proposed Development will not result in detrimental environmental impacts and that the proposed development satisfies the requirements of clause 7.7 Sensitive Lands of LLEP.	
Adverse Environmental and Amenity Impacts on Residential Properties		
Contention 10: The proposed development will have unacceptable environmental and amenity impacts arising from the activity associated with the importation of fill to the former quarry site, contrary to s4.15(1)(b) of the EP&A Act.	The proposed development will not have unacceptable environmental and amenity impacts arising from the proposed development contrary to s4.15(1)(b) of the EPA Act.	
Particulars a. There are a number of residences located on Sandham Road, between Bells Line of Road and the subject site, and others proximate to Sandham Road/Chifley Road that will be impacted by the following amenity concerns: i. noise, dust and vibration impacts arising from the 74 heavy vehicles (up to 42.5 tonnes) daily trips to and from the site over the 15 year life of the Project; ii. public safety issues for school buses, cyclists and residents using Sandham Road given the existing condition and character of the road; iii. increase in bushfire risk due to loss of water source in existing quarry for local firefighting; iv. potential for noise disturbance from trucks queuing to enter the site prior to 7.00am opening. b. Adverse traffic impacts on residents located on Bells Line of Road and Great Western Highway east of Mt Victoria from increase in heavy truck movements associated with the Project.	a. The proposed development complies with the EPA's Road Noise Policy. Notwithstanding, the applicant is prepared to accept the condition in contention 12(b) and therefore considers that the development application will be acceptable with respect to noise impacts. b. Current traffic volumes along Sandham Road are understood to be around 30 vehicles per day (or three vehicles during the peak hour assuming a 10 per cent peak hour conversion factor) and trips would largely be contained within the sealed section of the road. As mentioned previously, the proposed increase of 37 vehicle movements per day on average (six vehicle movements in the peak hour) and 74 vehicle movements during peak activities (12 vehicle movements in a peak hour) is considered minor, with a low frequency of two opposing vehicles meeting on Sandham Road at the same time. Further, this road is understood to have been satisfactorily used by Bell Quarry vehicles when previously operational over many years since the 1960s. In the event of opposing vehicles meeting along Sandham Road, a vehicle would be able to pull to one side of the road to allow for the other vehicle to pass. This is not dissimilar to what occurs on narrow local roads in urban areas. The applicant has made an offer of a Voluntary Planning Agreement to contribute to specified upgrades to road works. c. Dewatering of the voids will not increase the bushfire risk in the local area and a landowner is not obliged to maintain a water source on privately owned land for firefighting purposes. This was the position stated in the RFS submission. However the proposed filling volume has been reduced and the north western void will be retained and be available to provide a supply of clean water for firefighting purposes, as needed	Section 3.4 and Appendix G

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	d. The applicant is prepared to accept a condition in the nature of contention 12(b) and therefore says that contention 10(a)(iv) is resolved. e. The anticipated average traffic activity is consistent with historical quarry operations and the Traffic Impact Assessment prepared by GHD dated July 2018 evidences that the proposed development will have a negligible impact on function of the surrounding road network.	
Public Interest		
Contention 11: The notification of the Designated Development application attracted submissions from relevant Government agencies, local government, special interest groups and individuals. A total of 470 submissions of objection, excluding duplicates, were received by Council including 321 individual submissions and 149 form letters, expressing concerns in relation to: – Adverse environmental impacts on Greater Blue Mountains World Heritage Area; – Impacts of the importation of the fill on groundwater; – Impacts of dewatering on Blue Mountains National Park; – Potential contamination of Wollangambe and Colo Rivers, including domestic water supply from Colo River; – Spraying of water to mitigate dust and washdown of trucks will flow into Wollangambe River, part of the Hawkesbury-Nepean Catchment; – Loss of water source in quarry will increase bushfire risk for local communities and restrict RFS aircraft capability to fight local fires; – Traffic impacts on Bells Line of Road and Great Western Highway, in particular in Mt Victoria from additional heavy truck movements; – Existing condition and width of Sandham Road unable to safely accommodate heavy truck movements, particularly in respect to the school bus, pedestrians, cyclists and local resident movements and needs to be upgraded if the proposal is approved; – Intersection of Sandham Road and Bells Line of Road has poor sight lines and needs to be improved; – Potential for queuing of trucks in Sandham Road and Bells Line of Road prior to 7.00am opening of facility; and – Amenity impacts on Sandham Road residences with dust, noise and public safety.	The proposed development is in the public interest. a. The particulars of all other contentions are repeated here. b. The proposed development is permissible with consent and the planning decisions must generally reflect an assumption that, in some form, development which is consistent with statutory planning controls will be permitted. c. There are no matters under LLEP or the ISEPP that when taken into consideration should lead to refusal. d. Mere opposition does not mean that the proposed development is not in the public interest. e. The carrying out of the proposed development will result in an acceptable landform, re-establishment of soils and vegetation communities over current quarry voids, and a return to pre-quarry surface and groundwater hydrological regimes. This is a benefit to the public interest. f. Revegetation of off-site areas to restore and rehabilitated land in National Parks estate and other lands in a public benefit. g. The proposed development will not compromise the safety or amenity of surrounding areas.	
Contentions that may be resolved by conditions of consent		

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Contention 12:		
The key matters to be addressed by conditions would include the following: (a) Surrounding land use: Conditions should be imposed to the effect recommended by the former OEH in relation to the following matters: (i) Work within the Blue Mountains National Park (ii) Introduction of pathogens to the site (iii) Monitoring and adaptive management (iv) Mitigation of impacts (v) Boundary survey and fencing.	The applicant accepts the conditions to the effect recommended by the former OEH in relation to the matter raised in contention 12(a).	
(b) Noise: As noise disturbance from truck movements is the primary concern for residential properties located on Sandham Road at Bell during the night-time period (10.00pm to 7.00am) the potential for trucks to queue in Sandham Road prior to the opening of the quarry at 7.00am could lead to a significant noncompliance with the relevant noise standard for night-time given the relatively low background noise levels currently enjoyed by residents since the closure of the Rocla quarry nearly 10 years ago. A condition that prevented truck access to Sandham Road at its intersection with the Bells Line of Road prior to 7.00am would resolve that issue in respect to noise disturbance during the hours of 10.00pm and 7.00am. Conditions should be imposed on any consent to ensure that the development complies with the EPA's Road Noise Policy at all receivers	The applicant accepts conditions to the effect of those in contention 12(b).	
(c) Traffic and Transport: The development involves significant heavy vehicle movements over an extended period of time. This will impact on the required maintenance of the road and the safety of other road users. If the development were to be approved, significant measures would be required to mitigate these impacts. The recommendations of Council's Engineer for the widening and sealing of Sandham Road would address local concerns as to dust and public safety in the event of the approval of the development embodying the Council Engineer recommendations.	The existing condition of Sandham Road is considered suitable for supporting the Proposed Development with only minor improvement works and is it not considered appropriate to put the onus of any wholesale upgrades to the road solely on the Applicant. Notwithstanding, the Applicant has made an offer to enter into a planning agreement with Council in relation to contributions to be applied by Council towards specified upgrades of the sealed section of Sandham Road and is prepared to undertake maintenance and repair (such as potholes and dust suppression) on the unsealed portion of Sandham road biannually and/or after weather events as required.	Section 3.4 and Appendix G.

Appendix B

Environmental Management Plan and Staging Plans

Environmental Management Plan

Bell Quarry Appeal

Bell Quarry Rehabilitation Project Pty Ltd

19 November 2021

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→ **The Power of Commitment**

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1. Introduction

1.1 Overview

Bell Quarry Rehabilitation Project Pty Ltd (the Applicant) seeks to rehabilitate the Bell Quarry site, located on Sandham Road at Newnes Junction, approximately ten kilometres east of Lithgow in NSW as shown on Figure 2-1. The development application seeks (DA) to achieve the final rehabilitated landform via importation of emplacement material sourced from Sydney and the local regional area which meets:

- the definition of virgin excavated natural material (VENM) as defined by the *Protection of the Environment Act, 1997* (POEO Act) from time to time
- the criteria of excavated natural material (ENM) as set out in the Excavated Natural Material Order and Exemption 2014 issued by the Environmental Protection Authority under clause 93 of the Protection of the Environmental Operations (Waste) Regulation 2014; or
- an exemption granted by the Environment Protection Authority (EPA) pursuant to clauses 91 and 92 of the Protection of the Environmental Operations (Waste) Regulation 2014) and which specifically relates to the site (comparable material).

The key objectives for the Project include:

- Rehabilitate the site to a condition closely representing the pre-quarry original landform and that of the adjoining Blue Mountains National Park.
- Maximise resource recovery through diversion of fill and comparable materials away from landfill for beneficial reuse in site rehabilitation activities.
- Undertake the rehabilitation works to be sympathetic to the surrounding land-use and environmental setting.
- Provide ongoing local employment opportunities.
- Revegetation of the site with locally endemic species to provide effective integration with the surrounding landscape.

The rehabilitation process will involve:

- Importation of approximately 1 million m^3 of VENM, ENM and comparable material).
- Vehicle haulage at a rate of up to 140,000 tonnes per annum (tpa).
- Staged emplacement and compaction of fill within the existing quarry voids.
- Shaping of fill to closely represent the pre-quarry landform and to allow surface water drainage across the final landform.
- Development of a water management system including management plans to control surface water discharges throughout the rehabilitation program and from the final landform.
- Revegetation of the site with locally endemic species to provide effective integration with the surrounding landscape.
- Ongoing monitoring and maintenance for life of Project and minimum two years post completion.

1.2 Purpose of this environmental management plan

The purpose of this environmental management plan (EMP) is to provide an environmental management framework and associated management procedures to avoid or minimise the potential environmental impacts associated with rehabilitation of the quarry during establishment, operation, and closure.

The EMP has been prepared based upon the concept design details presented in Section 2, principles of water management contained in the Revised Water Resources Assessment (GHD 2021) and will be updated during detailed design of the construction and emplacement works and to reflect any approval conditions for the DA.

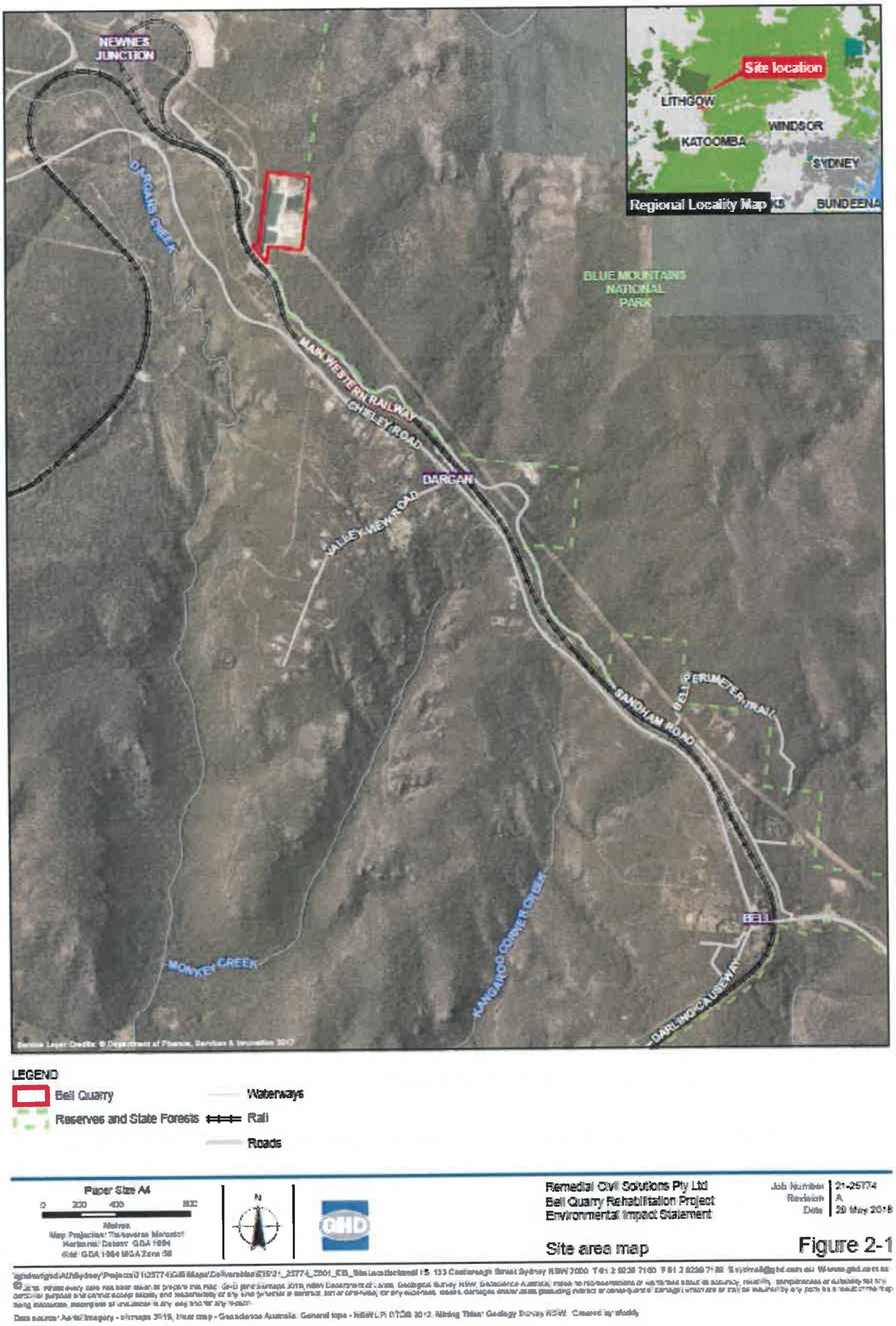

Figure 1.1 *Site Area Map (GHD, 2018)*

2. Project Design

2.1 Staging

2.1.1 Overview of changes from EIS submission

Changes were made to the staging plans presented in the EIS for the initial development application. These changes have been summarised below:

- The proposed fill staging has been altered to reflect the revised surface water management system
- The footprint of the landform has been amended but remains fully within the footprint included in the original DA and the maximum height of the final landform has not been altered
- The eastern void is to be retained throughout the filling of the first 4 stages to allow for storage of contact water prior to disposal via irrigation (or, in the event a treatment plant is required, via treat and release).
- The fill footprint and final landform in the southern void have been adjusted to provide an alternative access which is developed as part of the filling of Stage 1.
- All areas proposed to be filled will be lined with HDPE geomembrane (or equivalent) on the base and clay on the sidewalls where they are adjacent to the natural substrate (i.e., in the pits).
- The basal lining of each stage includes a geonet drainage geocomposite (or equivalent) and riser to allow extraction of leachate (if required).
- Groundwater diversion system to promote groundwater movement down-gradient of the basal liner
- A temporary clean water diversion system will be constructed to the west of the site to allow diversion of upstream catchment around active emplacement areas.
- The contact water dam will be lined with a HDPE geomembrane (or equivalent)
- Areas proposed to be filled will be capped with LLDPE geomembrane (or equivalent), overlaid with a subsurface drainage system, and revegetated

  Areas of the site have been identified for excavation works to supply site won material for site intermediate capping and a minimum of 600 mm of final capping materials
- Excavation areas are within the extents of the proposed filling works and includes an area in the northern portion of the site as described in the original DA and a former deposition area in the eastern portion of the site.
- A stockpile of site won material is to be placed in the northeast corner of the site (for the later stages use)
- A potential future final filling stage involves filling the contact water dam at the conclusion of proposed emplacement activities and will be subject to a future application or modification under Section 4.55 of the *Environmental Planning and Assessment Act, 1979* (EP&A Act) should development consent be granted by the Land and Environment Court. The modification application would be based on an assessment of the facility performance over the first 4 stages and development of a system for management of contact water during the completion of the filling operations. The assessment would quantify whether all or part of the contact water pond can be removed, and the final landform adjusted to suit.

2.1.2 Work stages

The rehabilitation work is split into Site Establishment works and 4 stages of filling works. Staging descriptions below are to be read in conjunction with the staging plan sketches SK001 to SK011, as included in Appendix A.

Table 2.1 shows a summary of the staged quantities and areas. Stage 5 has not been included as its development will be subject to ongoing assessment of the facility performance during the filling of Stages 1 to 4.

Table 2.1 ***Staged quantities and areas (subject to detailed design)***

	Excavation[1] (m^3)	Volume[2] (m^3)	Base lining area[3]** (m^2)	Sidewall lining area** (m^2)	Active filling area* (m^2)	New intermediate cover area** (m^2)	Final cap area** (m^2)
Stage 1A		104,300	4,100	11,740	12,400	-	-
Stage 1B		115,800	-	4,500	12,400	7,390	5840
Stage 2		48,800	11,800	-	12,560	1,820	11,880
Stage 3a		89,850	10,500	3,600	17,900[4]	4,400[4]	0
Stage 3b		244,200	-	10,450	16,700[4]	8,870[4]	11,690
Stage 3c		25,800	-	-	7,660	-	8,150
Stage 3d		169,050	-	8,160	6,500	4,340	10,150
Stage 4	Up to 60,500	255,250	3,800	13,500	15,180[5]	-	22,230
Total	***60,500***	***1,053,050***	***30,200***	***51,950***	**-**	***26,820***	***69,930***

* plan area

** slope area

2.1.2.1 Site establishment works

Before filling occurs, site establishment works are required to prepare the site for filling works. This will involve the following:

- Dewatering of the southern and western voids to separate the water between the voids. A bund will be created, if needed, to ensure future separation and completely dewater the southern void.
- A geomembrane (or equivalent) lining system will be installed in contact water pond after it is dewatered.
- The southern void will be dewatered, and a geomembrane (or equivalent) lining system installed in preparation for Stage 1 filling of the southern void.
- The water in the western void will be drawn down and an overflow channel installed to allow clean water to drain directly offsite by gravity (bypassing the eastern void).

2.1.2.2 Stage 1

Stage 1 involves filling of the southern void in two stages:

- Stage 1A – initially fill against the southern and eastern batters to develop a new site access road which is within the site boundary.
- Stage 1B – fill the remaining available capacity in the Stage 1 area.

During filling:

- Contact water will be collected and pumped to the contact water pond for storage and disposal.
- Where filling is being undertaken above surrounding ground level, a soil bund will be constructed at the perimeter of each lift to prevent run off and a low point created to collect contact water.
- Intermediate capping will be installed progressively on the northern intermediate batter as each lift is placed.
- Final capping will be installed progressively on areas final surface areas as each lift is placed.
- Sediment laden water will be directed from the intermediate cap areas to the temporary pond (developed when filling proceeds above ground) for management before discharge.

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[1] Excavation represents the stage/area where the excavation is achieved. It does not represent the timing of excavation works. All other values in this table assume that this excavation work is undertaken as required.

[2] Volume represents volume from existing surface or design excavation surface to top of final cap. Stage fill capacities must also consider airspace lost to lining, cover and capping works.

[3] Material required for groundwater depressurisation and seal bearing layers under the base lining system are assumed to be won from within the filling footprint as part of stage preparation works.

[4] Where the entire stage catchment area is greater than 1.3 ha, filling works will be staged, and intermediate cover used to maintain an actual contact water area of less than 1.3 ha at any time. Additional intermediate cover material may be required to achieve this requirement. Additional onsite soil generation has been included for this purpose.

- South-eastern area will be lined in preparation for Stage 2 filling works.
- Site access around the south-eastern area will be developed to allow filling in Stage 2 area.

2.1.2.3 Stage 2

Stage 2 involves filling of the south-eastern area. During filling:

- Contact water will be collected and pumped / directed to the contact water pond for storage and disposal.
- Where filling is being undertaken above surrounding ground level, a soil bund will be constructed at the perimeter of the active fill area to prevent run off and a low point created to collect contact water.
- Intermediate capping using site won material will be installed progressively on the western intermediate batter.
- Final capping will be installed progressively on areas as they reach final surface levels.
- Sediment laden water will be directed from the intermediate cap areas to the temporary pond (developed in preliminary works) for settlement before discharge.

A temporary clean water diversion system will be constructed to direct water from the west of the site. The diversion drain will cause clean water to enter further south of the site, over the now-filled Stage 1 intermediate batter. The water will then flow through the site and directly offsite. It is expected that the diversion system will require:

- Construction of a shallow open channel on north side of existing entry, flowing south, nominally within 5-10 metres of the crest of the void.
- Construction of a headwall and upstream pond, nominally within 20-30 m of the crest of the void.
- Construction of a deep open channel to the south of the existing entry, flowing south, nominally within 20-30 metres of the crest of the void.
- Construction of open channel on the Stage 1 batter and across the site to allow discharge of clean water directly offsite.
- Vegetation of all areas of intermediate batter draining into this diversion structure to control erosion.

The western void will be dewatered, the clean water overflow will be decommissioned, and a lining system will be installed in preparation for Stage 3 filling.

2.1.2.4 Stage 3

Stage 3 involves fill the western void in four stages:

- Stage 3A – the entire void area to be filled to approximately RL1032 m.
- Stage 3B – the southern section of the void will be filled to final landform levels to allow clean water drainage over the rehabilitated surface.
- Stage 3C – once the final clean water drainage pathway over the rehabilitated surface has been established, decommission the temporary clean water diversion drain over the Stage 1 batter and fill the remaining Stage 1 and Stage 2 intermediate batters.
- Stage 3D – northern section of the void will be filled in.

During filling:

- Filling works will be undertaken to ensure a contact water area of less than 1.3 hectares is maintained (where filling occurs above grade and not within a below grade void).
- Contact water will be collected and pumped to the contact water pond for storage and disposal.
- Where filling is being undertaken above surrounding ground level, a soil bund will be constructed at the perimeter of the active fill area to prevent run off and a low point created to collect contact water.
- Intermediate capping will be installed progressively on the intermediate batters.
- Final capping will be installed progressively on areas that reach final surface levels.
- A temporary sediment pond will be developed in the northern part of site and the Stage 1 temporary pond will be removed when required.

- Sediment laden water will be directed and pumped from intermediate capping areas to the temporary pond for settlement before discharge.
- Additional excavation will be undertaken, as required, between the Stage 3 and Stage 4 areas.
- Lining system will be constructed in the northern area in preparation for Stage 4 filling.
- Temporary cover material stockpile area will be developed in the north-east, including required sediment and erosion controls.

2.1.2.5 Stage 4

Stage 4 involves filling the northern area. During filling:

- Filling works will be undertaken to ensure a contact water area of less than 1.3 hectares is maintained by temporary bunding or similar (where filling occurs above grade and not within a below grade void).
- Contact water will be collected and pumped to the contact water pond for storage and disposal.
- Where filling is being undertaken above surrounding ground level, a soil bund will be constructed at the perimeter of the active fill area to prevent run off and a low point created to collect contact water.
- Final capping will be installed progressively on areas that reach final surface levels.
- The temporary sediment pond adjacent to the cover material stockpile will be utilised or temporary ponds established in the operational areas as required.
- Temporary sediment and erosion controls will be maintained around the cover material stockpile area.

If Stage 5 is developed for filling, Stage 4 works will also include:

- Cleaning and dewatering of the contact water pond and development of alternative contact water management measures, as required.
- Lining of the Stage 5 area in preparation for filling.

2.1.2.6 Stage 5 (potential)

A potential final filling stage, Stage 5, will be subject to a future application or modification. Any subsequent application would be based on an assessment of the facility performance over the first 4 stages in relation to water management. The assessment would quantify whether all or part of the contact water pond can be removed, and the final landform adjusted to suit. If developed for filling:

- Filling works will be undertaken to ensure a contact water area of less than 1.3 hectares (or otherwise determined) is maintained.
- Contact water will be collected and pumped to the contact water pond for storage and disposal.
- Where filling is being undertaken above surrounding ground level, a soil bund will be constructed at the perimeter of the active fill area to prevent run off and a low point created to collect contact water.
- Final capping will be installed progressively on areas that reach final surface levels.
- Temporary sediment and erosion controls will be maintained around the cover material stockpile area.

2.1.2.7 Final rehabilitation surface

At the conclusion of site filling, the contact water pond (if remaining) will be dewatered and cleaned, and the liner retained and would be a clean water pond available.

2.1.3 Excavation

Excavation works have been included to provide soil materials for operational uses, including:

- Intermediate cover.
- Final capping and rehabilitation works.

These excavation works would be undertaken on an as-needs basis from the Stage 4 footprint area.

The proposed extents of excavation are wholly within the proposed fill boundary and located within areas proposed to be filled during Stage 4. The preliminary design of this excavation surface has allowed for:

- Excavation batters of 1 (vertical) in 2 (horizontal).

- Minimum base dimension is around 35 metres to allow for vehicle movements within the base of the voids.

Vehicle access into this excavation will be considered as part of the detailed design and development of this void.

This area is known to have been previously quarried, and rock materials may be found within the proposed excavation footprint. Historical documents show that the intention was to excavate the quarry to RL1018 m. The base of the current water-filled voids is around RL1023 m. The lowest point of this excavation area is RL1030 m. Where rock walls are located around the perimeter of these excavations the batters may be able to be made steeper to follow the steeper rock surface.

Appropriate erosion and sediment controls will be installed as part of excavation works. These would be developed as part of the detailed design and will include construction and operation of a temporary sediment basin within the excavation void while excavation, bunding and diversion of surface water, sediment fencing and dust suppression.

2.1.4 Machinery/equipment to be used

Anticipated plant and equipment to be used for the project is shown in Table 2.2.

Table 2.2 Anticipated plant and equipment

Project Activity	Equipment	Plant
Imported material		Up to 42.5 tonne truck and trailer haulage vehicles
Emplacement activities	Generator, site office / amenities building spill kits, refuelling/spill bunds,	1 grader, 1 tipper truck, 1 dozer, 2 front end loaders, Roller, Fuel delivery truck, water truck
Water management system	Submersible and centrifugal pumps	Contingency water treatment plant (if required)
Revegetation activities	Mechanical and electrical equipment,	Hydro-seeding (and planting of tubestock)

2.1.5 Estimated duration of work and operating hours

The Project is expected to take approximately 15 years to complete.

Operation hours for the proposed rehabilitation works will be in accordance with Table 2.3.

Rehabilitation activities and haulage to the site will be restricted to the hour of 7.00 am to 6.00 pm Monday to Friday and 7.00 am to 1.00 pm on Saturdays. Minor site preparation activities involving the use of a grader and roller to prepare the site for haulage vehicles is proposed between 6.00 am and 7.00 am Monday to Saturday.

Table 2.3 *Operating hours*

Activity	Day of week	Time	Assessment period
Rehabilitation related activities and transport of materials	Monday-Friday	7:00 am to 6:00 pm	Day
	Saturday	7:00 am to 1:00 pm	Day
	Sunday and Public Holidays	None	-
Preparation of ground on-site for haul trucks	Monday-Friday	6:00 am to 7:00 am	Night
	Saturday	6:00 am to 7:00 am	Night
	Sunday and Public Holidays	None	-

2.1.6 Acceptance of fill

Rehabilitation of the final landform to be achieved via importation of material sourced across Sydney and the local regional area which meets:

1. the definition of VENM as defined by the *Protection of the Environment Operations Act 1997* (PoEO Act) from time to time.
2. the criteria of ENM as set out in the Excavated Natural Material Order and Exemption 2014 (ENM Order) issued by the Environmental Protection Authority (EPA) under clause 93 of the Protection of the Environmental Operations (Waste) Regulation 2014.
3. an exemption granted by the Environment Protection Authority pursuant to clauses 91 and 92 of the Protection of the Environmental Operations (Waste) Regulation 2014 and which specifically relates to the site (Comparable Material).

The PoEO Act defines VENM as 'natural' material (such as clay, gravel, sand, soil, or rock fines):

a. that has been excavated or quarried from areas that are not contaminated with manufactured chemicals, or with process residues, as a result of industrial, commercial, mining or agricultural activities, and
b. that does not contain any sulfidic ores or soils or any other waste.

ENM refers naturally occurring rock and soil (including but not limited to materials such as sandstone, shale, clay and soil) that has:

c. been excavated from the ground, and
d. contains at least 98% (by weight) natural material, and
e. does not meet the definition of Virgin Excavated Natural Material in the Act.

Excavated natural material does not include material located in a hotspot; that has been processed; or that contains asbestos, Acid Sulfate Soils (ASS), Potential Acid Sulfate Soils (PASS) or sulfidic ores.

Limiting concentrations for ENM in accordance with the ENM Order is included in Table 2.4.

Table 2.4 Limiting concentrations in ENM as per the ENM order (EPA 2014b)

Chemicals and other attributes	Maximum average concentration for characterisation (mg/kg 'dry weight' unless otherwise specified)	Absolute maximum concentration (mg/kg 'dry weight' unless otherwise specified)
1. Mercury	0.5	1.0
2. Cadmium	0.5	1.0
3. Lead	50	100
4. Arsenic	20	40
5. Chromium (total)	75	150
6. Copper	100	200
7. Nickel	30	60
8. Zinc	150	300
9. Electrical Conductivity	1.5 dS/m	3 dS/m
10. pH *	5 to 9 pH units	4.5 to 10 pH units
11. Total PAHs	20	40
12. Benzo(a)pyrene	0.5	1.0
13. Benzene	NA	0.5
14. Toluene	NA	65
15. Ethyl-benzene	NA	25
16. Xylene	NA	15
17. TPH C10-C36	250	500
18. Rubber, plastic, bitumen, paper, cloth, paint and wood	0.05 %	0.10 %

* The ranges given for pH are for the minimum and maximum acceptable pH values in the excavated natural material.

Sampling, testing and certification of the fill would be per the requirements of the POEO Act and NSW EPA website guidance for VENM; *excavated natural material order and exemption 2014* (NSW EPA, 2014b) for ENM and as stipulated in any specific resource recovery order and exemption approved by the EPA for the site.

The incoming fill will be visually inspected by the operator at the tipping face for signs of contamination such as excessive foreign materials. Any non-conforming fill will be segregated and temporarily stockpiled within the emplacement area for transfer offsite to an appropriately licensed facility.

Incoming fill audits will be undertaken for every 50,000 tonnes of fill placed at the site.

It is noted that under Section 144AA of the POEO Act it is an offence to misclassify waste with penalties for an individual up to $240,000, or 18 months imprisonment, or both.

2.1.7 Fill placement procedure

Fill will be placed within the former quarry void according to the proposed rehabilitation strategy and filling plans to be developed as part of operations (refer Section 2.1.8). The placement procedure will address potential impacts to the environment and required environmental performance outcomes. Management measures include the following:

- An active placement area no larger than 1.3 ha will be established in accordance with the proposed staging plan.
- Fill will be delivered to the placement area by trucks. The unloaded fill will be spread out by bulldozer and compacted by roller.
- Designated vehicle wash down areas will be set up to prevent tracking of fill outside of the active emplacement areas. This will also include cattle grates at the site entry and exit points.

- A mapping system will be developed to document the location of material deposited on site from each off-site location it originated from. This will facilitate the development of management measures should SSTLs be exceeded.
- Fill will be placed in lifts and compacted to a minimum of 95% standard maximum dry density. Compaction testing will confirm that average compaction is being achieved. The lift height would be developed as part of the detailed design to allow for sufficient area for operations and placement of the capping material.
- The horizontal fill lifts will be graded to allow for free draining of surface water and to avoid localised ponding.
- Dust suppression controls will be implemented to manage the generation of dust during placement. This will include water trucks for roads and active tipping areas and spray irrigation on non-active areas/
- The sidewall liner system will be inspected prior to placement of fill and after any rainfall event for any indications of damage such as scouring, tears or punctures. Fill placed against the side wall liner system will be pushed against the wall and the compaction limited to avoid damage to the liner system.
- Interim fill batters will be limited to 1(vertical) in 2 (horizontal) and final batters will be per the landform design.
- Intermediate cover material will be placed on all batters that do not form part of the final landform and will comprise site won material. Where possible the intermediate cover material will be stripped back and reused prior to placement of additional fill.
- The final landform will be progressively capped to ensure stability of the emplacement areas, control erosion and minimise rainfall infiltration into the fill.

2.1.8 Filling Plan

Filling plans will be developed for each stage identified in Table 2.1 and updated as required during operations. The plans will address the fill placement procedure requirements in Section 2.1.7 and following key factors:

- Access for construction and operational plant and vehicles
- Spatial allowance for truck turning circles
- Maintenance of contact water area of less than 1.3 hectares
- Erosion and sediment control including surface water diversion and bunding around the active area to capture contact water, sediment fencing and vegetative matting on areas of final capping and dust control measures on non-active areas and access points
- Lift height and compaction requirements
- Final and intermediate cover stockpile management and placement requirements
- Interfacing requirements with other stages and irrigation areas
- Additional excavation requirements, as required

2.2 Water system operations

2.2.1 Surface water

Overview

A revised surface water management system has been developed involving management of surface water within the site in three separate streams:

- Water from upstream catchment (off-site) areas: This water shall be conveyed through/around the site without interaction with site waters wherever practicable, with direct discharge to the downstream receiving system. Where mixing of upstream and site waters is unavoidable, (for example, a cascade of upstream waters currently enters the western void of the site) the upstream waters shall mix only with sediment-laden water (not contact water). Where this mixing occurs the sediment laden water management approach shall include the volumetric contribution of the upstream waters.
- Sediment laden water: This is runoff from areas where disturbed, non-vegetated soil is present but does not consist of foreign imported fill material. In these areas runoff is to be managed in accordance with *Managing Urban Stormwater: Soils and Construction Volume 1, Landcom 2004 and Volume 2, DECC 2008*. The requirements within the documents that apply to a “sensitive” receiving environment would be adopted.

- Contact water: This water comprises any surface water that has interacted with emplacement material and will be captured in a contact water pond for reuse via on-site irrigation to prevent discharge of surface water from the site. There will be no discharges of surface contact waters would occur other than when treated to background water quality conditions (if this were required).

Adopted assessment criteria

The revised assessment has adopted an elevated assessment criteria for the works based upon achieving a neutral or beneficial effect, based upon the State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011 as well as the corresponding WaterNSW guideline *Neutral or Beneficial Effect on Water Quality Assessment Guideline.*

It is noted the site is not located within Sydney's drinking water catchment, however the neutral of beneficial effect (NoRBE) approach has been applied to the proposed development to achieve the highest level of protection given the sensitivities of receiving waters in the Wollongambe River catchment and the Greater Blue Mountains World Heritage Area.

A neutral or beneficial effect on water quality is satisfied if the development:

(a) has no identifiable potential impact on water quality, or

(b) will contain any water quality impact on the development site and prevent it from reaching any watercourse, waterbody or drainage depression on the site

The criteria above have been developed based on the State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011 as well as the corresponding WaterNSW guideline *Neutral or Beneficial Effect on Water Quality Assessment Guideline*. This has been applied to each category of water as follows:

- Where upstream water does not come into contact with site waters it is anticipated to *have no identifiable potential impact on water quality* and as such satisfy the Neutral or Beneficial requirement of the SEPP (refer Section 3.1a of the guideline).
- Sediment laden water would be managed in accordance with *Managing Urban Stormwater: Soils and Construction Volume 1 and Volume 2* which are current recommended practices (CRPs) in accordance with the SEPP. The SEPP states that new developments or activities should incorporate CRPs and standards endorsed by Water NSW or adopt approaches that achieve the same or better water quality outcomes. Inferring that the outcomes achieved through implementation of the CRPs constitute the appropriate environmental outcomes under the SEPP.
- It is noted that the risk posed through leaching of substances from foreign imported materials is not fully covered under the abovementioned CRPs. As such, for contact runoff areas surface waters would either be contained or treated to achieve background conditions before discharge (if this contingency treatment option is triggered).

2.2.2 Final cover and basal liner profile

Final cover profile (top to bottom):

- Revegetation layer suitable for the establishment and long-term viability of vegetation.
- Subsurface drainage layer to ensure stability of the revegetation layer and minimise infiltration.
- Geosynthetic barrier system that will minimise infiltration to as low as reasonably practicable and prevent 'bath tubbing' above the basal liner.
- Seal bearing layer to support the geosynthetic barrier layer.

Basal and sidewall liner profile (top to bottom):

- Compacted clay sidewall barrier progressively placed in lifts to minimise the horizontal migration of leachate out of the fill and seepage of groundwater into the fill.
- Geonet drainage geocomposite (or equivalent) to minimise damage of the basal liner barrier system and allow monitoring of leachate in the cells.
- Geosynthetic basal barrier layer to form a barrier between the placed fill and the groundwater, soil and substrata and minimise seepage to as low as reasonably practicable.
- Seal bearing layer to support the geosynthetic barrier layer.

- Groundwater diversion system to promote groundwater movement down-gradient of the basal barrier layer.

2.2.3 Leachate levels

Numerical groundwater modelling was performed Martens and Associates (2021).

The modelling established that, taking into consideration groundwater inflow and outflow, infiltration from the cap and seepage through the liner, over the long term, leachate levels are expected to rise and equalise with the surrounding groundwater table level (approximately 1037.5 mAHD).

The basal drainage layer at the base of the quarry void would allow monitoring of leachate in the fill. Monitoring of leachate levels at the riser will be undertaken in accordance with the details provided in the Revised Water Resources Assessment (GHD 2021) to confirm that leachate is not accumulating/increasing within the quarry void creating a bathtub effect. As the site is being progressively capped and revegetated this issue will be able to be monitored during site operations.

2.2.4 Irrigation management

Contact water will result from runoff from active emplacement areas and minor quantities from any vehicle washdown. All contact water will be contained within the site or treated and discharged at background water quality conditions. Irrigation of contact water will only be applied within the contact water catchment.

Contact water will be contained by installation of diversion bunds and drained to the contact water storage. The accumulated contact water will be collected for irrigation within the emplacement area by:

- Tanker through application to the active placement area for dust suppression and moisture conditioning to achieve target compaction rates.
- Mobile sprinklers that will be located within the emplacement area outside of haulage routes.

The operation of the sprinklers will consider irrigation demand, wind speed and prevailing wind direction and elevation with the aim to prevent spray drift outside of the emplacement areas or exposure to workers. Irrigation activities will not take place during wet weather periods or during high wind speed condition depending on the elevation of the emplacement area. The mobile sprinklers will be sited within the emplacement area based on fill moisture monitoring by conductivity meter. The irrigation rate will be developed to minimise runoff, and to not exceed the capacity of the fill to absorb the contact water. A surface water and groundwater monitoring program will be implemented (refer Section 2.2.1 and 2.2.3) which will be designed to detect any migration of contact water from the site.

2.2.5 Water Treatment Plant operation

As part of the precautionary approach, the Supplementary EIS includes a contingency option for a water treatment plant to be installed at the site if storage levels in the contact water pond reach 45% or if required to treat leachate. The following measures will be undertaken to identify inform whether the water treatment plant is required.

- Monthly monitoring of contact water levels from when 30% contact water storage capacity is reached
- Six months of contact water and leachate sampling and analysis for the analytes identified in table 4 of the water options technical memorandum (GHD 2021). Leachate levels in the contact water pond and quality will be monitored on a quarterly basis during operation.
- Review of the water balance assessment (detailed on the Revised Water Resources Assessment GHD 2021) based on contact water level monitoring to inform long-term management procedures for the site and adjust site operations to contain untreated contact water onsite, as required

If required, the water treatment plant will be located in the central portion of the site as shown in the staging plans. The general treatment process for the plant will involve:

- Pump system to transfer water from the contact water storage to the Plant.
- Contact water will be treated via reverse osmosis (RO) treatment process where the contaminants are removed by filtration.
- Pre-treatment filtration for RO membrane protection from any unexpected solids that pass through the RO treatment system.

- The filter membranes will be regularly maintained and replaced as required to prevent clogging.
- Associated instrumentation for control and operation of the system.
- Wastewater from the process will be returned to the lined emplacement for containment (refer Section 2.2.6) with treated water discharged to the downstream system.
- The treated discharge water will be tested for compliance with the target 80th percentile water quality data for the background water quality (Office of Environment and Heritage 2015).
- In the event the unit is required to be stopped due to no or low level in the storage pond, it is recommended that the membranes are flushed and kept hydrated even if the system itself is not operational for a period of days. If the plant is not operational for a period of weeks, the RO membranes will need to be preserved in a sodium bisulphate solution or similar.

Once the project commences, as more water quality data is obtained from the in-situ runoff, contact water and leachate and refinement of the water quality data occurs, further assessment will be undertaken to better inform subsequent design stages (if treatment is required).

Contingencies are available and achievable if additional water quality data indicates contact water or leachate water has higher contaminant concentrations than the RO system can treat to achieve the required limits. These include blending of clean water runoff with RO system feed water (contact water or a combination of contact and leachate water) or blending of treated water with RO feed water to aid in achieving treated water discharge limits.

2.2.6 Brine management

Concentrated brine will be generated as a by-product of the plant (should the plant be needed). The brine will be stabilised prior to on-site disposal by mixing with fill to maintain a closed circuit with the emplaced materials. The beneficial reuse of the brine waste will be explored to determine if a commercial solution is available and if it is it may be adopted.

The fill and brine will be mixed within a lined skip bin such that the resulting consistency is generally capable of being picked up by a spade or shovel. The brine will be pumped directly to the skip bin and fill blended in using an excavator. The mixing area will be bunded to contain any leaks or contact water runoff. The mixed batches will not be stored for extended periods of time. Alternatively, the brine may be pumped directly to the relevant stage and mixed and placed in situ.

The brine mix will be disposed of within the quarry void via the trench and fill method. The spadable material will be unloaded from the skip bin/s and covered immediately after placement. The quantity and disposal area location will be recorded in the waste placement mapping system. Disposal of stabilised brine will not take place during or immediately following wet weather to control the risk of runoff from the placement area.

2.3 Site management and safety

2.3.1 Site offices/amenities

A portable site office and amenities building will be established in the central portion of the site as shown in the staging plan (refer to Appendix A). The site office caters for staff requirements and single administration / first aid area and amenities area. The amenities area will be serviced with a pump-out sewerage system with the sewage to be disposed off-site.

2.3.2 Waste management

Limited waste is anticipated to be generated through undertaking the project as summarised in Table 2.5.

Table 2.5 Operational waste

Source	Waste	Disposal/recycling
Operation of the site office	General waste (such as food scraps, cans, glass bottles, plastic and paper containers, paper, cardboard, and other office wastes)	Appropriately licensed recycling facility or landfill facility
On-site amenities	Wastewater	Licensed sewage treatment plant
Imported fill	Any non-conforming waste	Appropriately licensed waste facility
Water treatment plant	Brine RO filter cakes	Contained within the lined quarry void Possible off-site reuse

2.3.3 Site access and fencing

Access to the quarry is via the Sandham Road from Bells Line of Road as shown in Figure 1.1. Sandham Road passes through the village of Bell and runs parallel to arterial road Chifley Road on the western side of the Main Western Railway Line and follows a north-western alignment to the access point to the quarry.

A new site access road has been included in the design to be developed during filling of the Stage 1. The existing fence line will be relocated to align with the updated boundary survey and the access road that transect the adjacent lot will be rehabilitated in accordance with the Vegetation Management Plan developed by Cumberland Ecology.

Temporary internal roads will be built on an ad hoc basis based on filling profile and decommissioned as filling progresses. The location, maintenance and management of temporary roads will be included in the relevant stage filling plan (refer Section 2.1.8).

2.3.4 Public safety

Site access will be restricted during rehabilitation works for safety reasons. There will be no general public or pedestrian access to the site.

2.4 Incident and complaints protocols

2.4.1 Incident reporting

All personnel shall report all environmental incidents to the Project Manager and complete an environmental incident report form. The Proponent may use internal Health, Safety and Environment (HSE) incident management systems for recording, investigation, and close-out of incidents. Examples of environmental incidents include the following:

- Fuel, oil and/or chemical spills.
- Fire and/or explosions.
- Unearthing of historical or Indigenous cultural heritage.
- Major erosion and sediment control failure.

The Proponent shall be responsible for investigating environmental incidents and maintaining records of actions taken. Where applicable, environmental incidents shall be reported to the relevant Regulatory Authority by the Proponent, or in accordance with relevant contractual obligations.

2.4.2 Complaints

Complaints represent an opportunity for improvement or enhancement of project environmental performance. All project complaints, including those from members of the public, stakeholder groups and regulatory authorities, shall be recorded by the Proponent. The Proponent may use internal management systems for investigating and responding to complaints in a timely manner.

As a minimum, a standardised Environmental Complaint Record Form will be created as part of the detailed design development to record all complaints and will include the contact details and requirements to notify the relevant Regulatory Authority. The Project Manager shall be responsible for investigating and responding to complaints in a timely manner.

2.4.3 Non-conformance and preventative/corrective actions

Non-conformances managed by the Proponents CEMP shall include the following:

- An incident or near miss with potential or actual environmental impact.
- Complaints regarding project activities.
- Not meeting an objective or target or conformance testing criteria.
- Acceptance of non-conforming fill.
- Management review not being undertaken.

The Project Manager shall be responsible for identifying and implementing any preventative and/or corrective actions in response to any non-conformance. Preventative and correction actions shall be incorporated into the Proponents CEMP as required.

2.5 Traffic management

2.5.1 Vehicle movements

The traffic and truck haulage routes will be consistent with that presented in the EIS.

Table 2.6 Predicted peak hour traffic generation

Traffic Scenario	Light Vehicles (veh/h)		Heavy Vehicles (veh/h)		Total vehicles (veh/h)	
	Inbound	Outbound	Inbound	Outbound	Inbound	Outbound
Average Haulage	2	2	2	2	4	4
Worst Case Haulage	2	2	4	4	6	6

2.5.2 Adherence to Traffic Management Plan

A detailed Traffic Management Plan (TMP) will be prepared by the Proponent prior to site establishment. The TMP will include the following:

- Traffic control measures on the access road to allow single lane entry/exit procedures (such as traffic lights)
- Traffic control measures in works areas
- Restrictions on the delivery of heavy plant and materials to site during peak traffic periods
- Appropriate entry/exit points for proposed compound area(s)
- Advising motorists of the change in traffic conditions associated with the work.

The applicant is committed to develop a driver code of conduct as part of a Traffic Management Plan for the Project, to guide transport operations on all public roads including Sandham Road. This will include specific requirements such as limiting the speed limit to 40 km/hr for all trucks on Sandham Road and incorporate a haulage route complaint management system.

2.6 Site facilities

2.6.1 Equipment and fuel storage

Plant, equipment and fuel will be stored at the designated plant parking and refuelling area located on the eastern side on the site adjacent to a portable site office/amenities building. Appropriate bunding will be installed to manage any runoff from this area. A refuelling procedure will be prepared to manage potential spills and leaks.

2.6.2 Loading/unloading

Plant and equipment loading and unloading will occur at the designated loading area located near the on-site parking area. Sufficient area will be allowed for heavy vehicle to enter and exit in a forward motion.

2.7 Noise and vibration

A detailed Noise and Vibration Management Plan (NVMP) will be prepared by the Proponent prior to site establishment commencing. The NVMP will describe the methods that will be implemented for each work phase to minimise noise and vibration impacts and will identify any noise monitoring requirements as part of the works.

Environmental management measures identified in Section 3.1 will be implemented to comply with project noise trigger levels identified in the EIS (GHD 2018) (refer Table 2.7).

Table 2.7 Project noise trigger levels – residential noise receivers, dBa

Criteria LAeq(15min)	Residential receivers		
	Day	Evening	Night
Intrusiveness noise level	40	35	35
Project amenity noise level (rural)	48	43	38
Project noise trigger levels	40	35	35

Notes:

The Noise Policy for Industry (NPI) defines Day as 7 am to 6 pm Monday to Friday and 8 am to 1 pm Sunday and Public Holidays, Evening 6pm to 10 pm and Night as the remaining periods.

In accordance with the NPI, the minimum assumed Rating Background Level (RBL) during the daytime is 35 dBA and 30 dBA for the evening and night periods (measured background noise levels are lower than these RBLs) Noise from the site is to be measured at the most affected point within the residential boundary, or at the most affected point within 30 metres of the dwelling where the dwelling is more than 30 metres from the boundary, to determine compliance with the project noise trigger levels, except where otherwise specified below.

The Blue Mountains National Park area directly to the south and east of the site is classified as a passive recreation area with a recommended amenity noise level of L_{Aeq} 50 dB (when in use). However, the national park area to the south and east of the site is not easily accessible by the public.

2.8 Air quality

During site establishment and operation, daily monitoring of climate conditions will be undertaken to inform dust mitigation measures. Inspections will be carried out during emplacement activities to detect any visible dust plumes. Visual monitoring on Sandham Road will be undertaken to observe as visible plumes from heavy vehicles travelling towards sensitive receivers (R18 and R28). Dust suppression mitigation measures as described in Section 3.2 will be implemented to comply with EIS impact assessment criteria (GHD 2018) shown in Table 2.8.

Table 2.8 Air quality impact assessment criteria

	Averaging period	Concentration (µg/m^3)
Total suspended particulates	Annual	90
PM10	24 hours	50
	Annual	25
PM2.5	24 hours	25
	Annual	8
Dust deposition	Annual	2 g/m^2/month

2.9 Vegetation

Implementation of the Vegetation Management Plan (VMP), Supplementary Ecological Information (SEI) and Ecological Monitoring Plan (EcMP) (Cumberland Ecology, 2021) will be undertaken in accordance with their monitoring and reporting requirements.

3. Environmental management plan

Environmental mitigation, management measures and monitoring requirements that will be undertaken during site establishment and operation of the project are detailed in this section.

3.1 Noise and vibration

A NVMP will be developed in accordance with Table 3.1 below.

Table 3.1 Noise CEMP

Environmental aspect	**Noise**	
Objective	To minimise noise impacts to nearby receivers and preserve the noise amenity of the surrounding area	
Issue	Risk	Mitigation and management measures
Noise generated during rehabilitation works	– Excessive noise – Noise disturbance and impact to nearby residences	– A detailed NVMP will be prepared by the Proponent prior to site [The NVMP will describe the methods that will be implemented for each work phase to minimise noise and vibration impacts and track compliance against project specific trigger levels developed in accordance with relevant EPA Guidelines as outlines in the EIS. The following measures will be adopted in the plan – All activities on site should be confined between the hours: daytime hours of 7:00 am to 6:00 pm from Monday to Friday and 7:00 am to 1:00 pm on Saturday, with the exception of site preparation works between 6:00 am and 7:00 am Monday to Saturday. Haul trucks should not arrive on site (or depart) before 7:00 am. – Site preparation works should not occur between the hours of 6:00 pm and 6:00 am. – All personnel on site should be made aware of the potential for noise impacts and should aim to minimise impact or elevated noise levels, where possible. – Regular identification of noisy activities and adoption of improvement techniques. – Minimise the need for vehicle reversing. – All employees, contractors and sub-contractors will receive an environmental induction. – The following measures will be implemented to reduce noise at source: **Substitution:** • Where reasonably practicable, noisy plant will be replaced by less noisy alternatives **Modification of equipment:** • All engine covers will be kept closed while equipment is operating • Plant and vehicles will be kept properly serviced and fitted with appropriate mufflers and silencers, where applicable • The use of exhaust brakes will be eliminated, where practical • Where practical, plant operating on site will be fitted with broadband reversing alarms. • Acoustic enclosures will be provided for suitable equipment **Use and siting of plant** • Plant used intermittently will be throttled down or shut off • Regular and effective maintenance: • Regular inspection and maintenance of equipment to ensure it is in good working order and checking the condition of mufflers

Environmental aspect	Noise	
		• Ensure air lines on pneumatic equipment do not leak • All trucks entering and exiting the quarry should keep at or below 40 km/hr for haulage on Sandham Road. • Machines found to produce excessive noise compared to industry best practice should be removed from the site or stood down until repairs or modifications can be made. • Vehicles should be kept properly serviced and fitted with appropriate mufflers. The use of exhaust brakes should be eliminated, where practicable.

3.2 Air quality

Air quality will be managed in accordance with Table 3.2 below.

Table 3.2 Air Quality CEMP

Environmental aspect	Air quality	
Objective	To minimise air quality (dust) impacts to nearby receptors	
Issue	Risk	Mitigation and management measures
Dust generated during rehabilitation works	Dust impacts to nearby receptors	– Where appropriate, fill will be watered prior to it being loaded for on-site haulage, loads will be covered, and placed fill will be kept moist via irrigation/water trucks. – The size of stockpiles and storage piles will be minimised where possible. – Cleared areas will be monitored and dust suppression (watering, vegetation) will be used when adverse conditions prevail. – Cleared areas of land will be limited where practicable and only cleared when necessary to reduce fugitive dust emissions. – On-site traffic will be controlled by designating specific routes for haulage and access and limiting vehicle speeds to below 25 km/h. – All trucks hauling fill should be covered before entering the public road network and should maintain a reasonable amount of vertical space between the top of the load and top of the trailer. – Operations conducted in areas of low moisture content fill will be suspended during high wind speed events or contact water sprays will be used. – Rock saws will be equipped with in built wet control systems that reduce dust generation to negligible levels. These wet control systems will be used during all rock sawing activities. – Water will be applied to exposed surfaces that are causing dust generation. Surfaces may include unpaved roads, stockpiles, hardstand areas and other exposed surfaces (for example recently covered areas). – Vehicles must travel at appropriate speeds to limit dust generation. – Fill spillage on sealed roads should be cleaned up as soon as practicable. – These measures will assist in reducing impact on all areas off-site.
Dust generated during rehabilitation works impacting Sandham road	Dust impacts to nearby receptors	– Dust dispersion modelling identified haul trucks operating on unsealed surfaces are a significant source of dust. In order to control potential dust impacts from Sandham Road, and to meet the project criteria, Level 1 (2L/m2/hr) water spraying should be undertaken on Sandham Road whenever visible plumes of dust are observed to be blowing towards nearby receivers (specifically R18 and R28). This should be undertaken during daytime weather conditions that assist dust dispersion (dry and windy). – Traffic on Sandham road will be controlled by limiting vehicle speeds to below 40 km/h.

3.3 Water Resources

A site specific Water Management Plan will be developed consistent with the detailed management, monitoring requirements specified in the Revised Water Resources Assessment (GHD, 2021).

The conceptual details for developing this plan are predominantly based on the staging plans and to ensure that it is tailored for the site it will also be developed around the conditions of consent and the detailed design for the construction (including dewatering of the voids) and material emplacement works. Particular sections that apply from the Revised Water Resources Assessment (GHD, 2021) include sections 5.6, 5.7, 6.5.5, 6.5.6 and 6.5.7.

3.4 Biodiversity

A VMP, SEI and EcMP (Cumberland Ecology, 2021) has been developed for the project.

In addition to the requirements contained in the VMP, SEI and EcMP biodiversity at the site will be managed in accordance with Table 3.3 below.

Table 3.3 Biodiversity CEMP

Environmental aspect	Biodiversity	
Objective	To protect flora and fauna biodiversity surrounding and within the project site	
Issue	Risk	Mitigation and management measures
Clearing of vegetation	Removal of habitat resources and degradation of landscape Disruption and damage to natural habitats Pollution of land	– Disturbance of vegetation will be limited to the minimum necessary to construct the project. – Where the project area adjoins native vegetation, mark the limits of clearing and install temporary protective fencing around the vegetated area prior to site establishment to prevent vegetation and habitat removal. – All water quality risks associated with disturbance of vegetation is to be managed in accordance with the water management strategy of the Revised Water Resources Assessment. – Erosion and sediment control measures will be established prior to site establishment. – Erosion and sediment control measures will be regularly inspected, particularly following rainfall events, to ensure their ongoing functionality. – Stabilised surfaces will be reinstated as quickly as practicable after works per the proposed staging plan. – All stockpiled material should be stored in sediment fenced areas and kept away from waterways to avoid sediment entering the waterway. – Stockpiles of fill or vegetation should be placed within existing cleared areas (and not within areas of adjoining native vegetation). – Measures to suppress dust would be put in place during site establishment and operation. – Vehicles must be appropriately washed prior to work on site to prevent the potential spread of Cinnamon Fungus (Phytophthora cinnamomi) and Myrtle Rust (Pucciniales fungi) in accordance with the national best practice guidelines for Phytophthora (DEH, 2006) and the Myrtle Rust factsheet (DPI 2011) for hygiene control.
Impacts on flora and fauna	Further endanger threated flora and fauna Loss of native species Degrade water quality and thus endanger aquatic habitats	– All workers will be provided with an environmental induction prior to starting work in the project area. This will include information on the ecological values of the study area, protection measures to be implemented to protect biodiversity and penalties for breaches. – A Flora and Fauna Management Plan will be prepared for the project, incorporating recommendations below, and expanding where necessary. – Equipment storage and stockpiling of resources will be limited to designated areas. – A trained ecologist will be present during the clearing of native vegetation or removal of potential fauna habitat to avoid impacts on resident fauna and to salvage habitat resources as far as is practicable. Clearing surveys should include:

Environmental aspect	Biodiversity	
		• Any hollow-bearing trees to be felled should be marked prior to clearing of vegetation. The removal of hollow bearing trees is to be undertaken in accordance with a hollow-bearing tree management protocol and would include the presence of a qualified ecologist or wildlife expert experienced in the rescue of fauna. • Habitat features (fallen logs and tree hollows) removed from site would be salvaged and relocated within adjacent areas of vegetation. • Inspections of native vegetation for resident fauna and/or nests or other signs of fauna occupancy. – Deferral of vegetation removal and associated activity in areas occupied by more mobile threatened fauna until the fauna has vacated the Project footprint. – Water should be applied to exposed surfaces that are causing dust generation. Surfaces may include unpaved roads, stockpiles, hardstand areas and other exposed surfaces (for example recently graded areas). – Vehicles must follow appropriate speeds to limit dust generation. – Spill kits would be made available to site vehicles. A management protocol for accidental spills would be put in place.
Introduction of foreign species	Foreign species (weeds) impact existing biodiversity	– Weed management actions were developed (as part of the EcMP) to manage weeds during the site establishment and operations phase of the project. This included the management and disposal of the weeds that were recorded within the project area including the priority weeds listed in section 11.2.2 of the EIS (GHD, 2019) in accordance with the Biosecurity Act. – Vehicles and other equipment to be used within the impact area will be cleaned to minimise seeds and plant material entering the site to prevent the introduction of further exotic plant species or disease. – Protocols to prevent introduction or spread of chytrid fungus will be implemented (as part of the EcMP following OEH Hygiene protocol for the control of disease in frogs (NSW Department of Environment and Climate Change, 2008). – No fill is to be imported from areas known to contain Phytophthora, Myrtle Rust or Chytrid fungus – Samples of fill from each source location will be tested for pathogens at the point of origin, [and results received prior to transporting to Bell Quarry. In the event that a positive result is returned, the fill will not be imported to the site – A baseline study of pathogens at the site should be conducted and an ongoing monitoring and review program established. – Incorporate control measures in the design of the Project to limit the spread of weed propagules downstream of study area. Wheel washes, cattle grates and sediment control devices, such as silt fences, will be included to assist in reducing the potential for spreading weeds. – Exposed soil should be sown with native seed immediately to prevent colonisation by weeds. – Locally endemic species typical for the area should be used for rehabilitation. – Ongoing management of priority weeds according to legislative requirements. – Ongoing management of environmental weeds according to best practice methods. – Monitoring of rehabilitation outcomes.

3.5 Traffic and transport

A Traffic Management Plan will be prepared by the Proponent in accordance with Table 3.4 below.

Table 3.4 Traffic and transport CEMP

Environmental aspect	Traffic and transport	
Objective	To manage traffic to protect site worker and road user safety	
Issue	Risk	Mitigation and management measures
Additional vehicle movements	Project leads to overcrowding local roadways and disruption to local road users Unsafe traffic conditions	Contribution through a Voluntary Planning Agreement to fund road upgrade works as outlined in Attachment 1 of the Traffic Statement prepared by Stantec (2021) that includes widening of Sandham Road near Old Bells Line of Road by around 2 metres to allow for effective sealed road width of 7 metres. A detailed Traffic Management Plan (TMP) will be prepared by the Proponent and approved by prior to site establishment. The TMP will include the following: – Traffic control measures in works areas. – Restrictions on the delivery of heavy plant and materials to site during peak traffic periods. – Appropriate entry/exit points for the proposed compound area(s). – Advising residents and motorists of the change in traffic conditions associated with the work. – Only existing roads and access roads will be utilised. – All traffic control devices will be in accordance with AS 1742.3-2009 – Manual of uniform traffic control devices: traffic control for works on roads and Roads and Maritime Traffic control at worksites manual. – A maximum of 37 heavy vehicles per day (74 movements to and from site) will be permitted to haul fill to the site. – Minor pruning of trees along the northern side of Bells Line of Road
Interaction between vehicles and public	Risk to pedestrians	– Appropriate exclusion barriers, signage and site supervision to ensure that the site is controlled and that unauthorised vehicles and pedestrians are excluded from the works area. – The community will be kept informed about the project through advertisements in the local media, notices and/or signs. – A heavy vehicle speed limit of 40 km/hour will be adopted for all trucks utilising Sandham Road. – Heavy vehicles will have a maximum capacity of 42.5 tonnes. – All trucks hauling fill should be covered before entering the public road network and should maintain a reasonable amount of vertical space between the top of the load and top of the trailer.

3.6 Land resources and contamination

Land resources and contamination will be managed as per Table 3.5 below.

Table 3.5 Land resources and contamination

Environmental aspect	Land resources and contamination	
Objective	To minimise the effects of erosion and spread of contamination	
Issue	Risk	Mitigation and management measures
Erosion control	Excessive erosion	Soil and Water Management Plan which includes erosion and sediment control plans (as discussed in Section 10.4 of the EIS (GHD, 2018) will be prepared by the Proponent prior to commencing work. This plan will be developed for each stage of the works and address the principles for water management detailed in the Revised Water Resources Assessment (GHD 2021). To ensure that it is tailored for the site it will also be developed around the conditions of consent and the detailed design for the construction (including dewatering of the voids) and material emplacement works. Relevant sections from the Revised Water Resources Assessment (GHD 2021) include sections 5.3. 5.6 and 5.7.
Contamination control	Spread of contamination and hazardous materials Impact to the environment from contamination Exposure of site personnel to hazardous material	Procedures to manage potential contaminants of concern and/or hazardous materials to be used during the project will be developed Potentially contaminated areas directly affected by the project will be managed in accordance with the requirements of the *Contaminated Lands Management Act* (NSW Government, 2020a) and *Contaminated Land Guidelines: Consultants reporting on contaminated land* (NSW EPA, 2020).
Contamination control	Acceptance of non-conforming fill	Incoming fill audits will be undertaken for every 50,000 tonnes of fill placed at the site. The audit will include review of: – VENM/ENM certification records. – Visual inspection of incoming fill. – Representative sampling, testing and recording of import material per the requirements of the *excavated natural material order and exemption 2014* (NSW EPA, 2014b). – Following the requirements of any specific resource recovery order and exemption sought and issued by the EPA for material that may be received at the site.
Vehicle refuelling	Fuel spills and leaks contaminate land	A refuelling procedure would be developed by the Proponent. This would include procedures to address spills and leaks from refuelling.

3.7 Waste management

A Waste Management Plan will be prepared by the Proponent in accordance with Table 3.6 below.

Table 3.6 Waste management CEMP

Environmental aspect	Waste management	
Objective	To manage waste generated on site	
Issue	Risk	Mitigation and management measures
Waste generation, handling, recovery, storage and disposal	Production of unnecessary waste Inappropriate disposal of site generated waste	A Waste Management Plan will be prepared by the Proponent and included as part of the project. The plan will include procedures for the management of wastes in accordance with relevant NSW legislation and the principles of the waste management hierarchy set out in the NSW Waste Avoidance and Resource Recovery Strategy 2014-21 (EPA 2014a). The plan will be developed in accordance with: – The NSW EPA (2014c) 'Waste Classification Guidelines' – Relevant regulatory requirements of the *Waste Avoidance and Resource Recovery Act 2001* (NSW Government, 2001). – Relevant regulatory requirements of the *Protection of the Environment Operations Act 1997* (NSW Government, 2021d). – NSW EPA Environmental Guidelines – Solid waste landfills (Second edition, 2016) (NSW EPA, 2016). Cleared vegetation will be shredded and mulched and used for soil manufacture or reused on site where practicable. Care will be taken to ensure any onsite reuse would not spread weeds. General waste from site personnel will be temporarily stored in mobile skip bins or wheelie bins on the site before being collected for offsite recycling or disposal. Recyclable waste such as containers, paper and cardboard etc would be collected separately to facilitate offsite recycling. Wastewater and sewage from site offices/amenities will be appropriately stored and regularly transported off site for disposal at a licensed facility. Concentrated brine, developed as a by-product of the Plant, will be managed in accordance with Section 2.2.6. It will be stabilised prior to on-site disposal by mixing with fill material. The brine will be disposed of within the quarry void via the trench and fill method.
Beneficial reuse of waste	Non compliance with VENM/ENM acceptance criteria or other relevant resource recovery orders/exemptions that applies to the site	– At the time the fill (VENM) is received at the premises, it must be classified as VENM (for guidance see Virgin excavated natural material (nsw.gov.au)). ENM must meet all the chemical and other material requirements (via stringent sampling and testing) for excavated natural material which are required before the supply of fill under 'the excavated natural material order 2014'. – Any comparable material will be required to obtain a specific resource recovery order and exemption from the EPA by demonstrating that it poses minimal risk of harm to the environment or human health and address any other criteria stipulated by the EPA. The comparable material would need to meet the specific resource recover order before being transported to the site. – The consumer (Bell Quarry Rehabilitation Pty Ltd) must keep a written record of the following for a period of six years: • The quantity of any excavated natural material received; and • The name and address of the supplier of the excavated natural material received. – The consumer must make any records required to be kept under this exemption available to authorised officers of the EPA on request.

Environmental aspect	Waste management	
		– The consumer must ensure that any application of excavated natural material to land must occur within a reasonable period of time after its receipt. – Written records will be maintained in accordance with the requirements of the ENM exemption and applied as fill within the existing quarry voids. – All testing of samples will be undertaken by analytical laboratories accredited by the National Association of Testing Authorities (NATA) or equivalent and undertaken in accordance with the test methods in the ENM order. – The generator of ENM must keep a written record of the following for a period of six years: • The sampling plan required to be prepared under clause 4.1.1 • All characterisation sampling results in relation to the excavated natural material supplied • The volume of detected hotspot material and the location • The quantity of the excavated natural material supplied • The name and address of each person to whom the generator supplied the excavated natural material – Fill will be transferred to site at a maximum rate of 140,000 tpa, using truck and trailer combinations of up to 42.5 tonne capacity. Haulage vehicles will enter the site and place material directly within the active rehabilitation cell for each stage of the development.

3.8 Visual

Visual impacts will be managed as per Table 3.7 below.

Table 3.7 Visual CEMP

Environmental aspect	Visual	
Objective	To preserve the visual amenity of the site during site establishment and operations	
Issue	Risk	Mitigation and management measures
Rehabilitation activities including land clearing and reshaping	Changes to landscape character within the proposed works areas Damage to visual amenity of the site	– Earthwork activities will be limited to standard hours. – Screening vegetation will be maintained where practicable. – Community updates and newsletters will be provided to nearby properties. – Revegetation will be undertaken consistent with the objectives of the VMP and SEI as soon as practical after earthworks have been completed. – Maintenance of visual buffers currently in place around pit boundaries. – Revegetation with plant species representative of native vegetation in the local area to integrate with the surrounding landscape so that the site becomes sympathetic with the adjoining Blue Mountains National Park.

3.9 Bushfire management

Bushfires will be managed as per Table 3.8 below.

Table 3.8 ***Bushfire management CEMP***

Environmental aspect	Visual	
Objective	To manage the risk of bushfire at the site	
Issue	Risk	Mitigation and management measures
Naturally occurring bushfires	Risks to onsite workers	– From the commencement of rehabilitation until completion of the project, the administration building shall incorporate a 20m APZ, including an Inner Protection Area and Outer Protection Area, in accordance with the dimensions identified in Table A2.5 in Appendix 2 of PBP, and the NSW RFS document 'Standards for asset protection zones'. – The IPA should provide a tree canopy cover of less than 15% and should be located greater than 2 m from any part of the roofline of a dwelling. Garden beds of shrubs are not to be located under trees and should be no closer than 10 m from an exposed window of door. Trees should have lower limbs removed up to a height of 2 metres above ground. – An OPA should provide a tree canopy cover of less than 30% and should have understorey managed (mowed) to treat all shrubs and grasses on an annual basis in advance of the fire season (usually September). – For the administration building, a dedicated firefighting water supply must be: • Provided at 10,000 litre capacity. • Located within the IPA (but away from the structure). • Fitted with a 65mm Storz outlet (and gate or ball valve fitted). • Manufactured of concrete or metal (for above ground tanks), with shielding where located on the hazard side of the building. • With associated external piping and taps made of metal. – Where located, underground tanks must have an access hole of 200 mm to allow tankers to direct fill from the tank, and a hardened ground surface for truck access within four metres of the hole. – Electricity will be supplied via underground or overhead power lines with 30 m pole spacing and in accordance with Energy Australia specifications (NS179, 2002) (Ausgrid, 2020) and maintained according to National distribution network standards. – Bottle gas supplies, where installed, will be in accordance with AS/NZS 1596 (2014). – An emergency evacuation plan is to be prepared as a condition of consent to cover the site establishment and operation of the site. – The National Construction Code does not provide for any bush fire specific performance requirements for Class 5 to 8 buildings and therefore they do not apply to the development.

4. Closure

4.1 Final capping

Final capping will be installed progressively on areas as they reach final surface levels as outlined in Table 2.1. The final cap will be a minimum of 600 mm thick and comprise a suitable thickness of site won material. The material will be sourced from on site where possible or imported from local sources to have a similar geochemistry to the surrounding landscape.

The final landform is to be revegetated in accordance with the requirements of the SEI (Cumberland, 2021). The final landform will have a typical slope of 9-25% to facilitate runoff of surface water and prevent ponding of water over the surface of the final cap.

4.2 Progressive Closure Plan

The concept design provides for progressive closure of the site during operation as fill reaches the final design height. A Progressive Closure Plan (PCP) will be developed as part of detailed design and will detail the steps to be taken to progressively close and stabilise the final landform. The PCP will address:

- the materials to be used and the construction quality assurance plan for the final capping,
- the requirements and timeframe for ongoing closure management and monitoring measures.
- the requirements and timeframe for post-closure management, maintenance, and monitoring measures (refer Section 4.2.4).
- be consistent with all applicable conditions of the development consent or other planning approvals that apply to the premises.

4.2.1 Environmental management

Ongoing management of the rehabilitated areas will be undertaken by the proponent following establishment of the final capping. This would consist primarily of ongoing monitoring and maintenance should it be required.

The proponent will ensure that all stormwater controls and reporting practices are maintained at the same level employed during the operational phase. These environmental management measures will continue until the proponent can demonstrate that the site does not pose a threat to the environment.

The proponent will ensure that fill is not received for disposal at the site after operations cease. Any materials that are intended for use in the rehabilitation will be documented and reported.

4.2.2 Environmental monitoring

The Proponent will review the operational monitoring programs and reporting practices as used throughout the operation of the site. Based on this review, the Proponent will implement a modified monitoring program.

Monitoring will continue until the Proponent is able to demonstrate that the fill no longer has the potential to negatively impact on the environment. The proponent will ensure that all neighbouring residents are advised of contact persons to report any problems. Any complaints that are received will be recorded in the complaints register.

4.2.3 Maintenance

The Proponent will undertake regular maintenance of the final rehabilitated surface to maintain its integrity. This will include the following:

- Monitoring of surface water drains, and undertaking repairs as required.
- Filling of any cracks or slippages that may occur in the rehabilitated surface.
- Filling of depressions created by settlement of the fill (to ensure shedding of surface water runoff).
- Replacement of vegetation, if necessary, to maintain the denseness of the vegetation cover.

- Repairing erosion scours.

The above activities will continue until the fill has stabilised.

4.2.4 Post closure management, maintenance, and monitoring

Prior to final closure of the site the PCP will be reviewed and a Post Closure Management and Monitoring Plan (PCMMP) will be developed. The PCMMP will address site specific conditions and environmental performance at the time of closure. The PCMMP will include environmental management, monitoring and maintenance measures required during the post closure period including:

- Visual inspections for cap integrity
- Sampling and testing of surface water
- Sampling and testing of groundwater
- Sampling and testing of leachate
- Visual inspections of established vegetation and management of priority weeds

The frequency and duration of post closure monitoring and maintenance will be subject to the observed trends in monitoring data.

5. Implementing the EMP

5.1 Roles and responsibilities

The roles and responsibilities of the following key participants in the Project are outlined below:

- The Proponent.
- Project Manager.
- Environmental manager.
- Site personnel.

Table 5.1 Roles and responsibilities

Title	Role
The Proponent	– Develop a detailed EMP that is consistent with, and no less stringent than, the intended outcomes identified in this outline EMP. – Carry out rehabilitation works in accordance with the requirements of the EMP. – Review the EMP periodically during rehabilitation works and update as necessary. – Make all staff aware of the requirements of the EMP and provide the required Health, Safety and Environmental training to enable staff to safely undertake their work activities and ensure environmental impacts are managed. – Ensure staff comply with all relevant environmental guidelines. – Keep a register of all environmental accidents, incidents, non-conformances and complaints. – Carry out environmental audits, inspections and monitoring to verify compliance with the EMP. – Undertake complaint investigations and report complaint investigation findings to the Relevant Authority. – Correct all non-conformances to the satisfaction of Council in the timeframe specified by the Relevant Authority. – Report on the implementation and effectiveness of corrective actions specified by the Relevant Authority or implemented to ensure correction of non-compliances. – Provide monitoring and reporting to the Relevant Authority on all activities on site as required in the EMP. – Communicate project need and objectives with the public and residents. Notify the public in advance of any activities likely to impact their amenity (e.g., high noise generating works that are likely to exceed noise criteria).
Project Manager	A Project Manager will be appointed to oversee all operational requirements and adherence to conditions. The Project Manager will be responsible for incident and complaint management, and remedial actions.
Environmental Manager	The Environmental Manager is responsible for overseeing the environmental management of the project and supervision of environmental services. The Environmental manager has the authority to stop work if an adverse impact on the environment has occurred or is likely to occur. The Environmental Manager will: – Be responsible for the presentation or certification of all EMP's and procedures – Be responsible for considering and advising on matters specified in the conditions of consent and compliance with such matters – Oversee the receipt and response to complaints about the environmental performance of the project – Facilitate an introduction and environmental compliance training program for all persons involved with construction, filling and rehabilitation activities – Be in charge of establishment and management of environmental monitoring, wet weather monitoring and ad-hoc sampling as required and interpretation and management of monitoring data
All site personnel	All site personnel including subcontractors are responsible for day to day implementation of environmental controls and visual monitoring as required and adherence to this EMP.

5.2 Training

All personnel working on the site, including sub-contractors, shall be competent to conduct their work without harm to people, environment or assets. Personnel will complete all necessary site training and induction requirements before commencing work on site.

The Proponent will be responsible for the maintenance and currency of all training material and training registers, encompassing records of all employees' qualifications (and training if occurring both on and off site). Each employee will have copies of certificates of prior training retained on their personal / training file. All training will be supported by the use of attendance records to assist with auditing purposes.

The principal EMP training & awareness methods include, but not limited to:

- Induction protocols
- Daily Pre-Start Meetings
- Toolbox talks.

These methods are described in more detail in the following sections. Other EMP training & awareness methods may include:

- Daily Co-Ordination Simultaneous Operations (SIMOPs) Meetings
- Notice Board bulletins
- Safety Alerts
- Safety Observations
- Weekly Project Meetings.

5.2.1 Induction protocols

All employees, contractors and sub-contractors will receive a site-specific environmental induction prior to commencing any work on site. The induction will include:

- All relevant project specific and standard noise and vibration mitigation measures
- Relevant licence and approval conditions.
- Permissible hours of work.
- Any limitations on high noise generating activities.
- Location of nearest sensitive receivers.
- Employee parking areas.
- Designated loading/ unloading areas and procedures.
- Designated traffic routes.
- Driver code of conduct.
- Site opening/closing times (including deliveries).
- Environmental incident procedures.
- Unexpected find protocols.
- Ecological values of the study area, protection measures to be implemented to protect biodiversity and penalties for breaches.

5.2.2 Toolbox talks

Toolbox meetings will be undertaken weekly and used as a forum for the project team to raise specific health, safety and environmental (HSE) concerns or issues and will also be used to present weekly toolbox topics. Toolbox meetings are used to:

- Obtain feedback on safety performance from the workforce, including subcontractors
- Provide feedback regarding HSE performance and matters
- Communicate the results of HSE activities

Extraordinary special Toolbox meetings may follow an incident. These meetings will report on the findings and ensure any risks associated are understood and the necessary precautionary measures have been identified for each task to be conducted.

Participants in toolbox talks will sign the attendance sheet. The attendance sheet will be filed by the Project Manager.

5.2.3 Pre-start meetings

Pre-start meetings will be undertaken every morning in the site office and will address:

- Overview of the work to be performed during the shift
- Review of the Safe Work Method Statement for the task
- Highlight any new hazards
- Health and Safety Issues from the previous day
- Interfaces with other work.
- Work restrictions –time or place.
- Emergency planning or provisions.

A pre-start risk assessment will be undertaken as part of pre-start meetings, as described below.

Pre-start site risk assessment

The pre-start risk assessment is designed to ensure time is taken prior to the start of an activity to review the work-specific environmental aspects and impacts.

The work crew must be included in the process to ensure critical environmental information is communicated and also use their knowledge to identify any additional aspects.

The pre-start risk assessment must be conducted on a daily basis at the start of work and repeated when there is a change in work scope or conditions. The process aims to:

- Communicate site requirements and HSE controls (for example, permits, plans/studies and drawings).
- Identify job site specific aspects not captured and managed in the risk register.
- This meeting itemises the work that will be undertaken during the day, and where applicable, the following environmental related components:
  - Weather observations/forecast.
  - Work area restrictions, activities that may affect the works.
  - Environmental focus for the day (for example, housekeeping/litter clean-up, water management, dust control).
  - Feedback on environmental issues that have recently occurred within the area.
  - Notices about up-and-coming events such as environment and community meetings, audits, environmental inspections.
  - Feedback on previous day's work practices.
  - Feedback from environment, community and stakeholder meetings.

All personnel undertaking work within the project team will sign onto the pre-start attendance record form.

5.3 Inspections and audits

Environmental inspections will be undertaken by the Environmental Manager and Project Manager, in accordance with the program outlined in Table 5.2. The inspections assist to identify areas where improvements to the environmental performance of Bell Quarry operations can be achieved.

Table 5.2 Environmental Inspection Program

Potential Impact	Locations	Frequency	Reporting	Responsibility
General environmental impacts	Potential impacts listed in environmental plans and the environmental risk assessment	Daily	Site inspection report	– Proponent – Project manager
		Weekly	Weekly environmental inspection checklist and monthly report	– Proponent – Environmental manager
Overflow of contact water	Eastern void water storage	After a significant rainfall event (e.g., >10mm in 24 hours)	Inspect current volume in void and initiate treatment protocol if required (refer revised WRA) Include outcomes of each inspection in site inspection report	– Proponent – Environmental manager
Discharge of sediment laden water	All sediment laden water management basins	After a significant rainfall event (e.g., >10mm in 24 hours)	Treat to required environmental standard and discharge if appropriate (refer Revised WRA)	– Proponent – Environmental Manager
Air, noise, and water	Various	As specified in plans	Weekly environmental inspection checklist and periodic monitoring reports	– Proponent – Environmental manager

Six monthly audits will be undertaken by the Environmental manager in accordance with the AS/NZ ISO 19011:2003 - Guidelines for Quality and/or Environmental Management Systems Auditing. The audits will incorporate procedures for rectifying any non-compliance issues and will provide mechanisms for recording environmental incidents and the subsequent actions taken.

6. References

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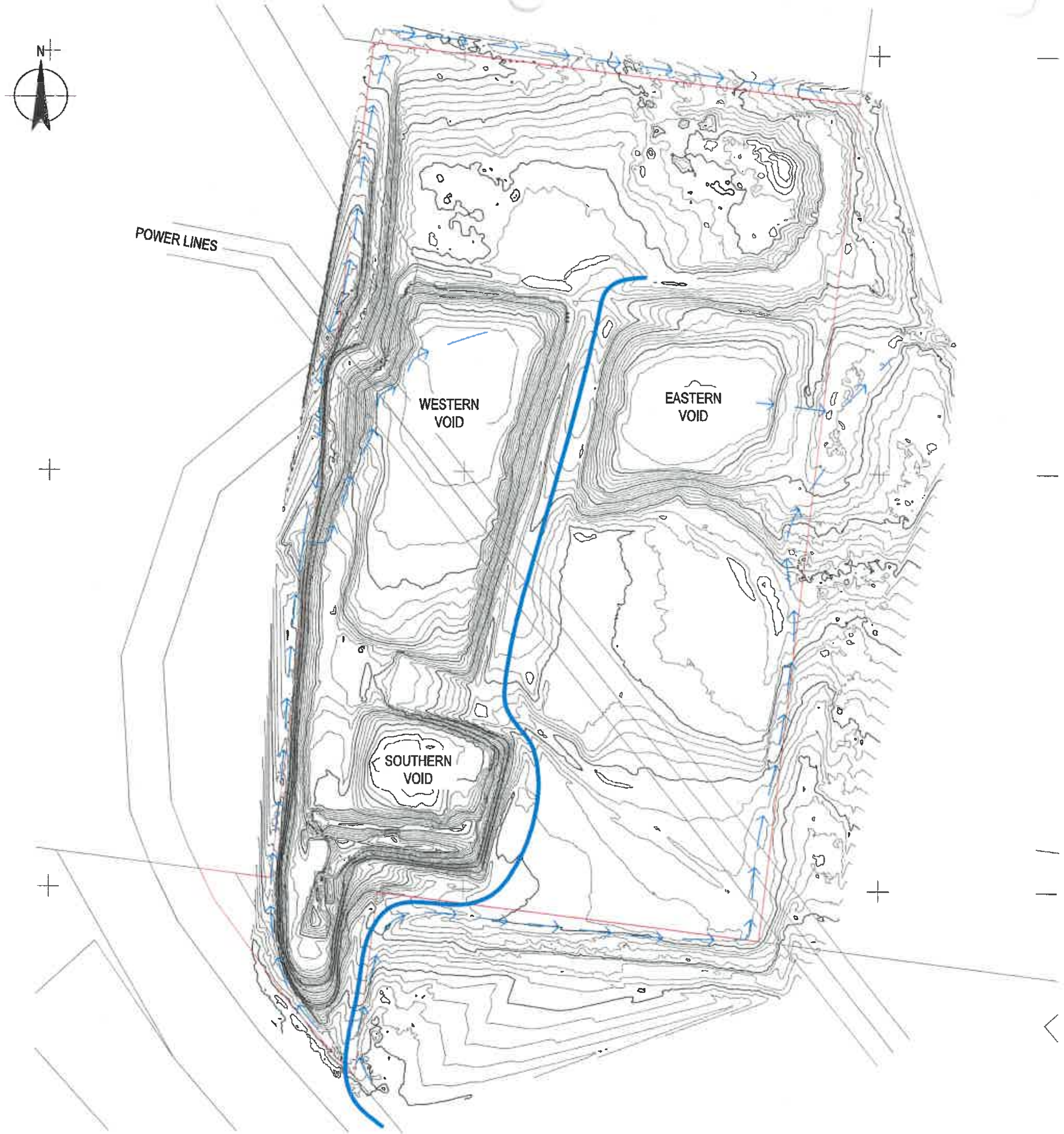
Appendices

Appendix A

Staging Plans



LEGEND

—	EXISTING SURFACE
—	DESIGN CONTOURS
→ —	CLEAN WATER FLOW
→ —	SEDIMENT LADEN FLOW
→ —	CONTACT WATER (PIPE)
→ —	TREATMENT WATER (PIPE)
🟩	REHABILITATED AREA
▭	INTERMEDIATE COVER AREA
🟥	ACTIVE FILLING AREA
▨	AMENITIES AREA
—	ACCESS ROAD

0 20 40 60m
SCALE 1:2000 AT ORIGINAL SIZE

PRELIMINARY

rev	description	app'd	date
C	UPDATED		05.11.21
B	INCL. EXCAVATION WORKS		03.11.21

BELL QUARRY REHABILITATION PROJECT
STAGING PLANS
EXISTING SITE LAYOUT

Level 15, 133 Castlereagh Street, Sydney NSW 2000 Australia
T 61 2 9239 7100 F 61 2 9239 7199
E sydmail@ghd.com W www.ghd.com

scale 1:2000 for A3
date NOV 2021
job no. 12541317
rev no. C

approved (PD) SK001

Date: 15 November 2021 - 11:45 AM Plotted by: Alison Horlyck

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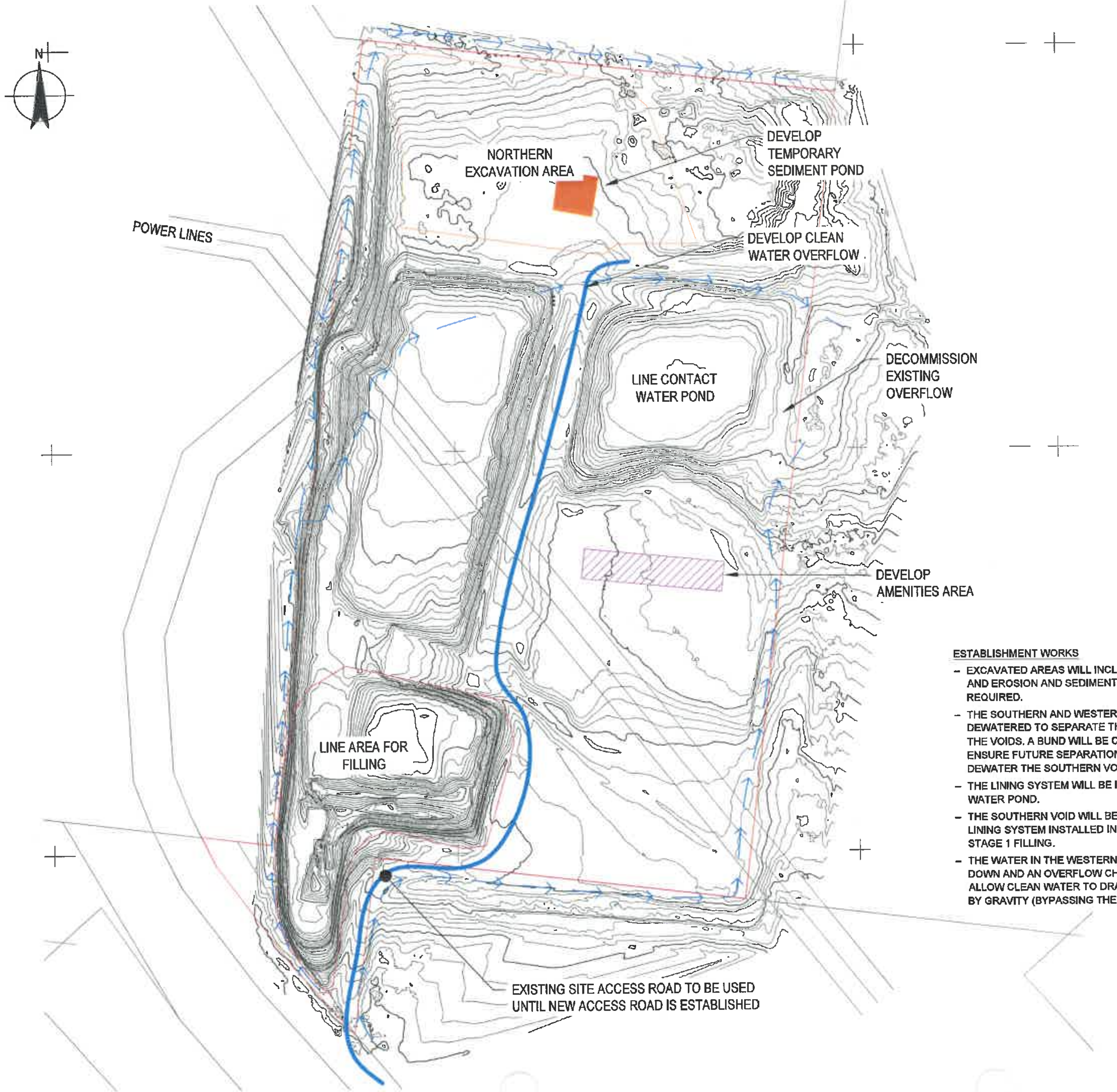

LEGEND

- EXISTING SURFACE
- DESIGN CONTOURS
- → — CLEAN WATER FLOW
- → — SEDIMENT LADEN FLOW
- → — CONTACT WATER (PIPE)
- → — TREATMENT WATER (PIPE)
- 🟩 REHABILITATED AREA
- ▭ INTERMEDIATE COVER AREA
- 🟥 ACTIVE FILLING AREA
- ▨ AMENITIES AREA
- ━ ACCESS ROAD

0 20 40 60m
SCALE 1:2000 AT ORIGINAL SIZE

ESTABLISHMENT WORKS

- EXCAVATED AREAS WILL INCLUDE SEDIMENT PONDS AND EROSION AND SEDIMENT CONTROLS, AS REQUIRED.
- THE SOUTHERN AND WESTERN VOIDS WILL BE DEWATERED TO SEPARATE THE WATER BETWEEN THE VOIDS. A BUND WILL BE CREATED, IF NEEDED, TO ENSURE FUTURE SEPARATION AND COMPLETELY DEWATER THE SOUTHERN VOID.
- THE LINING SYSTEM WILL BE INSTALLED IN CONTACT WATER POND.
- THE SOUTHERN VOID WILL BE DEWATERED AND A LINING SYSTEM INSTALLED IN PREPARATION FOR STAGE 1 FILLING.
- THE WATER IN THE WESTERN VOID WILL BE DRAWN DOWN AND AN OVERFLOW CHANNEL INSTALLED TO ALLOW CLEAN WATER TO DRAIN DIRECTLY OFFSITE BY GRAVITY (BYPASSING THE EASTERN VOID).

PRELIMINARY

rev	description	app'd	date
D	UPDATED		15.11.21
C	UPDATED		05.11.21

BELL QUARRY REHABILITATION PROJECT
STAGING PLANS
ESTABLISHMENT WORKS

GHD
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scale | 1:2000 for A3 job no. | 12541317
date | NOV 2021 rev no. | D

approved (PD) . SK002

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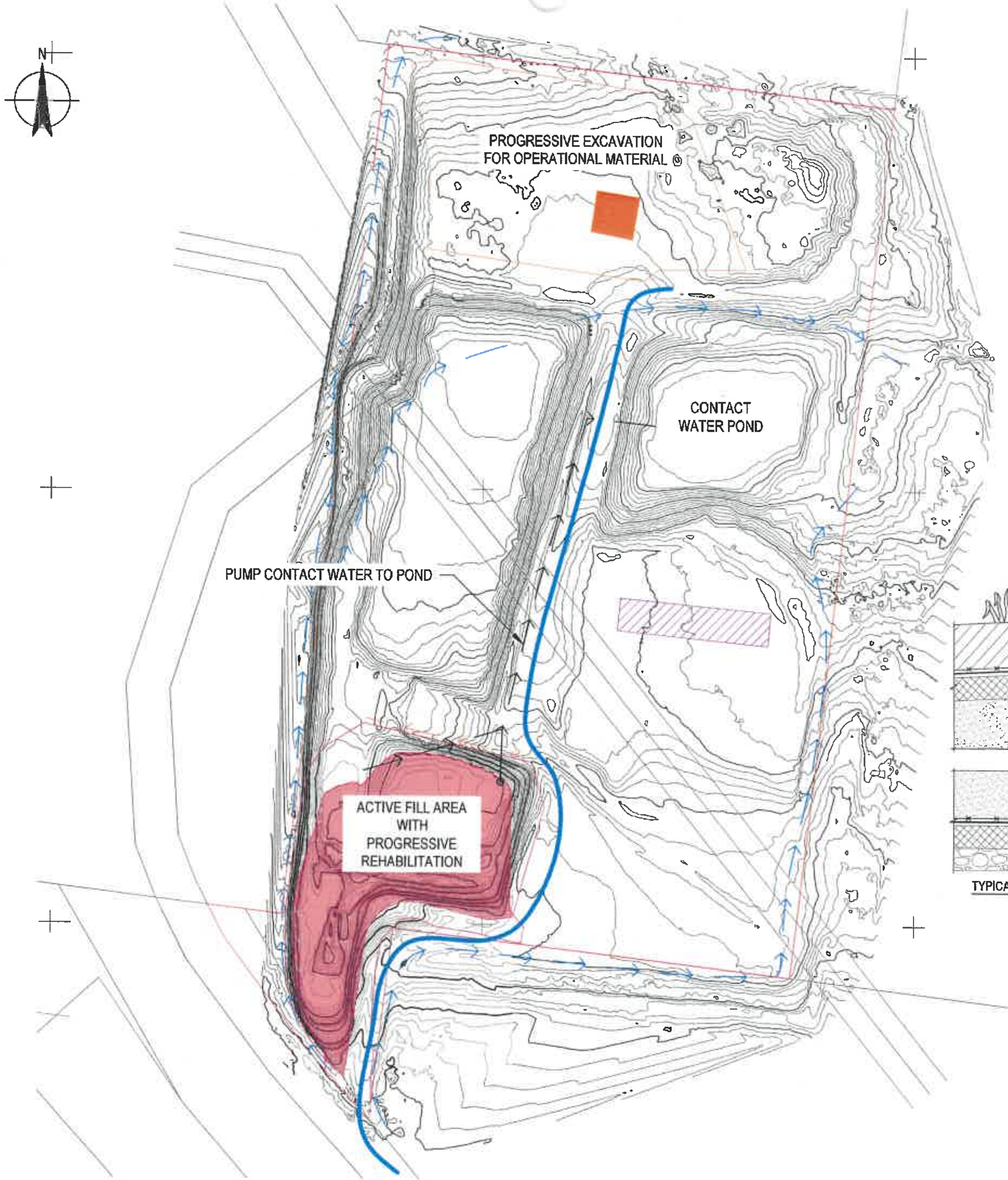
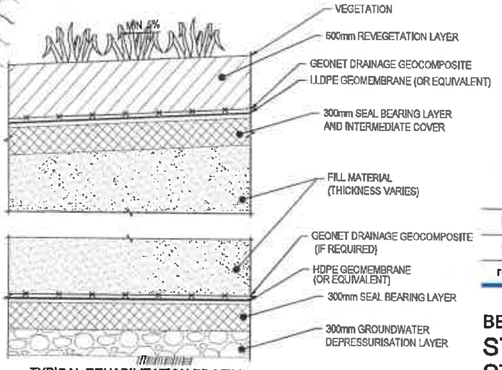


LEGEND

═	EXISTING SURFACE
═	DESIGN CONTOURS
→ —	CLEAN WATER FLOW
→ —	SEDIMENT LADEN FLOW
→ —	CONTACT WATER (PIPE)
→ —	TREATMENT WATER (PIPE)
🟩	REHABILITATED AREA
▭	INTERMEDIATE COVER AREA
🟥	ACTIVE FILLING AREA
▨	AMENITIES AREA
—	ACCESS ROAD

0 20 40 60m
SCALE 1:2000 AT ORIGINAL SIZE



TYPICAL REHABILITATION PROFILE

NTS

STAGE 1A WORKS

- PRIORITISE FILLING TO CREATE ACCESS ROAD WITHIN STAGE 1 FOOTPRINT
- PROGRESSIVE EXCAVATION IN NORTHERN EXCAVATION AREA TO SUPPORT PROGRESSIVE PLACEMENT OF INTERMEDIATE COVER AND FINAL CAPPING
- CONTACT WATER WILL BE COLLECTED AND PUMPED TO THE CONTACT WATER POND FOR STORAGE AND DISPOSAL.
- WHERE FILLING IS BEING UNDERTAKEN ABOVE SURROUNDING GROUND LEVEL, A SOIL BUND WILL BE CONSTRUCTED AT THE PERIMETER OF THE ACTIVE FILL AREA TO PREVENT RUN OFF AND A LOW POINT CREATED TO COLLECT CONTACT WATER.
- INTERMEDIATE CAPPING WILL BE INSTALLED PROGRESSIVELY ON THE NORTHERN INTERMEDIATE BATTER.
- SEDIMENT LADEN WATER WILL BE DIRECTED FROM THE INTERMEDIATE CAP AREAS TO THE TEMPORARY POND (DEVELOPED IN PRELIMINARY WORKS) FOR SETTLEMENT BEFORE DISCHARGE.

PRELIMINARY

rev	description	app'd	date
D	REVISED		15.11.21
C	REVISED		05.11.21

BELL QUARRY REHABILITATION PROJECT
STAGING PLANS
STAGE 1A

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scale | 1:2000 for A3 job no. | 12541317
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SK003A

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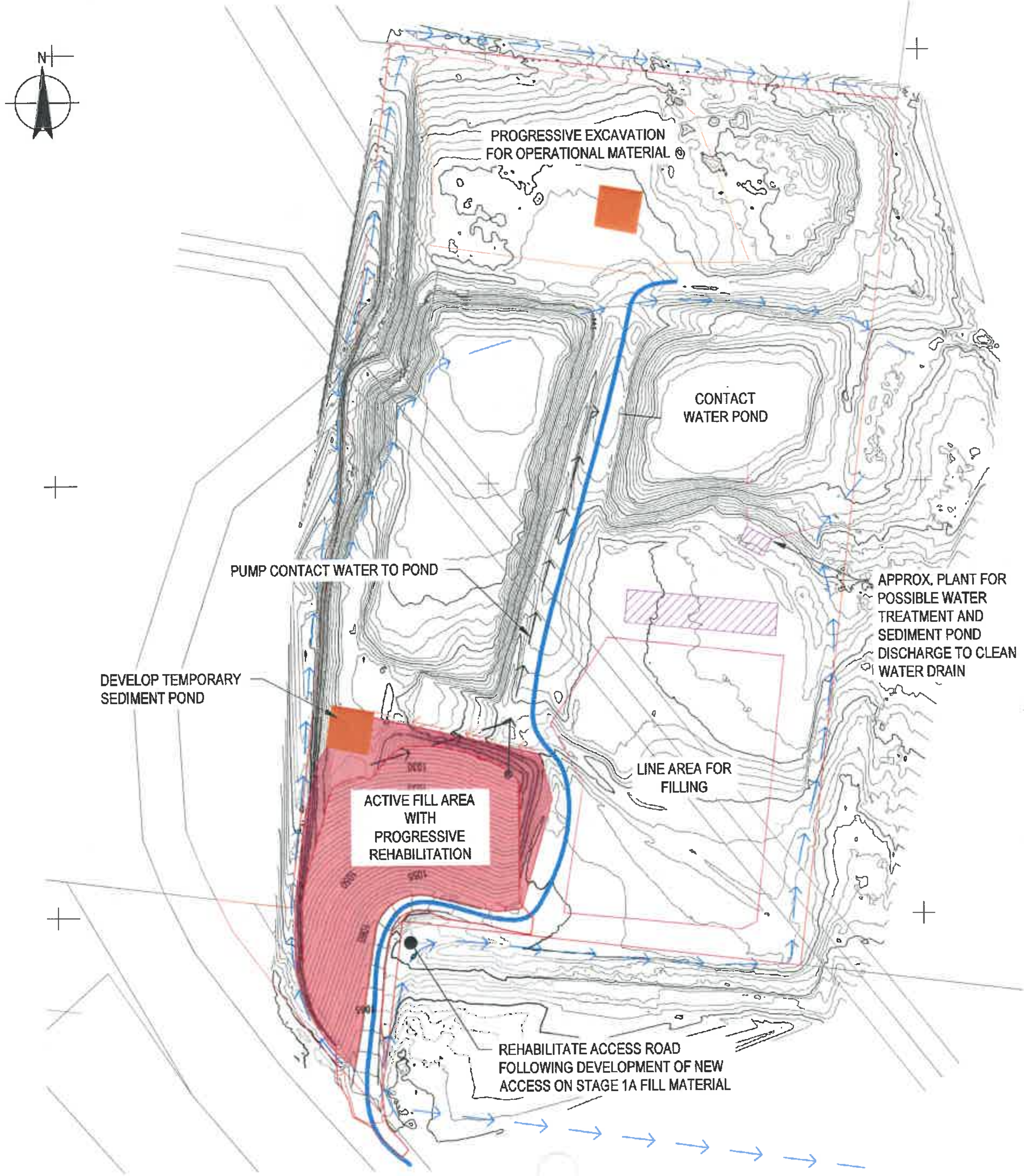

LEGEND

═	EXISTING SURFACE
═	DESIGN CONTOURS
→ —	CLEAN WATER FLOW
→ —	SEDIMENT LADEN FLOW
→ —	CONTACT WATER (PIPE)
→ —	TREATMENT WATER (PIPE)
🟩	REHABILITATED AREA
🟧	INTERMEDIATE COVER AREA
🟥	ACTIVE FILLING AREA
▨	AMENITIES AREA
—	ACCESS ROAD

0 20 40 60m
SCALE 1:2000 AT ORIGINAL SIZE

STAGE 1B WORKS

- CONTACT WATER WILL BE COLLECTED AND PUMPED TO THE CONTACT WATER POND FOR STORAGE AND DISPOSAL
- PROGRESSIVE EXCAVATION IN NORTHERN EXCAVATION AREA TO SUPPORT PROGRESSIVE PLACEMENT OF INTERMEDIATE COVER AND FINAL CAPPING.
- WHERE FILLING IS BEING UNDERTAKEN ABOVE SURROUNDING GROUND LEVEL, A SOIL BUND WILL BE CONSTRUCTED AT THE PERIMETER OF THE ACTIVE FILL AREA TO PREVENT RUN OFF AND A LOW POINT CREATED TO COLLECT CONTACT WATER.
- INTERMEDIATE CAPPING WILL BE INSTALLED PROGRESSIVELY ON THE NORTHERN INTERMEDIATE BATTER.
- FINAL CAPPING WILL BE INSTALLED PROGRESSIVELY ON AREAS AS THEY REACH FINAL SURFACE LEVELS.
- A TEMPORARY SEDIMENT POND WILL BE DEVELOPED IN STAGE 1 AREA WHEN FILLING PROCEEDS ABOVE GROUND AND CONNECTED BY A PUMP AND PIPEWORK TO THE CONTACT WATER POND. THIS WILL INVOLVE LINING AND INSTALLATION OF A SUMP PIT AND PUMP.
- SEDIMENT LADEN WATER WILL BE DIRECTED FROM THE INTERMEDIATE CAP AREAS TO THE TEMPORARY POND (DEVELOPED IN PRELIMINARY WORKS) FOR SETTLEMENT BEFORE DISCHARGE.
- SOUTH-EASTERN AREA WILL BE LINED IN PREPARATION FOR STAGE 2 FILLING WORKS.
- SITE ACCESS AROUND THE SOUTH-EASTERN AREA WILL BE DEVELOPED TO ALLOW FILLING OF STAGE 2 WORKS

PRELIMINARY

rev	description	app'd	date
D	REVISED		15.11.21
C	REVISED		05.11.21

BELL QUARRY REHABILITATION PROJECT
STAGING PLANS
STAGE 1B

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SK003B

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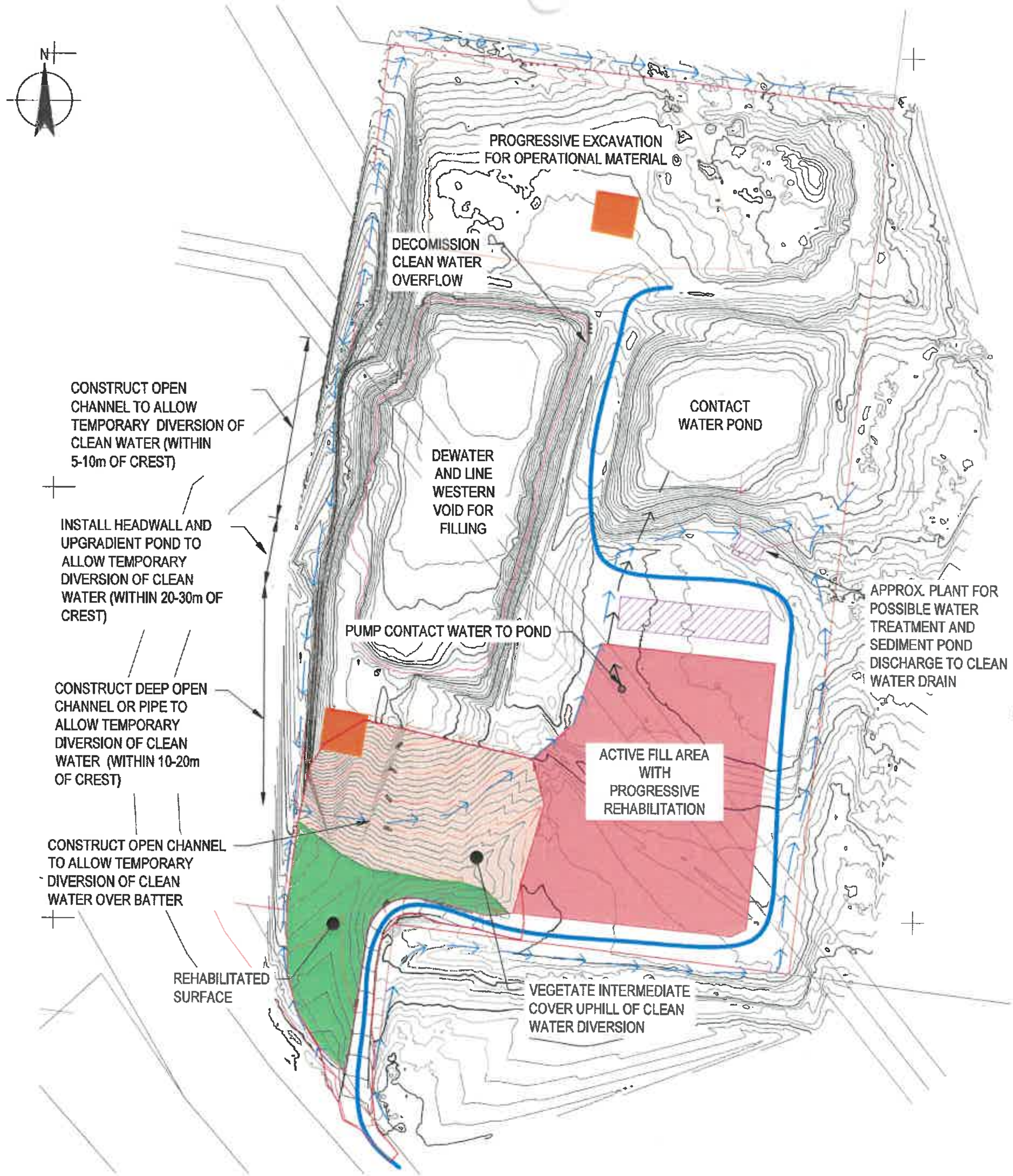

LEGEND

—	EXISTING SURFACE
—	DESIGN CONTOURS
→ —	CLEAN WATER FLOW
→ —	SEDIMENT LADEN FLOW
→ —	CONTACT WATER (PIPE)
→ —	TREATMENT WATER (PIPE)
🟩	REHABILITATED AREA
▭	INTERMEDIATE COVER AREA
🟥	ACTIVE FILLING AREA
▨	AMENITIES AREA
━	ACCESS ROAD

0 20 40 60m
SCALE 1:2000 AT ORIGINAL SIZE

STAGE 2 WORKS

- CONTACT WATER WILL BE COLLECTED AND PUMPED TO THE CONTACT WATER POND FOR STORAGE AND DISPOSAL.
- PROGRESSIVE EXCAVATION IN NORTHERN EXCAVATION AREA TO SUPPORT PROGRESSIVE PLACEMENT OF INTERMEDIATE COVER AND FINAL CAPPING.
- WHERE FILLING IS BEING UNDERTAKEN ABOVE SURROUNDING GROUND LEVEL, A SOIL BUND WILL BE CONSTRUCTED AT THE PERIMETER OF THE ACTIVE FILL AREA TO PREVENT RUN OFF AND A LOW POINT CREATED TO COLLECT CONTACT WATER.
- INTERMEDIATE CAPPING WILL BE INSTALLED PROGRESSIVELY ON THE WESTERN INTERMEDIATE BATTER.
- FINAL CAPPING WILL BE INSTALLED PROGRESSIVELY ON AREAS AS THEY REACH FINAL SURFACE LEVELS.
- SEDIMENT LADEN WATER WILL BE DIRECTED FROM THE INTERMEDIATE CAP AREAS TO THE TEMPORARY POND (DEVELOPED IN PRELIMINARY WORKS) FOR SETTLEMENT BEFORE DISCHARGE.
- A TEMPORARY CLEAN WATER DIVERSION SYSTEM WILL BE CONSTRUCTED TO DIRECT WATER FROM THE WEST OF THE SITE. THE DIVERSION DRAIN WILL CAUSE CLEAN WATER TO ENTER FURTHER SOUTH OF THE SITE, OVER THE NOW-FILLED STAGE 1 INTERMEDIATE BATTER. THE WATER WILL THEN FLOW THROUGH THE SITE AND DIRECTLY OFFSITE.
- THE WESTERN VOID WILL BE DEWATERED, THE CLEAN WATER OVERFLOW WILL BE DECOMMISSIONED AND A LINING SYSTEM WILL BE INSTALLED IN PREPARATION FOR STAGE 3 FILLING.

PRELIMINARY

rev	description	app'd	date
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C	REVISED		05.11.21

BELL QUARRY REHABILITATION PROJECT
STAGING PLANS
STAGE 2

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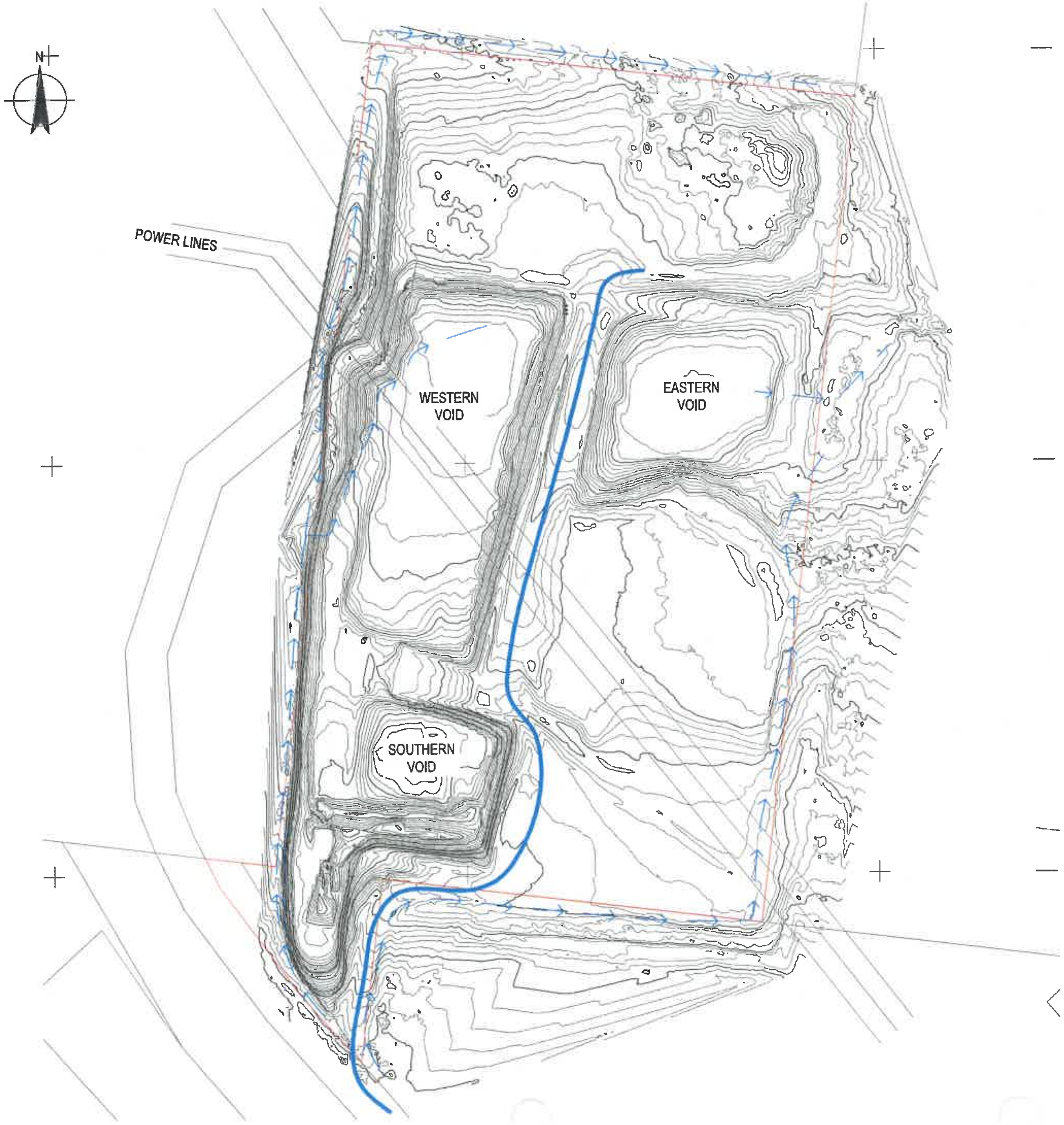

LEGEND

☰	EXISTING SURFACE
☰	DESIGN CONTOURS
→ —	CLEAN WATER FLOW
→ —	SEDIMENT LADEN FLOW
→ —	CONTACT WATER (PIPE)
→ —	TREATMENT WATER (PIPE)
🟩	REHABILITATED AREA
🟧	INTERMEDIATE COVER AREA
🟥	ACTIVE FILLING AREA
▨	AMENITIES AREA
—	ACCESS ROAD

0 20 40 60m
SCALE 1:2000 AT ORIGINAL SIZE

PRELIMINARY

rev	description	app'd	date
C	UPDATED		05.11.21
B	INCL. EXCAVATION WORKS		03.11.21

BELL QUARRY REHABILITATION PROJECT
STAGING PLANS
EXISTING SITE LAYOUT

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scale 1:2000 for A3
job no. 12541317
date NOV 2021
rev no. C
approved (PD)
SK001

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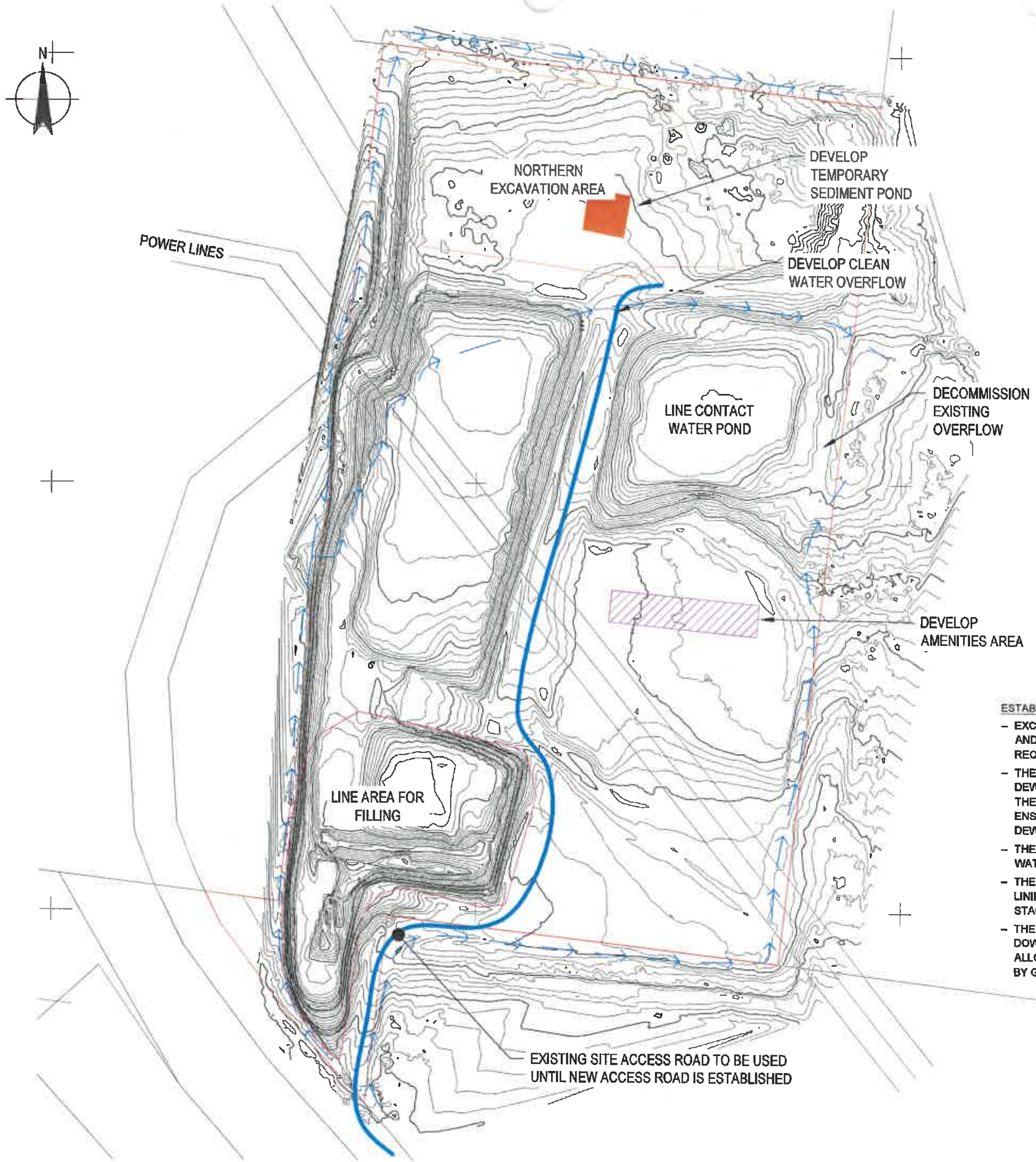

LEGEND

—	EXISTING SURFACE
—	DESIGN CONTOURS
→ —	CLEAN WATER FLOW
→ —	SEDIMENT LADEN FLOW
→ —	CONTACT WATER (PIPE)
→ —	TREATMENT WATER (PIPE)
🟩	REHABILITATED AREA
▭	INTERMEDIATE COVER AREA
🟥	ACTIVE FILLING AREA
▨	AMENITIES AREA
—	ACCESS ROAD

0 20 40 60m
SCALE 1:2000 AT ORIGINAL SIZE

ESTABLISHMENT WORKS

- EXCAVATED AREAS WILL INCLUDE SEDIMENT PONDS AND EROSION AND SEDIMENT CONTROLS, AS REQUIRED.
- THE SOUTHERN AND WESTERN VOIDS WILL BE DEWATERED TO SEPARATE THE WATER BETWEEN THE VOIDS. A BUND WILL BE CREATED, IF NEEDED, TO ENSURE FUTURE SEPARATION AND COMPLETELY DEWATER THE SOUTHERN VOID.
- THE LINING SYSTEM WILL BE INSTALLED IN CONTACT WATER POND.
- THE SOUTHERN VOID WILL BE DEWATERED AND A LINING SYSTEM INSTALLED IN PREPARATION FOR STAGE 1 FILLING.
- THE WATER IN THE WESTERN VOID WILL BE DRAWN DOWN AND AN OVERFLOW CHANNEL INSTALLED TO ALLOW CLEAN WATER TO DRAIN DIRECTLY OFFSITE BY GRAVITY (BYPASSING THE EASTERN VOID).

PRELIMINARY

D	UPDATED		15.11.21
C	UPDATED		05.11.21
rev	description	app'd	date

BELL QUARRY REHABILITATION PROJECT
STAGING PLANS
ESTABLISHMENT WORKS

Level 15, 133 Castlereagh Street, Sydney NSW 2000 Australia
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scale | 1:2000 for A3 job no. | 12541317
date | NOV 2021 rev no. | D

approved (PD)

SK002

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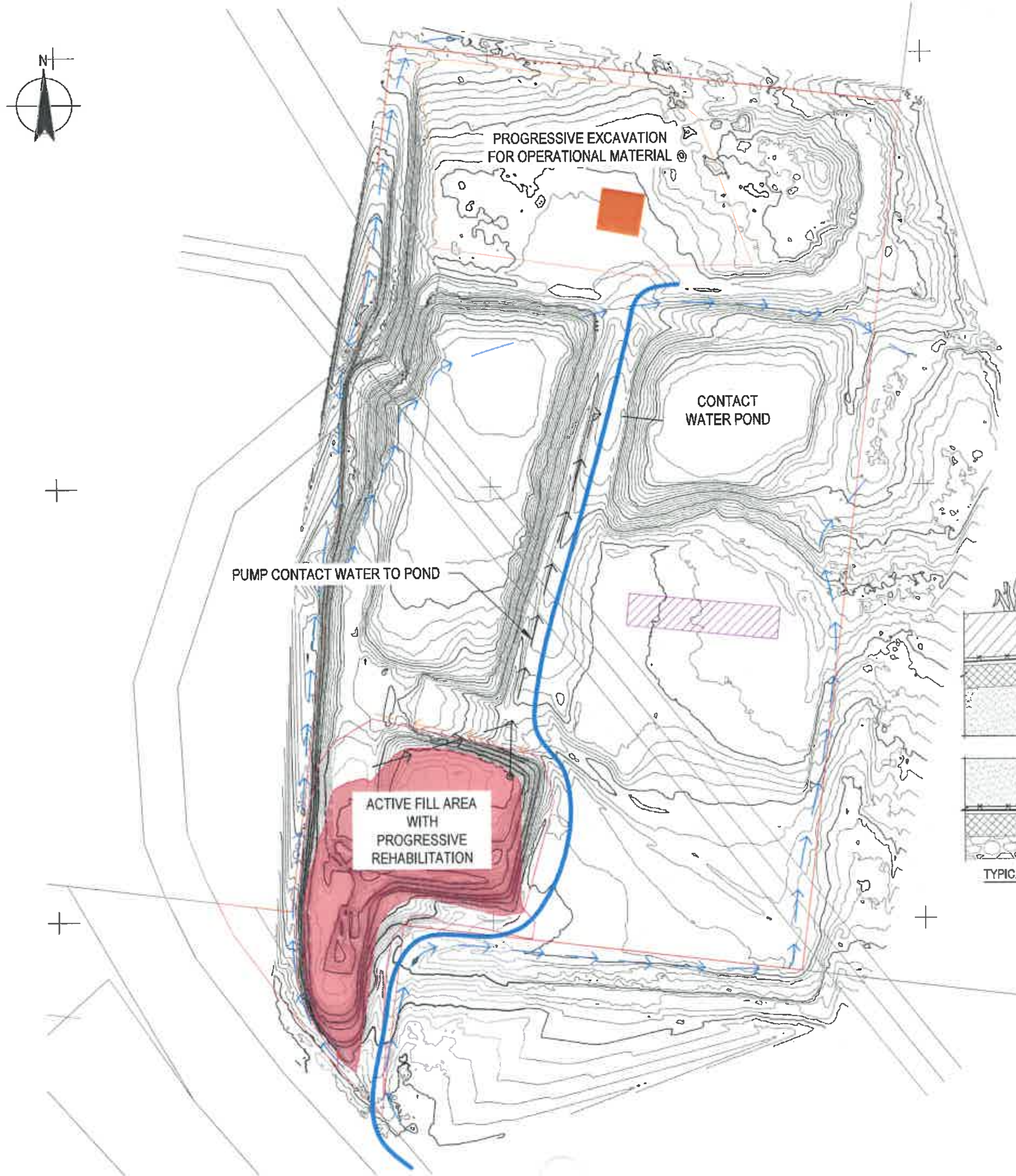
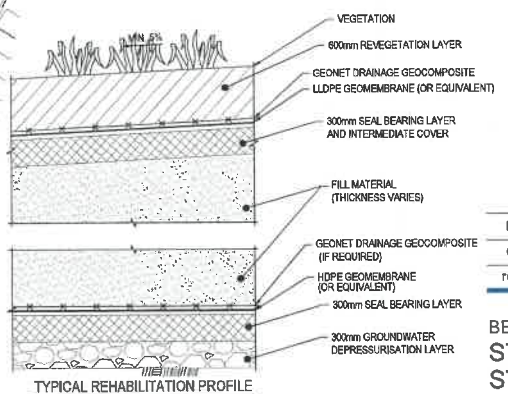


LEGEND

- ☰ EXISTING SURFACE
- ☰ DESIGN CONTOURS
- → — CLEAN WATER FLOW
- → — SEDIMENT LADEN FLOW
- → — CONTACT WATER (PIPE)
- → — TREATMENT WATER (PIPE)
- 🟩 REHABILITATED AREA
- 🟧 INTERMEDIATE COVER AREA
- 🟥 ACTIVE FILLING AREA
- ▨ AMENITIES AREA
- — ACCESS ROAD

0 20 40 60m
SCALE 1:2000 AT ORIGINAL SIZE



TYPICAL REHABILITATION PROFILE
NTS

STAGE 1A WORKS

- PRIORITISE FILLING TO CREATE ACCESS ROAD WITHIN STAGE 1 FOOTPRINT
- PROGRESSIVE EXCAVATION IN NORTHERN EXCAVATION AREA TO SUPPORT PROGRESSIVE PLACEMENT OF INTERMEDIATE COVER AND FINAL CAPPING
- CONTACT WATER WILL BE COLLECTED AND PUMPED TO THE CONTACT WATER POND FOR STORAGE AND DISPOSAL.
- WHERE FILLING IS BEING UNDERTAKEN ABOVE SURROUNDING GROUND LEVEL, A SOIL BUND WILL BE CONSTRUCTED AT THE PERIMETER OF THE ACTIVE FILL AREA TO PREVENT RUN OFF AND A LOW POINT CREATED TO COLLECT CONTACT WATER.
- INTERMEDIATE CAPPING WILL BE INSTALLED PROGRESSIVELY ON THE NORTHERN INTERMEDIATE BATTER.
- SEDIMENT LADEN WATER WILL BE DIRECTED FROM THE INTERMEDIATE CAP AREAS TO THE TEMPORARY POND (DEVELOPED IN PRELIMINARY WORKS) FOR SETTLEMENT BE SCHARGE.

PRELIMINARY

rev	description	app'd	date
D	REVISED		15.11.21
C	REVISED		05.11.21

BELL QUARRY REHABILITATION PROJECT
STAGING PLANS
STAGE 1A

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scale 1:2000 for A3
job no. 12541317
date NOV 2021
rev no. D
approved (PD)

SK003A

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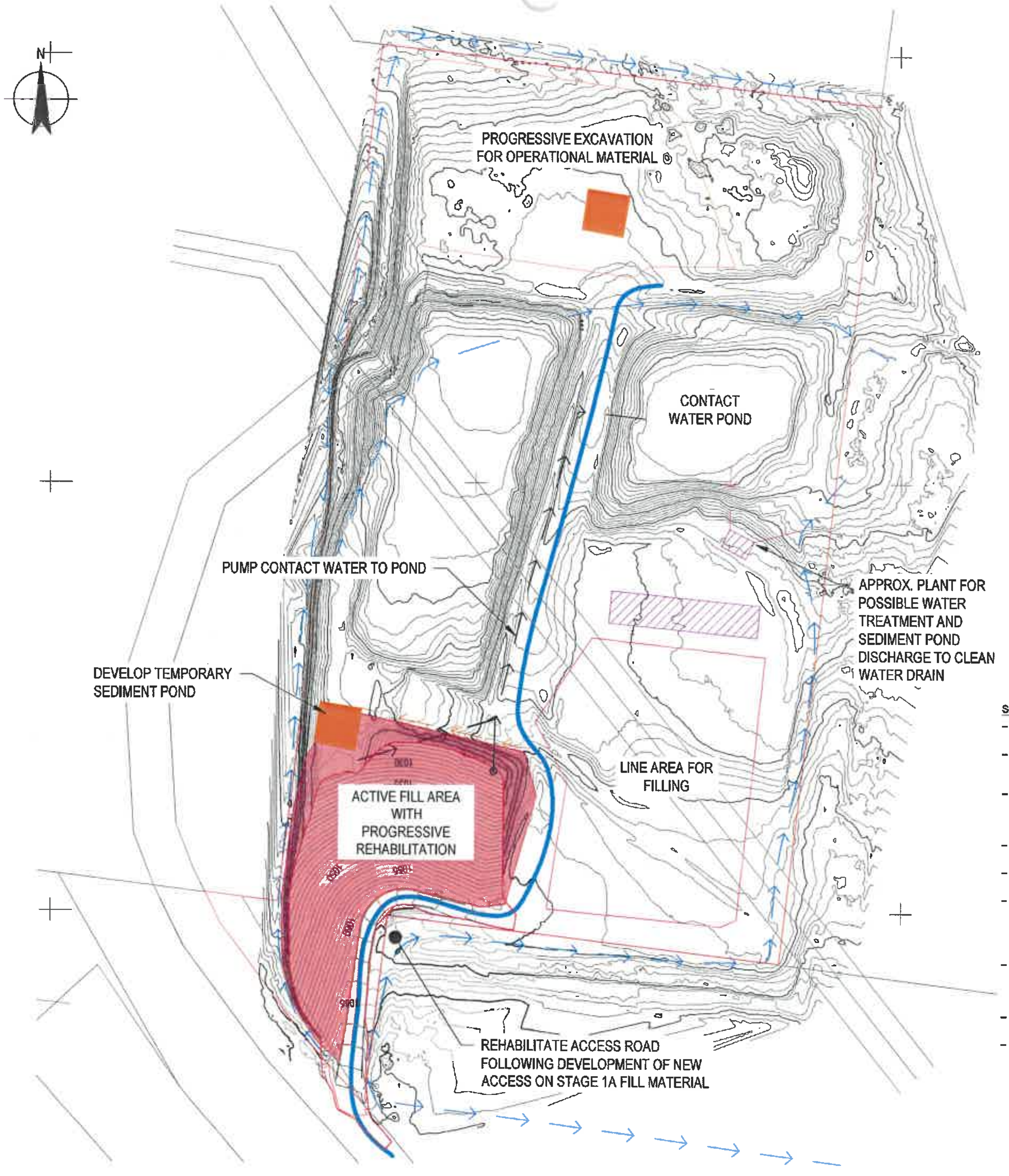

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═	EXISTING SURFACE
═	DESIGN CONTOURS
→ —	CLEAN WATER FLOW
→ —	SEDIMENT LADEN FLOW
→ —	CONTACT WATER (PIPE)
→ —	TREATMENT WATER (PIPE)
🟩	REHABILITATED AREA
▭	INTERMEDIATE COVER AREA
🟥	ACTIVE FILLING AREA
▨	AMENITIES AREA
━	ACCESS ROAD

0 20 40 60m
SCALE 1:2000 AT ORIGINAL SIZE

STAGE 1B WORKS

- CONTACT WATER WILL BE COLLECTED AND PUMPED TO THE CONTACT WATER POND FOR STORAGE AND DISPOSAL.
- PROGRESSIVE EXCAVATION IN NORTHERN EXCAVATION AREA TO SUPPORT PROGRESSIVE PLACEMENT OF INTERMEDIATE COVER AND FINAL CAPPING.
- WHERE FILLING IS BEING UNDERTAKEN ABOVE SURROUNDING GROUND LEVEL, A SOIL BUND WILL BE CONSTRUCTED AT THE PERIMETER OF THE ACTIVE FILL AREA TO PREVENT RUN OFF AND A LOW POINT CREATED TO COLLECT CONTACT WATER.
- INTERMEDIATE CAPPING WILL BE INSTALLED PROGRESSIVELY ON THE NORTHERN INTERMEDIATE BATTER.
- FINAL CAPPING WILL BE INSTALLED PROGRESSIVELY ON AREAS AS THEY REACH FINAL SURFACE LEVELS.
- A TEMPORARY SEDIMENT POND WILL BE DEVELOPED IN STAGE 1 AREA WHEN FILLING PROCEEDS ABOVE GROUND AND CONNECTED BY A PUMP AND PIPEWORK TO THE CONTACT WATER POND. THIS WILL INVOLVE LINING AND INSTALLATION OF A SUMP PIT AND PUMP.
- SEDIMENT LADEN WATER WILL BE DIRECTED FROM THE INTERMEDIATE CAP AREAS TO THE TEMPORARY POND (DEVELOPED IN PRELIMINARY WORKS) FOR SETTLEMENT BEFORE DISCHARGE.
- SOUTH-EASTERN AREA WILL BE LINED IN PREPARATION FOR STAGE 2 FILLING WORKS.
- SITE ACCESS AROUND THE SOUTH-EASTERN AREA WILL BE DEVELOPED TO ALLOW FILLING OF STAGE 2 WORKS

PRELIMINARY

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BELL QUARRY REHABILITATION PROJECT
STAGING PLANS
STAGE 1B

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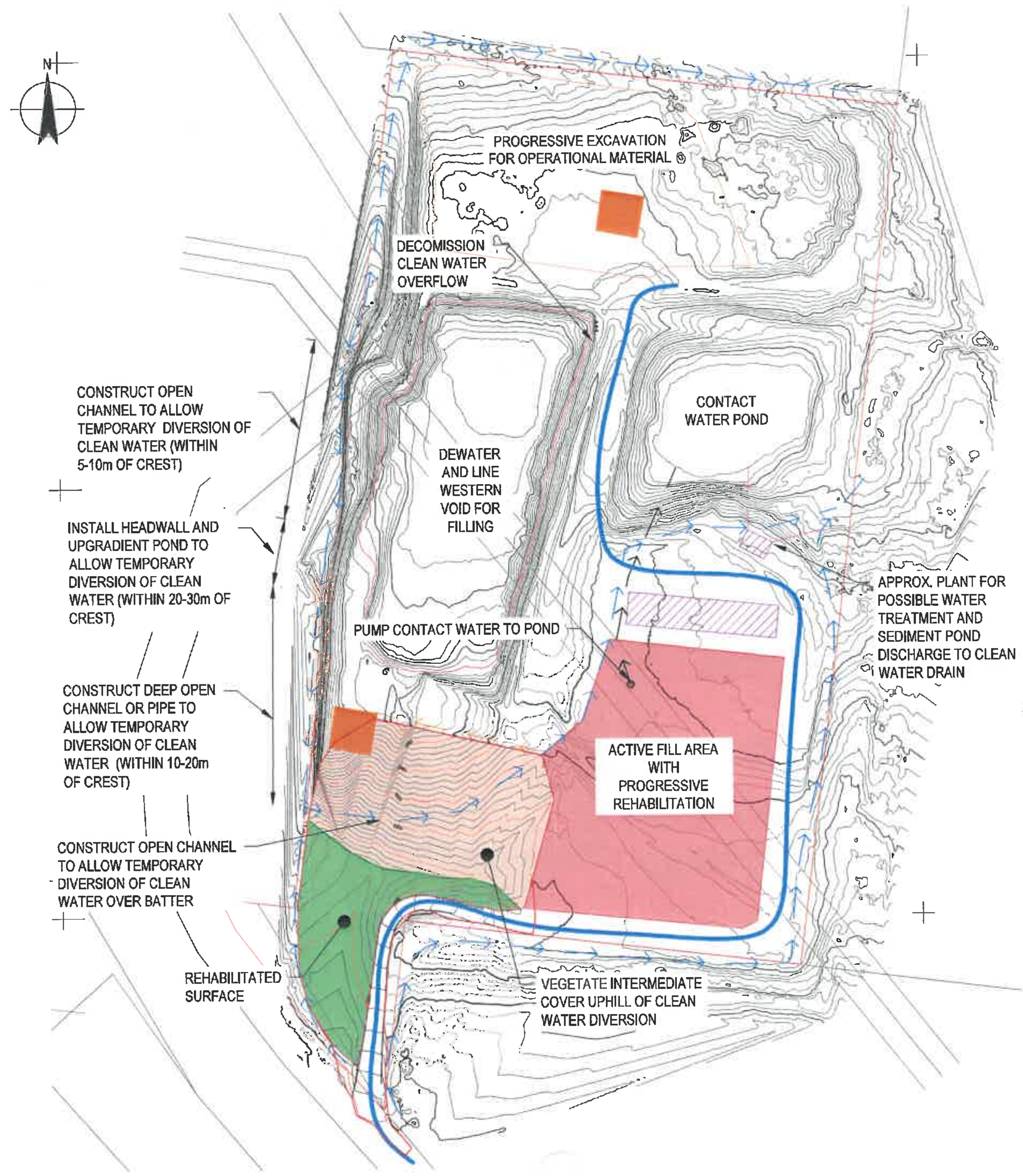

LEGEND

═	EXISTING SURFACE
═	DESIGN CONTOURS
→ —	CLEAN WATER FLOW
→ —	SEDIMENT LADEN FLOW
→ —	CONTACT WATER (PIPE)
→ —	TREATMENT WATER (PIPE)
🟩	REHABILITATED AREA
🟧	INTERMEDIATE COVER AREA
🟥	ACTIVE FILLING AREA
▨	AMENITIES AREA
—	ACCESS ROAD

0 20 40 60m
SCALE 1:2000 AT ORIGINAL SIZE

STAGE 2 WORKS

- CONTACT WATER WILL BE COLLECTED AND PUMPED TO THE CONTACT WATER POND FOR STORAGE AND DISPOSAL.
- PROGRESSIVE EXCAVATION IN NORTHERN EXCAVATION AREA TO SUPPORT PROGRESSIVE PLACEMENT OF INTERMEDIATE COVER AND FINAL CAPPING.
- WHERE FILLING IS BEING UNDERTAKEN ABOVE SURROUNDING GROUND LEVEL, A SOIL BUND WILL BE CONSTRUCTED AT THE PERIMETER OF THE ACTIVE FILL AREA TO PREVENT RUN OFF AND A LOW POINT CREATED TO COLLECT CONTACT WATER.
- INTERMEDIATE CAPPING WILL BE INSTALLED PROGRESSIVELY ON THE WESTERN INTERMEDIATE BATTER.
- FINAL CAPPING WILL BE INSTALLED PROGRESSIVELY ON AREAS AS THEY REACH FINAL SURFACE LEVELS.
- SEDIMENT LADEN WATER WILL BE DIRECTED FROM THE INTERMEDIATE CAP AREAS TO THE TEMPORARY POND (DEVELOPED IN PRELIMINARY WORKS) FOR SETTLEMENT BEFORE DISCHARGE.
- A TEMPORARY CLEAN WATER DIVERSION SYSTEM WILL BE CONSTRUCTED TO DIRECT WATER FROM THE WEST OF THE SITE. THE DIVERSION DRAIN WILL CAUSE CLEAN WATER TO ENTER FURTHER SOUTH OF THE SITE, OVER THE NOW-FILLED STAGE 1 INTERMEDIATE BATTER. THE WATER WILL THEN FLOW THROUGH THE SITE AND DIRECTLY OFFSITE.
- THE WESTERN VOID WILL BE DEWATERED, THE CLEAN WATER OVERFLOW WILL BE DECOMMISSIONED AND A LINING SYSTEM WILL BE INSTALLED IN PREPARATION FOR STAGE 3 FILLING.

PRELIMINARY

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STAGE 2

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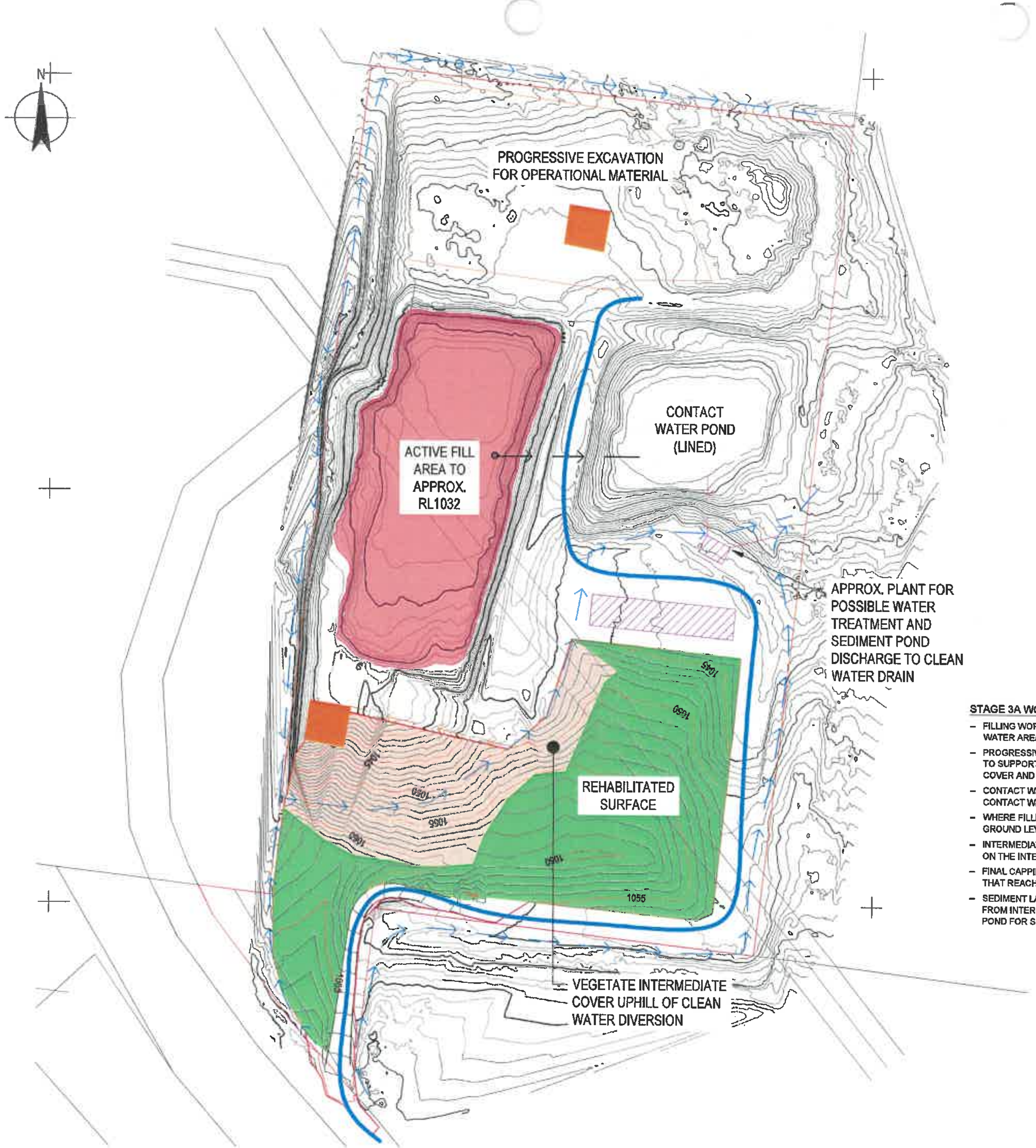

STAGE 3A WORKS

- FILLING WORKS WILL BE UNDERTAKEN TO ENSURE A CONTACT WATER AREA OF LESS THAN 1.5 HA IS MAINTAINED.
- PROGRESSIVE EXCAVATION IN NORTHERN EXCAVATION AREA TO SUPPORT PROGRESSIVE PLACEMENT OF INTERMEDIATE COVER AND FINAL CAPPING
- CONTACT WATER WILL BE COLLECTED AND PUMPED TO THE CONTACT WATER POND FOR STORAGE AND DISPOSAL.
- WHERE FILLING IS BEING UNDERTAKEN ABOVE SURROUNDING GROUND LEVEL,
- INTERMEDIATE CAPPING WILL BE INSTALLED PROGRESSIVELY ON THE INTERMEDIATE BATTERS.
- FINAL CAPPING WILL BE INSTALLED PROGRESSIVELY ON AREAS THAT REACH FINAL SURFACE LEVELS.
- SEDIMENT LADEN WATER WILL BE DIRECTED AND PUMPED FROM INTERMEDIATE CAPPING AREAS TO THE TEMPORARY POND FOR SETTLEMENT BEFORE DISCHARGE.

LEGEND

―	EXISTING SURFACE
―	DESIGN CONTOURS
→ ―	CLEAN WATER FLOW
→ ―	SEDIMENT LADEN FLOW
→ ―	CONTACT WATER (PIPE)
→ ―	TREATMENT WATER (PIPE)
🟩	REHABILITATED AREA
▭	INTERMEDIATE COVER AREA
🟥	ACTIVE FILLING AREA
▨	AMENITIES AREA
―	ACCESS ROAD

0 20 40 60m
SCALE 1:2000 AT ORIGINAL SIZE

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STAGE 3A

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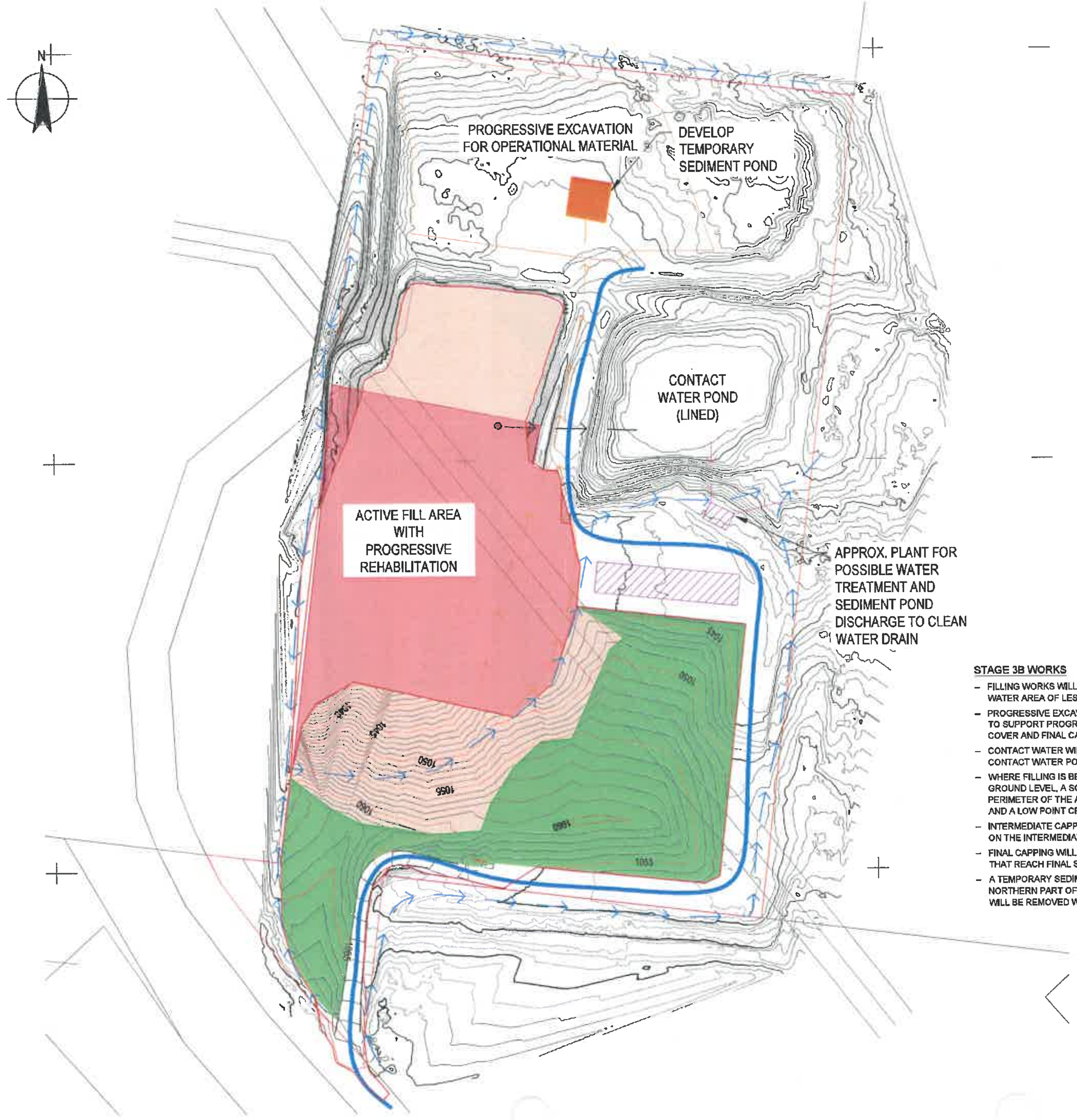

LEGEND

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☰	DESIGN CONTOURS
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→ —	SEDIMENT LADEN FLOW
→ —	CONTACT WATER (PIPE)
→ —	TREATMENT WATER (PIPE)
🟩	REHABILITATED AREA
▭	INTERMEDIATE COVER AREA
🟥	ACTIVE FILLING AREA
▨	AMENITIES AREA
—	ACCESS ROAD

0 20 40 60m
SCALE 1:2000 AT ORIGINAL SIZE

STAGE 3B WORKS

- FILLING WORKS WILL BE UNDERTAKEN TO ENSURE A CONTACT WATER AREA OF LESS THAN 1.5 HA IS MAINTAINED.
- PROGRESSIVE EXCAVATION IN NORTHERN EXCAVATION AREA TO SUPPORT PROGRESSIVE PLACEMENT OF INTERMEDIATE COVER AND FINAL CAPPING
- CONTACT WATER WILL BE COLLECTED AND PUMPED TO THE CONTACT WATER POND FOR STORAGE AND DISPOSAL.
- WHERE FILLING IS BEING UNDERTAKEN ABOVE SURROUNDING GROUND LEVEL, A SOIL BUND WILL BE CONSTRUCTED AT THE PERIMETER OF THE ACTIVE FILL AREA TO PREVENT RUN OFF AND A LOW POINT CREATED TO COLLECT CONTACT WATER.
- INTERMEDIATE CAPPING WILL BE INSTALLED PROGRESSIVELY ON THE INTERMEDIATE BATTERS.
- FINAL CAPPING WILL BE INSTALLED PROGRESSIVELY ON AREAS THAT REACH FINAL SURFACE LEVELS.
- A TEMPORARY SEDIMENT POND WILL BE DEVELOPED IN THE NORTHERN PART OF SITE AND THE STAGE 1 TEMPORARY POND WILL BE REMOVED WHEN REQUIRED.

PRELIMINARY

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BELL QUARRY REHABILITATION
STAGING PLANS
STAGE 3B

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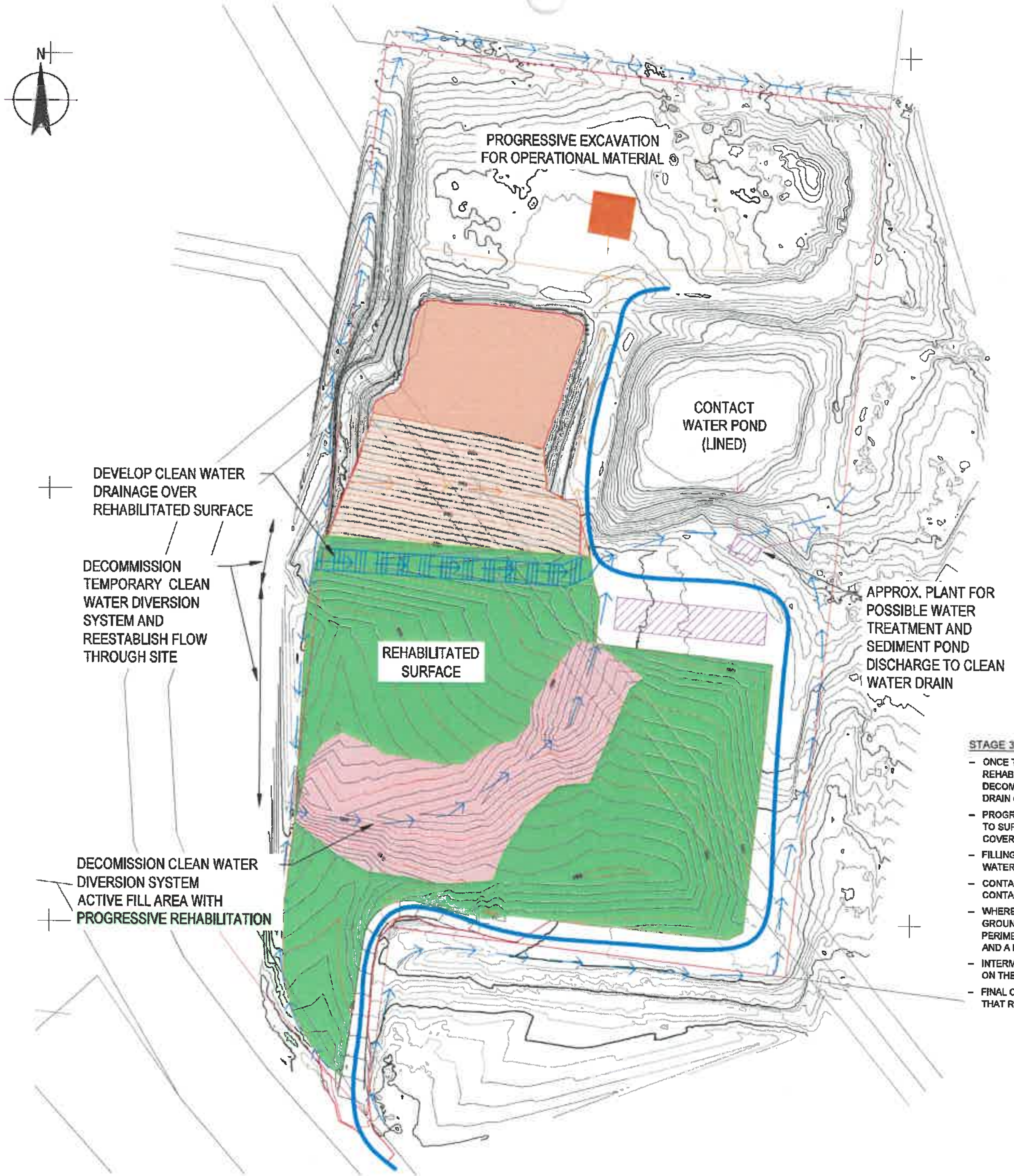

LEGEND

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═	DESIGN CONTOURS
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→ —	SEDIMENT LADEN FLOW
→ —	CONTACT WATER (PIPE)
→ —	TREATMENT WATER (PIPE)
🟩	REHABILITATED AREA
▭	INTERMEDIATE COVER AREA
▦	ACTIVE FILLING AREA
▨	AMENITIES AREA
━	ACCESS ROAD

0 20 40 60m
SCALE 1:2000 AT ORIGINAL SIZE

STAGE 3C WORKS

- ONCE THE FINAL CLEAN WATER DRAINAGE PATHWAY OVER THE REHABILITATED SURFACE HAS BEEN ESTABLISHED, DECOMMISSION THE TEMPORARY CLEAN WATER DIVERSION DRAIN OVER THE STAGE 1 BATTER
- PROGRESSIVE EXCAVATION IN NORTHERN EXCAVATION AREA TO SUPPORT PROGRESSIVE PLACEMENT OF INTERMEDIATE COVER AND FINAL CAPPING.
- FILLING WORKS WILL BE UNDERTAKEN TO ENSURE A CONTACT WATER AREA OF LESS THAN 1.5 HA IS MAINTAINED.
- CONTACT WATER WILL BE COLLECTED AND PUMPED TO THE CONTACT WATER POND FOR STORAGE AND DISPOSAL.
- WHERE FILLING IS BEING UNDERTAKEN ABOVE SURROUNDING GROUND LEVEL, A SOIL BUND WILL BE CONSTRUCTED AT THE PERIMETER OF THE ACTIVE FILL AREA TO PREVENT RUN OFF AND A LOW POINT CREATED TO COLLECT CONTACT WATER.
- INTERMEDIATE CAPPING WILL BE INSTALLED PROGRESSIVELY ON THE INTERMEDIATE BATTERS.
- FINAL CAPPING WILL BE INSTALLED PROGRESSIVELY ON AREAS THAT REACH FINAL SURFACE LEVELS.

PRELIMINARY

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BELL QUARRY REHABILITATION PROJECT
STAGING PLANS
STAGE 3C

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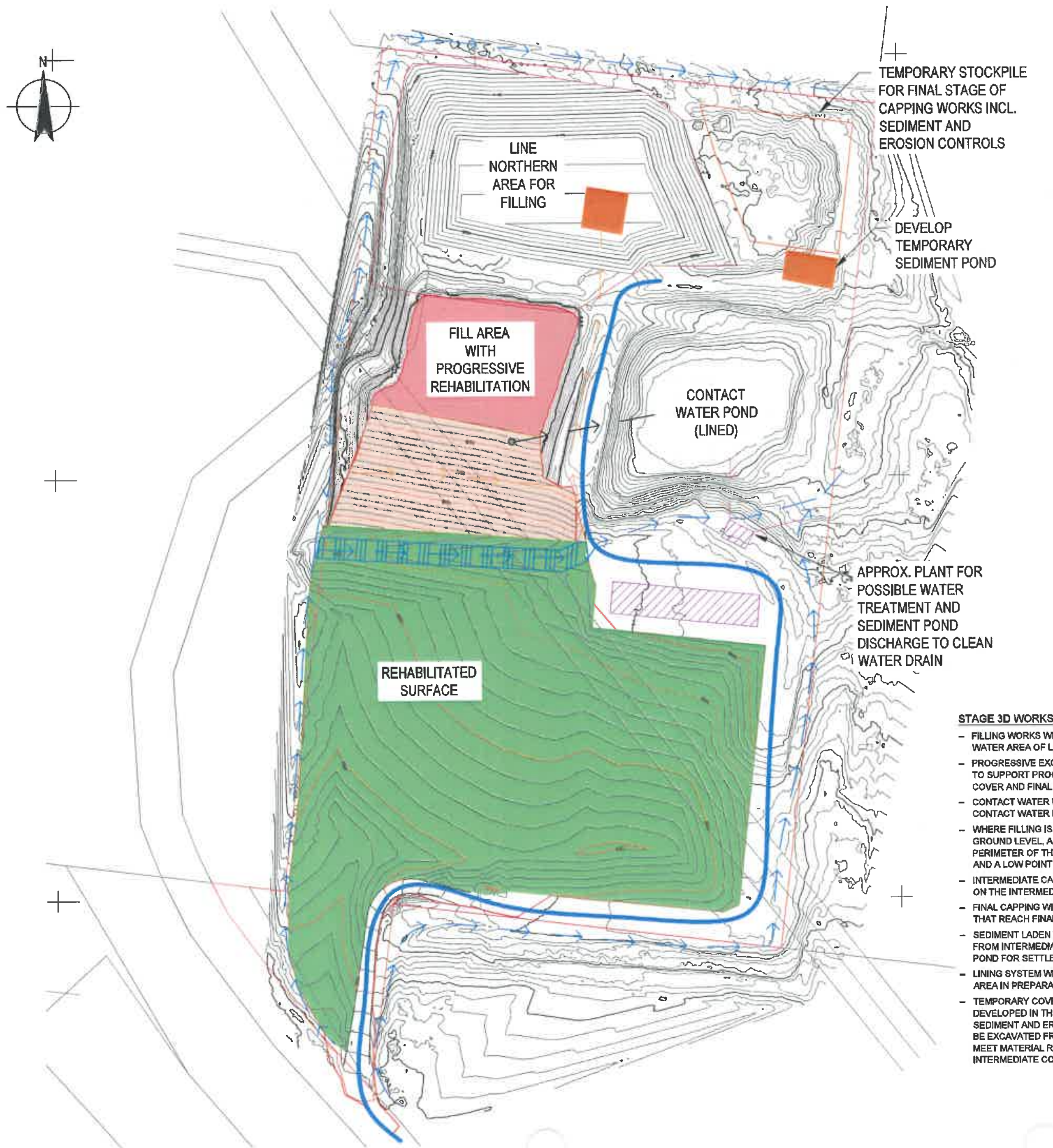

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☰	DESIGN CONTOURS
→ —	CLEAN WATER FLOW
→ —	SEDIMENT LADEN FLOW
→ —	CONTACT WATER (PIPE)
→ —	TREATMENT WATER (PIPE)
🟩	REHABILITATED AREA
🟧	INTERMEDIATE COVER AREA
🟥	ACTIVE FILLING AREA
▨	AMENITIES AREA
—	ACCESS ROAD

0 20 40 60m
SCALE 1:2000 AT ORIGINAL SIZE

STAGE 3D WORKS

- FILLING WORKS WILL BE UNDERTAKEN TO ENSURE A CONTACT WATER AREA OF LESS THAN 1.5 HA IS MAINTAINED.
- PROGRESSIVE EXCAVATION IN NORTHERN EXCAVATION AREA TO SUPPORT PROGRESSIVE PLACEMENT OF INTERMEDIATE COVER AND FINAL CAPPING.
- CONTACT WATER WILL BE COLLECTED AND PUMPED TO THE CONTACT WATER POND FOR STORAGE AND DISPOSAL.
- WHERE FILLING IS BEING UNDERTAKEN ABOVE SURROUNDING GROUND LEVEL, A SOIL BUND WILL BE CONSTRUCTED AT THE PERIMETER OF THE ACTIVE FILL AREA TO PREVENT RUN OFF AND A LOW POINT CREATED TO COLLECT CONTACT WATER.
- INTERMEDIATE CAPPING WILL BE INSTALLED PROGRESSIVELY ON THE INTERMEDIATE BATTERS.
- FINAL CAPPING WILL BE INSTALLED PROGRESSIVELY ON AREAS THAT REACH FINAL SURFACE LEVELS.
- SEDIMENT LADEN WATER WILL BE DIRECTED AND PUMPED FROM INTERMEDIATE CAPPING AREAS TO THE TEMPORARY POND FOR SETTLEMENT BEFORE DISCHARGE.
- LINING SYSTEM WILL BE CONSTRUCTED IN THE NORTHERN AREA IN PREPARATION FOR STAGE 4 FILLING.
- TEMPORARY COVER MATERIAL STOCKPILE AREA WILL BE DEVELOPED IN THE NORTH-EAST, INCLUDING REQUIRED SEDIMENT AND EROSION CONTROLS. SUFFICIENT MATERIAL TO BE EXCAVATED FROM NORTHERN AREA PRIOR TO LINING TO MEET MATERIAL REQUIREMENTS FOR FINAL STAGE 4 INTERMEDIATE COVER AND CAPPING WORKS.

PRELIMINARY

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STAGING PLANS
STAGE 3D

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LEGEND

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═	DESIGN CONTOURS
→ —	CLEAN WATER FLOW
→ —	SEDIMENT LADEN FLOW
→ —	CONTACT WATER (PIPE)
→ —	TREATMENT WATER (PIPE)
🟩	REHABILITATED AREA
▭	INTERMEDIATE COVER AREA
🟥	ACTIVE FILLING AREA
▨	AMENITIES AREA
━	ACCESS ROAD

0 20 40 60m
SCALE 1:2000 AT ORIGINAL SIZE

STAGE 4 WORKS

- FILLING WORKS WILL BE UNDERTAKEN TO ENSURE A CONTACT WATER AREA OF LESS THAN 1.5 HA IS MAINTAINED.
- CONTACT WATER WILL BE COLLECTED AND PUMPED TO THE CONTACT WATER POND FOR STORAGE AND DISPOSAL.
- WHERE FILLING IS BEING UNDERTAKEN ABOVE SURROUNDING GROUND LEVEL, A SOIL BUND WILL BE CONSTRUCTED AT THE PERIMETER OF THE ACTIVE FILL AREA TO PREVENT RUN OFF AND A LOW POINT CREATED TO COLLECT CONTACT WATER.
- FINAL CAPPING WILL BE INSTALLED PROGRESSIVELY ON AREAS THAT REACH FINAL SURFACE LEVELS.
- TEMPORARY SEDIMENT AND EROSION CONTROLS WILL BE MAINTAINED AROUND THE COVER MATERIAL STOCKPILE AREA

PRELIMINARY

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STAGING PLANS
STAGE 4

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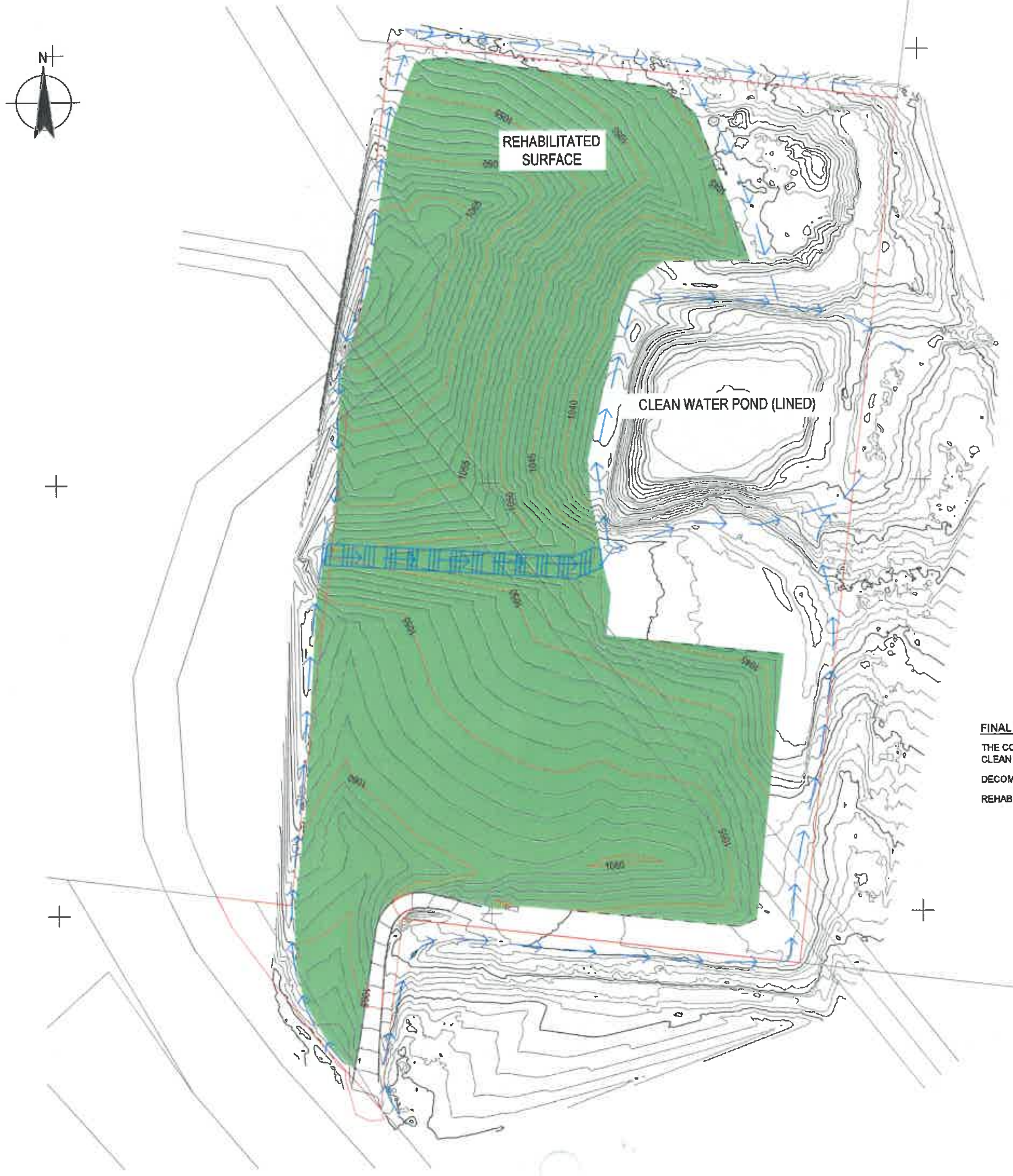

LEGEND

☰	EXISTING SURFACE
☰	DESIGN CONTOURS
→ —	CLEAN WATER FLOW
→ —	SEDIMENT LADEN FLOW
→ —	CONTACT WATER (PIPE)
→ —	TREATMENT WATER (PIPE)
🟩	REHABILITATED AREA
☐	INTERMEDIATE COVER AREA
🟥	ACTIVE FILLING AREA
▨	AMENITIES AREA
—	ACCESS ROAD

0 20 40 60m
SCALE 1:2000 AT ORIGINAL SIZE

FINAL WORKS

THE CONTACT WATER POND WILL BE CLEANED AND RETAINED FOR CLEAN WATER STORAGE.

DECOMMISSION TREATMENT PLANT IF REQUIRED.

REHABILITATE STOCKPILE AREA AND SEDIMENT POND.

PRELIMINARY

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C	REVISED		05.11.21

BELL QUARRY REHABILITATION PROJECT
STAGING PLANS
REHABILITATED SURFACE

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Appendix C

Vegetation Management Plan and Ecological Monitoring Program

Rehabilitation of the Former Bell Quarry – DA 294/19

Vegetation Management Plan

HWL Ebsworth Lawyers

16 November 2021

Final

cumberland ecology

Report No. 20109RP4

The preparation of this report has been in accordance with the brief provided by the Client and has relied upon the data and results collected at or under the times and conditions specified in the report. All findings, conclusions or commendations contained within the report are based only on the aforementioned circumstances. The report has been prepared for use by the Client and no responsibility for its use by other parties is accepted by Cumberland Ecology.

Version	Date Issued	Amended by	Details
1	16 November 2021		Final issued for submission

Approved by:	**Dr David Robertson**
Position:	Director
Signed:	David Robertson
Date:	16 November, 2021

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Glossary

Term / Abbreviation	Definition
BC Act	NSW *Biodiversity Conservation Act 2016*
Biosecurity Act	NSW *Biosecurity Act 2015*
BQRP	Bell Quarry Rehabilitation Project Pty Ltd
CEMP	Construction Environmental Management Plan
ENM	Excavated natural material
EP&A Act	NSW *Environmental Planning and Assessment Act 1979*
EPA	NSW Environment Protection Authority
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
EPL	Environment Protection Licence
MZ1	Management Zone 1
MZ2	Management Zone 2
MZ3	Management Zone 3
NPWS	National Parks and Wildlife Service
NSW	New South Wales
OEH	NSW Office of Environment and Heritage
PCTs	Plant Community Types
Project	The Bell Quarry Rehabilitation Project
Project area	Area within which the Project is being undertaken
Subject land	Lot 23 DP 751631
VENM	Virgin excavated natural material
VMP	Vegetation Management Plan
VMP Area	Area subject to the VMP as shown in **Figure 1**

1. Introduction

Cumberland Ecology has been requested by HWL Ebsworth Lawyers on behalf of Bell Quarry Rehabilitation Project Pty Ltd (BQRP) to prepare a Vegetation Management Plan (VMP) for the Bell Quarry Rehabilitation Project (the 'Project'). The Project is located within Lot 23 DP 751631, Sandham Road, Dargan (the 'subject land'). The Project sought designated and integrated development consent under Part 4 of the New South Wales (NSW) *Environmental Planning and Assessment Act 1979* (EP&A Act). The Development Application for the Project was refused by the Western Regional Planning Panel in April 2020. This VMP has been prepared to provide guidance for the management of land to the east of the subject land's eastern boundary of the Project where previous land use activities has impacted Blue Mountains National Park. The Project is subject to proceedings in the NSW Land and Environment Court (No. 2021/00091361). Development consent for the management and revegetation of the land that is the subject of this VMP is not sought under development application 294/18 (the DA). Approval for the management and revegetation under this VMP will be sought from National Parks and Wildlife Service (NPWS) under Part 5 of the EP&A Act.

In February 2019, the then Office of Environment and Heritage (OEH) indicated that it supported the rehabilitation of the portions of the Blue Mountains National Park that were impacted by the previous quarry operations, and restoration of a stable landform. OEH also indicated that it intended to issue a licence under the *National Parks and Wildlife Act 1974* to enable the proponent to undertake these works. OEH indicated that the licence conditions are to be determined by the NPWS and will be negotiated with BQRP.

The specific area subject to this VMP is referred to as the 'VMP Area' (see **Figure 1**). The VMP Area comprises an approximate 40m buffer from the eastern boundary of the subject land and is approximately 2.74 ha in area.

1.1. Purpose

The purpose of this document is to provide a plan to manage and reinstate vegetation within the VMP Area to a facsimile of the vegetation and condition before the land was previously modified. Specifically, this report will:

- Provide measures for the protection of undisturbed areas of the Blue Mountains National Park;
- Provide weed management measures to enhance the biodiversity values of the VMP Area;
- Provide revegetation measures for cleared and modified areas; and
- Provide for ongoing monitoring to maintain the biodiversity values.

1.2. Project Background

1.2.1. Site Background

Bell Quarry is located on Sandham Road, Dargan (Lot 23 DP 751631), approximately 10 km east of Lithgow, NSW. The quarry was in operation under existing use rights between 1967 and 1994, and subsequently operated under a DA approval from Lithgow City Council and an Environment Protection Licence (EPL) issued by the NSW Environment Protection Authority (EPA) (GHD 2018b). Active operations with the quarry ceased and the EPL was surrendered to the EPA on 24 October 2014 (GHD 2018b). BQRP acquired the quarry site and subsequently undertook future land use planning for the subject land.

The subject land covers a total area of approximately 13.7 hectares (ha) and is divided by the Main Western Railway. The subject land is zoned E3 Environmental Management under *Lithgow Environmental Plan 2014*. It is located adjacent to the Greater Blue Mountains World Heritage Area, and within the upper reaches of the Wollangambe River Catchment, which forms part of the broader Hawksbury-Nepean catchment.

1.2.2. Project Overview

BQRP is seeking to rehabilitate the subject land, with the final rehabilitated landform to be achieved via importation of virgin excavated natural material (VENM), excavated natural material (ENM) or comparable material (that meets an exemption pursuant to clauses 91 and 92 of the *Protection of the Environmental Operations (Waste) Regulation 2014)*, sourced from earthworks projects across Sydney and the local regional area.

The key features of the Project, as proposed to be amended are identified by GHD (2021) as follows:

- Importation of approximately 1.2 million cubic metres of VENM, ENM or comparable material (that meets an exemption pursuant to clauses 91 and 92 of the *Protection of the Environmental Operations (Waste) Regulation 2014)*, sourced from earthworks projects across Sydney and the local regional area.
- Vehicle haulage at a rate of up to 140,000 tonnes per annum;
- Emplacement and compaction of soil material within the existing quarry voids;
- Shaping of fill to closely represent the pre-quarry landform and to allow surface water drainage across the final landform;
- Development of a water management system to control surface water discharges throughout the rehabilitation program and from the final landform including a lined contact water pond; and
- Revegetation of the site with locally endemic species to provide effective integration with the surrounding landscape.

These works will be wholly contained within the project area.

1.3. Relevant Legislation

Legislation relevant to this VMP includes:

- NSW *Environmental Planning and Assessment Act 1979* (EP&A Act);
- NSW *Biodiversity Conservation Act 2016* (BC Act);
- NSW *Biosecurity Act 2015* (Biosecurity Act);
- NSW *National Parks and Wildlife Act 1974*;
- NSW *Pesticides Act 1999;* and
- Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

2. Methodology

2.1. Desktop Assessment

The preparation of this VMP involved a literature review to determine the most up to date methods of weed control for exotic species that are present in the VMP Area. This literature review involved a variety of sources including government fact sheets and websites. Cumberland Ecology staff with expertise in bushland maintenance were also consulted regarding current best practice weed control methods and techniques.

A review of vegetation community descriptions held within the BioNet Vegetation Classification databases and associated references was also undertaken. The information, in conjunction with the flora species information contained in GHD (2018a) and recent field surveys have been used to determine suitable native plant species for planting, as required for revegetation.

2.2. Site Inspection

A site inspection of the VMP Area was undertaken by Cumberland Ecology on 1 November 2021. The site inspection included walking traverses within the readily accessible portions of the VMP Area. The site inspection included the collection of notes on vegetation and its condition within the VMP Area, and collection of photographs.

The site inspection undertaken within the VMP Area supplemented previous surveys and inspections undertaken within the subject land and surrounds by Cumberland Ecology on 13 July 2020, 21 December 2020 and 15-19 March 2021.

3. Existing Biodiversity Values

This section summarises the existing environment of the VMP Area identified within the Biodiversity Impact Assessment (GHD 2018a) prepared for the Project as well as incorporating findings from the site inspections undertaken by Cumberland Ecology.

3.1.1. Plant Community Types

The VMP Area comprises a matrix of cleared land, native open forest in varying condition, and an artificial wetland. The extent of plant community types (PCTs) identified within the project area and study area are outlined within **Table 1**. None of the vegetation communities within the VMP Area comprise a threatened ecological community listed under the BC Act or EPBC Act.

Table 1 Plant community types within the VMP Area

PCT	Condition	VMP Area (ha)
1248: Sydney Peppermint - Silvertop Ash heathy open forest on sandstone ridges of the upper Blue Mountains, Sydney Basin Bioregion	Good	0.93
1248: Sydney Peppermint - Silvertop Ash heathy open forest on sandstone ridges of the upper Blue Mountains, Sydney Basin Bioregion	Moderate	1.57
*1071: Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion	-	0.10
Cleared Land	-	0.14
Total		**2.74**

** PCT identified is considered best-fit as the vegetation occurs within an artificial wetland*

3.1.1.1. Sydney Peppermint - Silvertop Ash Heathy Open Forest (PCT 1248)

This PCT is the dominant vegetation type within the VMP Area, and has been affected by the 2019/2020 bushfires. This PCT is characterised by a canopy of *Eucalyptus piperita* (Sydney Peppermint), with other canopy species such as *Eucalyptus sieberi* (Silvertop Ash), *Eucalyptus globoidea* (White Stringybark) and *Eucalyptus oreades* (Blue Mountains Ash) occurring less frequently. This PCT contains a diverse shrub layer and includes *Leptospermum trinervium* (Slender Tea-tree), *Leptospermum polygalifolium* (Tantoon), *Lomatia silaifolia* (Crinkle Bush), *Isopogon anemonifolius* (Broad-leaf Drumsticks), *Hakea dactyloides* (Finger Hakea), *Daviesia latifolia* (Bitter-pea), *Persoonia lanceolata* (Lance Leaf Geebung), *Acacia terminalis* (Sunshine Wattle), and *Amperea xiphoclada*. A ground layer comprise a number of grasses and forbs, including Austrostipa rudis, Echinopogon caespitosus (Bushy Hedgehog-grass), Gahnia sieberiana (Red-fruit Saw-sedge), Lomandra glauca (Pale Mat-rush), *Pteridium esculentum* (Bracken), *Dampiera stricta*, *Dianella revoluta* (Blueberry Lily), *Goodenia bellidifolia* subsp. *bellidifolia*, *Poranthera microphylla* (Small Poranthera), *Wahlenbergia gracilis* (Sprawling Bluebell) and *Xanthosia pilosa* (Woolly Xanthosia).

Within the VMP Area, this PCT occurs in two broad condition states, being 'intact' and 'moderate'. The intact condition state comprises relatively undisturbed areas (**Photograph 1**), whilst the moderate condition state comprises areas that have had landform modifications (**Photograph 2**).

Photograph 1 PCT 1248 (Intact Condition) within the VMP Area

Photograph 2 PCT 1248 (Moderate Condition) within the VMP Area

3.1.1.2. Phragmites australis and Typha orientalis Coastal Freshwater Wetlands (PCT 1071)

This PCT comprises an artificial wetland in the northern portion of the VMP Area. An existing excavated area has filled with water and native vegetation has established within this area, particularly at the fringes of the wetland. The characteristic species within this PCT is *Typha orientalis* (Broad-leaved Cumbungi). An example of this PCT within the VMP Area is shown in **Photograph 3**.

Photograph 3 PCT 1071 within the VMP Area

3.1.1.3. Cleared Land

A number of areas of cleared land occur within the VMP Area and comprise land that was previously quarried or utilised for access. An example of the cleared land within the VMP Area is shown in **Photograph 4**.

Photograph 4 Cleared land within the VMP Area

3.1.2. Flora Species

Over 200 flora species have been recorded within the subject land and surrounding areas. One priority weed, *Cytisus scoparius* subsp. *scoparius* (English Broom), listed under the Biosecurity Act for the Lithgow Local Government Area was recorded within the VMP Area. This species is also classified as a Weed of National Significance. Other weeds recorded within the VMP Area include Pampas Grass (*Cortaderia selloana*), African Lovegrass (*Eragrostis curvula*), *Gamochaeta americana* (Purple Cudweed), *Hypochoeris radicata* (Catsear), *Petrorhagia dubia*, *Sonchus oleraceus* (Common Sowthistle).

No threatened flora species have been recorded within the VMP Area or adjoining areas.

3.1.3. Fauna Habitat

The following broad fauna habitat type have been identified within the VMP Area:

- Regenerating vegetation;
- Intact native vegetation; and
- Quarry voids (aquatic):

Extensive connectivity occurs from the VMP Area through to other areas of the Blue Mountains National Park.

3.1.4. Fauna Species

A suite of native fauna species have been recorded across the subject land and adjoining areas, including six frog species, 30 bird species, six dragonfly and damselfly species, four terrestrial mammal species, three bat species and eight reptile species. A further two bat species had possible call recordings. No introduced fauna species were detected.

One threatened fauna species, the Large Bent-winged Bat (*Miniopterus orianae oceanensis*) had a possible call recording within the study area. The Large Bent-winged Bat is listed as Vulnerable under the BC Act.

4. Management Zones

The following management zones have been identified for the VMP Area:

- Management Zone 1 (MZ1) – 0.08 ha;
- Management Zone 2 (MZ2) – 0.03 ha; and
- Management Zone 3 (MZ3) – 2.63 ha.

The location of each management zone is shown in **Figure 2**. The management objectives of each management zone are summarised below.

4.1. Management Zone 1

This management zone comprises land that is proposed for ongoing use as an access road during Stage 1 of the Project. Following completion of Stage 1, this area of land will be managed to restore native vegetation. This management zone will therefore be managed in two phases, phase 1 being during Stage 1 of the Project, and phase 2 being after the completion of Stage 1.

The objectives for MZ1 include:

- Phase 1:
  - Protection of adjoining vegetation from inadvertent impacts through the implementation of fencing, and erosion and sediment control;
  - Removal of exotic species to prevent spread into adjoining areas;
- Phase 2:
  - Rehabilitation of landform through removal of road base and emplacement of soils;
  - Revegetation via planting of native canopy, shrub and ground layers;
  - Removal of exotic species within revegetation areas.

4.2. Management Zone 2

This management zone comprises land that is currently cleared and largely devoid of native vegetation.

The objectives for MZ2 include:

- Protection of adjoining vegetation from inadvertent impacts through the implementation of fencing, and erosion and sediment control;
- Reinstatement of habitat features;
- Removal of exotic species to facilitate natural regeneration of native species;
- Revegetation via planting of native canopy, shrub and ground layers;
- Utilising locally indigenous species of local provenance for plantings;

4.3. Management Zone 3

This management zone comprises land that is contains intact or modified native vegetation. Due to the presence of native vegetation within this management zone (PCT 1248 and PCT 1071), limited management actions are required.

The objectives for MZ3 include:

- Protection of adjoining vegetation from inadvertent impacts through the implementation of fencing, and erosion and sediment control; and
- Removal of exotic species to prevent spread into adjoining areas.

5. Vegetation Protection Plan

The Project has the potential to result in a number of indirect impacts to adjoining vegetation, including to the VMP Area. This chapter outlines the general vegetation protection measures to be undertaken to further minimise these indirect impacts beyond what is proposed for the Project. A suite of other mitigation measures will be undertaken within the project area which will be undertaken in accordance with the Construction Environmental Management Plan (CEMP) to be prepared for the Project. These measures include, but are not limited to environmental inductions, implementation of a flora and fauna management sub-plan, dust management, vegetation clearing protocols, pathogen management, erosion and sedimentation controls, weed management and habitat features salvage. The project area will also be rehabilitated following reprofiling of the land to a condition closely representing the original vegetation.

5.1. Fencing

Due to the interface between the Project and the Blue Mountains National Park, there is a requirement to manage access for both safety and biodiversity management. Fencing for the Project will be undertaken as follows:

- Maintain existing fence that insects the VMP Area during Stage 1 of the Project (to be removed once all boundary fencing established);
- Establish a new permanent boundary fence along the eastern boundary of the subject land from the northern end to the start of the MZ1 boundary;
- Establish temporary fencing between MZ1 and adjoining areas of MZ2 and MZ3 (to be removed once all permanent boundary fencing established); and
- Establish a new permanent boundary fence along the eastern boundary of the subject land following completion of Stage 1 of the Project.

The fencing plan for the VMP Area is shown in **Figure 4**.

5.2. Erosion and Sediment Control

Erosion and sedimentation from the project area into adjacent vegetation has the potential to smother vegetation, and facilitate weed invasion through the introduction of weed seeds and nutrients that favour weed species. This potential impact will be avoided through the implementation of appropriate erosion and sediment control measures such as:

- Installation and maintenance of sediment fences at the interface to the VMP Area prior to the commencement of the Project. During Stage 1 of the Project, instead of being located at the interface between the subject land and VMP Area, these fences will be located at the interface between MZ1 and the adjoining management zones;
- Relocation of the access road following completion of Stage 1 of the Project; and
- Progressive rehabilitation of the project area.

Specifications of erosion and sediment control measures for the Project will be detailed within the CEMP to be prepared for the Project. Erosion and sediment control measures are to be regularly inspected, particularly following rainfall events, to ensure their ongoing functionality.

5.3. Pathogen Management

A baseline study for pathogens, including Cinnamon Fungus (*Phytophthora cinnamomi*) and Myrtle Rust (*Austropuccinia psidii*), will be undertaken within the VMP Area. Annual testing will also be undertaken for the duration of the Project.

If detected, current hygiene procedures and guidelines will be followed. This may include the *Hygiene guidelines: Protocols to protect priority biodiversity areas in NSW from Phytophthora cinnamomi, myrtle rust, amphibian chyrtid fungus and invasive plants* (DPIE 2020). Measures would likely involve the disinfection of all machinery, clothing (such as boots and gloves) and tools which have been in contact with soil in the vicinity of the pathogen prior to entering and leaving the VMP Area.

A vehicle wash down area will be established at entry points to the pathogen affected areas and all vehicles entering these areas will be required to be hosed down prior to entry. Shoes will also be disinfected. The wash down area will remain in place until the affected area is no longer utilised, or further testing determined the pathogen is no longer present.

Recommended disinfectant products include:

- Non corrosive disinfectants including Coolacide®, Phytoclean®, or Biogram® for cleaning footwear, tools, tyres, machinery and other items in contact with soil;
- 70% Methylated spirits solution in a spray bottle which is suitable for personal use (clothing); and
- Sodium hypochlorite 1%, which is effective, but can damage clothing and degrades rapidly in light.

In order to prevent the introduction of pathogens from outside the VMP Area, all machinery and vehicles entering the VMP Area will also be required to be disinfected following the procedures outlined above. A wash down area will be established at the entry to the VMP Area and all vehicles entering will be washed down.

Specifications of soil pathogen management for the project area will be detailed within the Construction Environmental Management Plan to be prepared for the Project.

6. Habitat Reinstatement Plan

A selection of habitat features will be salvaged from within the project area for re-use within MZ2. Habitat features to be re-used within MZ2 include:

- Hollow-bearing trees (if found during pre-clearance surveys); and
- Fallen timber; and
- Bushrock.

Re-use of salvaged items will occur as follows:

- Hollow-bearing trees/fallen timber: Features will be placed on the ground, on leaning against mature trees (if present) to increase the structural complexity of habitat. Piles are to be avoided.
- Bush rock: Bush rocks will be placed on the ground to increase the structural complexity of habitat. Bush rocks may be place in small piles

7. Weed Management Plan

7.1.1. Objectives

The VMP Area contains a number of weeds and others are known from the subject land and surrounds. Works associated with the rehabilitation of the landform within the VMP Area and future development of the Project has the potential to contribute to the spread of exotic species into the VMP Area. The objectives of weed management in the VMP Area are to control the existing weeds that occur in order to facilitate the recovery of the native vegetation present and to prevent the establishment of any additional weed species, through ongoing maintenance. The weed management proposed within the VMP Area will complement the weed management that will be undertaken within the project area.

7.1.2. Relevant Legislation

Under the Biosecurity Act all weeds are required to be controlled by all persons under a "General Biosecurity Duty". The General Biosecurity Duty means that all public and private land owners or managers and all other people who deal with weed species (biosecurity matters) must use the most appropriate approach to prevent, eliminate, or minimise the negative impact (biosecurity risk) of those weeds (DPI 2017). The power for enforcement of penalties relating to compliance with the legislation is given to Local Control Authorities (i.e. Local Governments).

State-wide management of weeds under the Biosecurity Act is directed by the NSW Invasive Species Plan (DPI 2018). Weed responses are assigned to four categories:

- Prevention of new weeds establishing;
- Eradication of small and localised infestations where feasible;
- Containment of larger infestation to stop wider spread; and
- Protection of key assets, such as threatened plants and agricultural land, to prevent their damage or degradation by weed invasion.

Under the Biosecurity Act some weed species have been prioritised for management by specific regulations and controls under the Act. These are known as State Level Priority Weeds. Specific legal requirements exist for how these weeds are managed.

All land within the VMP Area is within the Central Tablelands Local Land Services region, and weed management within the region is be undertaken under the direction of the *Central Tablelands Regional Strategic Weed Management Plan 2017 – 2022* (LLS: Greater Sydney 2017). Appendix 1 of the plan outlines the State Listed Priority Weeds and Regional Priority Weeds, and Appendix 2 outlines other weeds of concern in the region.

Of the exotic species recorded within the VMP Area, one species *Cytisus scoparius* subsp. *scoparius* (English Broom) is listed as both State Priority Weeds within the *Central Tablelands Regional Strategic Weed Management Plan 2017 – 2022* (LLS: Greater Sydney 2017) and a Weeds of National Significance (WoNS) under the National Weeds Strategy. State-listed Priority weeds have specific legal requirements for management and have higher management priorities.

Weeds recorded within the VMP Area and subject land and surround are detailed in **Table 2**.

Table 2 Weed species recorded within the VMP Area and subject land and surrounds

Scientific Name	Common Name	Status	WoNS	Subject Land and Surrounds	VMP Area
Centaurium erythraea	Common Centaury	-	-	Yes	
Conyza bilbaoana		-	-	Yes	
Conyza bonariensis	Flaxleaf Fleabane	-	-	Yes	
Conyza sumatrensis	Tall fleabane	-	-	Yes	
Cortaderia selloana	Pampas Grass	-	-	Yes	Yes
Cyperus eragrostis	Umbrella Sedge	-	-	Yes	
Cytisus scoparius subsp. *scoparius*	English Broom	SP, RP	Yes	Yes	Yes
Eragrostis curvula	African Lovegrass	OWRC	Yes	Yes	Yes
Erodium cicutarium	Common Crowfoot	-	-	Yes	
Gamochaeta americana	Purple Cudweed	-	-	Yes	Yes
Hakea laurina		-	-	Yes	
Hypochoeris radicata	Catsear	-	-	Yes	Yes
Modiola caroliniana	Red-flowered Mallow	-	-	Yes	
Petrorhagia dubia		-	-	Yes	Yes
Plantago lanceolata	Lamb's Tongues	-	-	Yes	
Senecio madagascariensis	Fireweed	SP, RP	Yes	Yes	
Sida rhombifolia	Paddy's Lucerne	-	Yes	Yes	
Solanum sp.		-	-	Yes	
Sonchus oleraceus	Common Sowthistle	-	-	Yes	Yes
Trifolium subterraneum	Subterranean Clover	-	-	Yes	Yes

Key: SP = State Priority Weed, RP = Regional Priority Weed, OWRC = Other Weeds of Regional Concern, WoNS = Weed of National Significance.

7.2. Best Management Practice

Weed management within the VMP Area will be undertaken in accordance with best management practices to minimise impacts upon existing vegetation and habitats. This includes applying the following:

- The main principles of the Bradley Method of bush regeneration, i.e. not over-clearing (remove only targeted species), employment of minimal disturbance techniques to avoid soil and surrounding vegetation disturbance, and replacement of disturbed mulch/leaf-litter;

- Removal of fruiting/seeding parts of weeds carefully, to minimise spread of plant propagules;
- Use of chemicals and sprays only during suitable weather conditions (i.e. not during wet or windy conditions), and only during appropriate seasons; and
- All equipment should be thoroughly cleaned prior to entering the VMP Area to minimise contamination.

7.3. Weed Control Methods

All weed removal works in the VMP Area should be approached using the strategies outlined below. It is recommended that weed management be undertaken by a Bushland Regeneration Contractor (BRC).

7.3.1. Manual Weed Removal

Manual removal, or hand weeding, is an effective form of weed control when all viable parts of the plant are removed from the soil (roots, fruiting material and rhizomes) and site. All weeds removed by hand will be handled according to best practice bush regeneration techniques to prevent subsequent seed set from the removed weeds, and the unviable plant material will be retained on site to provide mulch and natural leaf litter to protect the soil surface.

7.3.2. Woody Weed Removal

Large woody weed species such as *Cytisus scoparius* subsp. *scoparius* (English Broom) are present within the VMP Area. Recommended removal techniques for this species include:

- The selective spraying of woody weed regrowth, with selective and non-selective herbicides;
- Cutting/scraping and painting deep rooted woody weeds and climbers with hand tools, chainsaws and brush cutters and painting cut stumps with herbicides containing Glyphosate or Picloram; and
- Target drilling and injecting certain large tree weeds with herbicides such as Glyphosate and a Garlon/diesel mix.

7.3.3. Use of Herbicides

All herbicides should be used according to recommendations on the herbicide label. Appropriate Personal Protective Equipment (PPE) should be worn and consideration given to time of day, likelihood of rainfall, wind direction and likely impact on native species as per guidelines on the label. Use of glyphosate will be appropriate for most species. Glyphosate is the preferred herbicide for use in environmentally sensitive areas as it is rapidly broken down by microbes in the soil so residue is short lived and will not affect remnant and planted native individuals in the long-term following application. In areas near water courses, an appropriate form of the herbicide should be used to minimise impact to aquatic life and amphibians. Herbicide use should be avoided within 2 m of the riparian edges. Examples of appropriate herbicide forms are Roundup Biactive and Clearup Bio 360 which have surfactants that are formulated to minimise harm to amphibians. As runoff is a likely way for herbicide residue to enter watercourses, chemical treatment should be avoided prior to or directly after rains.

It is important to note that there can be legal restrictions and permit requirements for use of specific herbicides for specific plants, and chemical labels and permit requirements always need to be researched prior to herbicide application. The relevant permit numbers are PER9907, and PER11916. These permits need to be obtained from the Federal Government body, the Australian Pesticides and Veterinary Management Authority.

Manual removal will be an appropriate form of control for some species, and all chemical treatment should be carried out according to best practice guidelines.

7.3.4. Use of Weed Suppression Materials

Use of weed suppression materials such as jute matting or mulch is not recommended within the VMP Area due to the small size of the area, and absence of dense concentrations of woody weeds, meaning erosion risks following weed removal are likely to be minimal, and presence of native species throughout. These materials suppress native regeneration as well as weed germination.

7.4. Weed Management in the VMP Area

7.4.1. Initial Weed Control

After installation of sediment fencing has been completed initial weed treatment in the VMP Area will commence. Initial weeding will involve treatment/removal of *Cytisus scoparius* subsp. *scoparius* (English Broom) and *Cortaderia selloana* (Pampass Grass), and spot treatment of small groundcover weeds.

Herbicide application will consist of spraying with Glyphosate 360g/L at a concentration of 10 mL herbicide to 1 L of water. This strength is commonly used in bushland regeneration works as it will effectively kill most herbaceous weed species. A marker dye should be used in the herbicide solution to ensure no areas are missed. Knapsack sprayers with a spray cone to direct the spray towards the ground are recommended to be used to prevent herbicide drift into adjacent vegetated areas. Spraying should be adjusted based on on-ground conditions and should target areas with weed infestations.

Following the initial spraying, the VMP Area should be left for three weeks to allow time for any treated weeds to die back. After this period, the treated areas should be resprayed with Glyphosate again, with a focus made on treating any exotic plant species that still have green colouring left in foliage, and any juvenile germinated exotic grasses.

7.4.2. Ongoing Weed Maintenance

The most cost and time effective method of controlling weed regrowth will be by spraying a non-selective Glyphosate herbicide. This is only to be used for large infestations. If targeting individual weeds, then wick wiping/direct press techniques are advisable.

Ongoing maintenance of the VMP Area should occur for the duration of the Project to diminish the soil seed bank of exotic weed species present. In order to eliminate the occurrence of these species they need to be controlled before they have a chance to set seed, otherwise progress will not be made.

It is important during site visits for ongoing weed maintenance that as many weed species as possible are controlled. This will minimise maturity and set seed of weeds between site visits. During site visits for weed control, Priority Weeds and WoNS must be prioritised for control. Individual plants of these species on site should not be allowed to achieve a reproductive stage in their life cycles.

8. Revegetation Plan

8.1. Introduction

The objectives of this revegetation plan are to provide details of the measures that will be implemented to restore the vegetation within MZ1 and MZ2. The revegetation works will seek to restore the previously occurring PCT 1248 Sydney Peppermint - Silvertop Ash heathy open forest.

8.2. Revegetation Preparation

Preparation for revegetation of the VMP Area will require the treatment of soils, and the installation of protective plant fencing. Recommended revegetation strategies include:

- Initial and ongoing control of weeds and competing grasses using bushland regeneration techniques and conventional best practice chemical and physical strategies as outlined in **Chapter 6**;
- Treatment of soils within each planted tube stock plant hole with a plant establishment aid that contains a mix of materials such as slow and quick release fertilisers, water holding crystals, rooting hormones and wetting agents, (i.e. products such as Terra Cottem by TC Advantage Pty Ltd or Sure Start by Barmac). These agents assist in establishing newly installed plants and can reduce establishment watering resources by up to 50%;
- Stabilising soils and suppressing weeds around individual plantings using products, such as 40 cm square jute fibre mats or woodchip leaf mulch to a 50 cm diameter and 75 mm depth; and
- Protecting individual tree and shrub plantings with a tree guard from feral animal grazing, frost and maintenance herbicide spraying overspray. Bamboo stakes 3 x 10-12 mm x 750 mm and 1 x 350 mm x 450 mm plastic tree guards are suitable for this purpose.

8.3. Recommended Revegetation Techniques

8.3.1. Species Selection

Appropriate plant species for PCT 1248 are provided in **Appendix A** and are to be used for revegetation of MZ1. Plants will be sourced from local provenance stock and may be sourced from seed collections or cuttings from within the existing vegetation within the subject land or from commercially sourced tube stock.

It is recommended that a mix of local native trees, shrubs, and ground layer plants are replanted at the specified densities outlined below. All plants must be disease and pest-free, hardened off and well-watered at the time of planting. All plants are to be provided in a healthy condition. They must have good root development and a sturdy shoot system.

Final species selection will be based upon:

- Availability of seed material;
- Exclusion of plants likely to naturally regenerate on the site; and
- Previous experience with species re-vegetation performance.

As many species as are able to be sourced should be planted to maximise the species richness within the VMP Area. The minimum numbers of species to be used in the initial establishment phase of the revegetation are:

- 3 canopy tree species;
- 12 subcanopy or shrub layer species; and
- 4 grasses/graminoids;
- 5 forbs;
- 1 fern; and
- 3 other species (i.e. vines and twiners).

8.3.2. Planting Densities

Differential cover of shrubs provides a greater diversity of fauna habitat, particularly for some small, woodland birds which forage in grassy areas and shelter in shrub thickets. Trees and shrubs should be planted unevenly in patches to mimic natural distribution.

MZ1 for the most part is devoid of canopy species, and vegetation is in poor quality, currently dominated by exotic species in some areas, and as such revegetation will be required of all strata.

The recommended planting specifications for PCT 1248 in MZ1 are:

- Canopy Trees @ 1 unit / 10 m^2;
- Shrubs @ 2 units / 10 m^2 (can be differentially spaced across the zone in thickets); and
- Groundcovers @ 6 units / 1 m^2 planted in clumps/thickets or singly.

Due regard will be given to existing native species in each stratum and plantings are only required in areas with less than the above recommended planting densities.

8.3.3. Species Richness of Plantings

The goal of revegetation should be to reach 50% of the species richness benchmark for PCT 1248 five years post commencement of revegetation works. The benchmark for PCT 1248 is five tree species, 23 shrub species, seven grasses/graminoids, nine forb species, two ferns, and five other species (i.e. vines and twiners). It is recognised that the ability to match benchmark species richness will be dependent on stock able to be obtained from local nurseries.

8.3.4. Characteristic Planting Units

Species should be planted in characteristic planting units to correspond with the topology, aspect, soil type and proximity to water. Grasses may be planted in clumps of three or more (spaced 15–20 cm apart within clumps) to generate physical / structural support for each other and microclimates. Wind pollinated grasses may be particularly planted in clumps to aid fertilisation and to create a natural grassland understorey within the restoration areas. Trees and shrubs should be planted unevenly in patches to mimic natural distribution.

8.3.5. Plant Supply

Any tube stock will be purchased of local provenance native plants identified in **Appendix A**. In the event that the required quantities of tube stock are not available then it may be necessary to collect or source suitable quantities of local native seed for the propagation.

Local native plant propagules should be collected using principles prescribed in 'Bringing the Bush back to Western Sydney' (DIPNR 2003). Seeds and vegetative propagules should be of local provenance from within the Lithgow LGA, preferably from within 10 km of the VMP Area. Material should be propagated in a local commercial or community nursery, with well-established plants used for revegetation, for trees and shrub species particularly. It may be necessary to get the required amounts of seed and vegetative material contract-collected and grown-on by specialist nurseries. Local native plants should be grown in "Hiko" tube, maxi cell or viro-tube, or Forestry Tube-type containers.

8.4. Maintenance

After planting works have been completed, treated areas in both zones should be maintained by appropriately qualified personnel, selectively spot spraying and hand weeding around native plants, watering plants and replacing dead plants as needed.

Tree guards should remain around all native planted trees and shrubs, for at least 18 months to protect them from herbivory. Rabbits can devastate revegetation areas soon after planting if tree guards are not used. Tree guards will also allow herbicide to be used for control of the majority of regrowth weeds, without damage to native plants by herbicide drift.

The following sequential steps are recommended to manage each area of the VMP Area effectively for each site visit:

- Initially the BRC visiting the revegetation area should sweep from one end of each area to the other. During this sweep weeds occurring within each tree guard alongside native plants should be removed by hand and any weed occurring within a patch of dominant native plants (such as a patch of grasses).
- A member of the team should then sweep the entire VMP Area, spraying all regrowth weeds between native plantings in open areas with herbicide, and spot spraying where possible in all other areas.

Re-growing environmental weeds such as vines, woody trees and shrubs, broadleaf annuals and naturalised grasses should be closely monitored and controlled using ecologically sensitive bushland regeneration hand weeding and spot-spraying methods, to ensure adequate weed control and native plant establishment (refer to **Chapter 6**). Weeding inside each planting tube by hand or selective herbicides will be required, as well as in an approximate 50 cm radius around the outside of each plant and tree guard.

Provision should be made to irrigate areas, as required, in the first three months after establishment (on at least four to five occasions, depending on rainfall conditions, more watering if required, particularly over summer months).

Plants that have died due to drought or pest and disease damage should be replaced as required. Plants that are observed to have died should be replaced by the bushland maintenance team with a planting of the same form.

9. Monitoring and Reporting

9.1. Responsibilities

It is recommended that a project manager from a Bushland Regeneration Contractor (BRC) be assigned to coordinate, supervise, and manage all works and correspondence with respect to the management of the VMP Area. The BRC will be responsible for ensuring the measures outlined in this VMP are implemented. The project manager will become familiar with the VMP Area and surrounds, and progress of all aspects of works undertaken.

The project manager will be responsible for allocation of maintenance tasks to personnel in response to ongoing monitoring results as well as reporting. Regular monitoring and feedback from personnel will assist in the allocation of labour relative to available funds.

9.2. Monitoring

A qualified BRC or ecological consultant will carry out a program of regular monitoring of the implementation of the VMP. General observations of the nature and condition of the VMP Area will be collected, along with the collection of quantitative data within:

- One 5 m x 10m plot within MZ1;
- One 5 m x 10m plots within MZ2; and
- Two 20 m x 20m plots within MZ3.

Indicative locations of monitoring plots are shown in **Figure 5**. Photo reference points should be established in the VMP Area at one corner of each monitoring plot and a photograph shall be taken at each photo reference point facing north, east, south, and west, and one diagonally across the monitoring plot, for a visual assessment of site progress. The following information will be collected within each of the monitoring plots:

- Estimates of the success rate of plantings and natural regeneration, and assessment of plant replacement requirements (MZ1 and MZ2 only);
- Weed coverage in each stratum; and
- Recommendations for corrective measures and/or vegetation management.

The monitoring program will include a monitoring survey will be completed as follows:

- MZ1 and MZ2: Every three months during the two years following revegetation works, and annually for the remainder of the Project; and
- MZ3: Annually for the duration of the Project (i.e. 15 years).

9.3. Reporting

A brief and concise report will be prepared annually based on the findings of the monitoring visits. The report will be prepared by a BRC or ecological consultant and forwarded to NPWS at the end of each yearly period for the duration of the Project.

Each annual report will:

- Describe the revegetation works undertaken;
- State the findings of the monitoring surveys;
- Discuss any problems encountered in implementing the VMP; and
- Recommend any adaptations or additions to the VMP.

The report will contain site photographs, as well as a short description of weeds in each management zone and a short comparison to the photographs to the previous years. Any other notable occurrences of weeds will also be reported. The report will also recommend and prioritise areas where weed control should be targeted for the following maintenance period.

10. Timing and Responsibilities

Timing and responsibilities at each component of the VMP Area are shown within **Table 3** along with performance criteria.

Table 3 Timing, responsibilities, and performance criteria

Management Area	Action	Responsibility	Performance Criteria	Timing
Vegetation Protection Works				
VMP Area	Establish new permanent boundary fence along the eastern boundary of the subject land from the northern end to the start of the MZ1 boundary	Construction Subcontractor	Permanent boundary fence erected	Before construction works commence
VMP Area	Establish temporary fencing between MZ1 and adjoining areas of MZ2 and MZ3	Construction Subcontractor	Temporary boundary fence erected	Before construction works commence
VMP Area	Establish a new permanent boundary fence along the eastern boundary of the subject land	Construction Subcontractor	Permanent boundary fence erected	Following completion of Stage 1 of the Project
VMP Area (and adjacent areas)	Removal of existing fence that intersects the VMP Area	Construction Subcontractor	Existing fence removed	Following establishment of all permanent fencing
VMP Area	Installation of sediment fences at the interface to the VMP Area	Construction Subcontractor	Erosion and sediment control measures installed	Prior to construction
VMP Area	Maintenance of sediment fences at the interface to the VMP Area	Construction Subcontractor	Erosion and sediment control measures maintained	Duration of the Project
VMP Area	Conduct baseline study for pathogens	Subcontractor	Baseline study of pathogens conducted	Before construction works commence
VMP Area	Conduct annual testing for pathogens	Subcontractor	Annual testing for pathogens completed	Duration of the Project

Management Area	Action	Responsibility	Performance Criteria	Timing
Habitat Reinstatement Works				
MZ2	Salvaged habitat features reused within MZ2	Construction Subcontractor	Habitat features reinstated in accordance with Chapter 6	Prior to commencement of revegetation works within MZ2
Weed Management				
MZ1	Carry out initial weed control	BRC	Main weed infestations removed, including Priority Weeds	Within 2 months of Project commencement
MZ2	Carry out initial weed control	BRC	Main weed infestations removed, including Priority Weeds	Within 2 months of Project commencement
MZ3	Carry out initial weed control	BRC	Main weed infestations removed, including Priority Weeds	Within 2 months of Project commencement
MZ1	Carry out maintenance weed control	BRC	Weed regrowth following initial weeding removed. Weed coverage should be < 20% at end of first year of maintenance, < 10% at end of second year, < 5% at end of third year onwards.	Six monthly, until the completion of Stage 1. Six monthly following commencement of revegetation works for five years. Annually after the first five years following commencement of revegetation works until completion of the Project (i.e. 15 years post commencement).
MZ2	Carry out maintenance weed control	BRC	Weed regrowth following initial weeding removed. Weed coverage should be < 20% at end of first year of maintenance, < 10% at end of second year, < 5% at end of third year onwards.	Six monthly following commencement of revegetation works for five years. Annually after the first five years following commencement of revegetation works until completion of the Project (i.e. 15 years post commencement)
MZ3	Carry out maintenance weed control	BRC	Weed regrowth following initial weeding removed.	Six monthly for the first five years of management.

Management Area	Action	Responsibility	Performance Criteria	Timing
			Weed coverage should be < 20% at end of first year of maintenance, < 10% at end of second year, < 5% at end of third year onwards.	Annually until the completion of the Project (i.e. 15 years post commencement).
Revegetation Works				
MZ1	Carry out initial weed control	BRC	As above (Weed Management).	As above (Weed Management).
MZ2	Carry out initial weed control	BRC	As above (Weed Management).	As above (Weed Management).
MZ1	Revegetate with trees, shrubs and ground cover species	BRC	Native plants have been planted (species from **Appendix A**) in all vegetation strata. Species richness targets in ***Section 8.3.3*** met	Within 2 months of initial weed management following completion of Stage 1 of the Project
MZ2	Revegetate with trees, shrubs and ground cover species	BRC	Native plants have been planted (species from **Appendix A**) in all vegetation strata. Species richness targets in ***Section 8.3.3*** met	Within 2 months of initial weed management following commencement of the Project
MZ1 and MZ2	Irrigate revegetation areas	BRC	Revegetation areas irrigated	At least four or five occasions within the first 3 months following revegetation (depending on rainfall)
MZ1 and MZ2	Carry out maintenance weed control	BRC	Weeds removed from tree guards. Weed growth minimised or controlled	Every six months for the duration of the Project
MZ1 and MZ2	Maintenance of plantings (if required)	BRC	Any dead plantings replaced	Every 3 months for the first two years following revegetation
Monitoring and Reporting				
VMP Area	Establish fixed monitoring plots	BRC or Ecologist	Using star pickets (or something smaller like a small stake and pink	At commencement of revegetation works (MZ1 and MZ2), or at

Management Area	Action	Responsibility	Performance Criteria	Timing
			flagging) and GPS establish monitoring plots in accordance with Chapter 9	commencement of the Project (MZ3)
VMP Area	Monitoring of revegetation works	BRC or Ecologist	Site inspection completed as outlined in Chapter 9	Every 3 months for two years following commencement of revegetation works.
VMP Area	Annual monitoring	BRC or Ecologist	Site inspection completed as outlined in Chapter 9	Once a year for the duration of the Project.
VMP Area	Progress report preparation	BRC or Ecologist	Annual Report prepared on progress of VMP works, and outline of further works needed	Once a year for the 5-year maintenance period of VMP
VMP Area	Final Inspection of Site	BRC or Ecologist	Final inspection carried out at completion of Project	After completion of the Project
VMP Area	Final Report	BRC or Ecologist	Final report detailing success of VMP works	After completion of the Project

11. References

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APPENDIX A :

Planting List

Table 4 Planting list for revegetation works

Growth Form Group	Family	Scientific Name	Common Name	Recorded in Surrounding Vegetation	BioNet Vegetation Classification
Tree (TG)	Cunoniaceae	*Ceratopetalum gummiferum*	Christmas Bush	X	
Tree (TG)	Myrtaceae	*Eucalyptus blaxlandii*	Blaxland's Stringybark	X	
Tree (TG)	Myrtaceae	*Eucalyptus globoidea*	White Stringybark	X	
Tree (TG)	Myrtaceae	*Eucalyptus oreades*	Blue Mountains Ash	X	
Tree (TG)	Myrtaceae	*Eucalyptus piperita*	Sydney Peppermint	X	X
Tree (TG)	Myrtaceae	*Eucalyptus radiata subsp. radiata*			X
Tree (TG)	Myrtaceae	*Eucalyptus sclerophylla*	Hard-leaved Scribbly Gum	X	X
Tree (TG)	Myrtaceae	*Eucalyptus sieberi*	Silvertop Ash	X	X
Tree (TG)	Myrtaceae	*Eucalyptus sparsifolia*	Narrow-leaved Stringybark		X
Tree (TG)	Proteaceae	*Banksia serrata*	Old-man Banksia	X	X
Shrub (SG)	Apiaceae	*Platysace lanceolata*	Shrubby Platysace	X	
Shrub (SG)	Apiaceae	*Platysace linearifolia*		X	X
Shrub (SG)	Araliaceae	*Polyscias sambucifolia*	Elderberry Panax	X	
Shrub (SG)	Asteraceae	*Cassinia aculeata*	Dolly Bush	X	
Shrub (SG)	Asteraceae	*Cassinia aculeata subsp. aculeata*		X	
Shrub (SG)	Asteraceae	*Ozothamnus diosmifolius*	White Dogwood	X	
Shrub (SG)	Casuarinaceae	*Allocasuarina nana*	Dwarf She-oak	X	
Shrub (SG)	Dilleniaceae	*Hibbertia obtusifolia*	Hoary Guinea Flower	X	
Shrub (SG)	Ericaceae	*Brachyloma daphnoides*	Daphne Heath	X	

Growth Form Group	Family	Scientific Name	Common Name	Recorded in Surrounding Vegetation	BioNet Vegetation Classification
Shrub (SG)	Ericaceae	*Epacris microphylla*	Coral Heath	X	
Shrub (SG)	Ericaceae	*Epacris pulchella*	Wallum Heath	X	
Shrub (SG)	Ericaceae	*Leucopogon lanceolatus*		X	
Shrub (SG)	Ericaceae	*Leucopogon spp.*		X	
Shrub (SG)	Ericaceae	*Monotoca scoparia*		X	X
Shrub (SG)	Euphorbiaceae	*Amperea xiphoclada*		X	
Shrub (SG)	Fabaceae (Faboideae)	*Bossiaea heterophylla*	Variable Bossiaea		X
Shrub (SG)	Fabaceae (Faboideae)	*Daviesia latifolia*	Bitter-pea	X	
Shrub (SG)	Fabaceae (Faboideae)	*Daviesia ulicifolia*	Gorse Bitter Pea		X
Shrub (SG)	Fabaceae (Faboideae)	*Podolobium scandens*	Netted Shaggy Pea	X	
Shrub (SG)	Fabaceae (Mimosoideae)	*Acacia baileyana*	Cootamundra Wattle	X	
Shrub (SG)	Fabaceae (Mimosoideae)	*Acacia brownii*	Heath Wattle	X	
Shrub (SG)	Fabaceae (Mimosoideae)	*Acacia longifolia*		X	
Shrub (SG)	Fabaceae (Mimosoideae)	*Acacia longifolia var. longifolia*	Sydney Golden Wattle	X	
Shrub (SG)	Fabaceae (Mimosoideae)	*Acacia spp.*	Wattle	X	
Shrub (SG)	Fabaceae (Mimosoideae)	*Acacia terminalis*	Sunshine Wattle	X	

Growth Form Group	Family	Scientific Name	Common Name	Recorded in Surrounding Vegetation	BioNet Vegetation Classification
Shrub (SG)	Fabaceae (Mimosoideae)	*Acacia ulicifolia*	Prickly Moses	X	
Shrub (SG)	Myrtaceae	*Baeckea linifolia*	Weeping Baeckea	X	
Shrub (SG)	Myrtaceae	*Leptospermum continentale*	Prickly Teatree	X	
Shrub (SG)	Myrtaceae	*Leptospermum grandifolium*	Woolly Teatree	X	
Shrub (SG)	Myrtaceae	*Leptospermum macrocarpum*		X	
Shrub (SG)	Myrtaceae	*Leptospermum polygalifolium*	Tantoon	X	
Shrub (SG)	Myrtaceae	*Leptospermum rotundifolium*		X	
Shrub (SG)	Myrtaceae	*Leptospermum trinervium*	Slender Tea-tree	X	X
Shrub (SG)	Phyllanthaceae	*Phyllanthus hirtellus*	Thyme Spurge	X	
Shrub (SG)	Polygalaceae	*Comesperma ericinum*	Pyramid Flower	X	
Shrub (SG)	Proteaceae	*Banksia ericifolia var. ericifolia*		X	
Shrub (SG)	Proteaceae	*Banksia marginata*	Silver Banksia	X	
Shrub (SG)	Proteaceae	*Banksia spinulosa*	Hairpin Banksia	X	X
Shrub (SG)	Proteaceae	*Grevillea laurifolia*	Laurel-leaf Grevillea	X	
Shrub (SG)	Proteaceae	*Grevillea rosmarinifolia subsp. rosmarinifolia*	Rosmary Grevillea	X	
Shrub (SG)	Proteaceae	*Hakea dactyloides*	Finger Hakea	X	X
Shrub (SG)	Proteaceae	*Hakea propinqua*		X	
Shrub (SG)	Proteaceae	*Hakea sericea*	Needlebush	X	
Shrub (SG)	Proteaceae	*Isopogon anemonifolius*	Broad-leaf Drumsticks	X	X

Growth Form Group	Family	Scientific Name	Common Name	Recorded in Surrounding Vegetation	BioNet Vegetation Classification
Shrub (SG)	Proteaceae	*Lambertia formosa*	Mountain Devil		X
Shrub (SG)	Proteaceae	*Lomatia silaifolia*	Crinkle Bush	X	X
Shrub (SG)	Proteaceae	*Persoonia chamaepitys*	Mountain Geebung	X	
Shrub (SG)	Proteaceae	*Persoonia lanceolata*	Lance Leaf Geebung	X	
Shrub (SG)	Proteaceae	*Persoonia laurina*	Laurel Geebung		X
Shrub (SG)	Proteaceae	*Persoonia levis*	Broad-leaved Geebung	X	X
Shrub (SG)	Proteaceae	*Persoonia linearis*	Narrow-leaved Geebung	X	
Shrub (SG)	Proteaceae	*Persoonia mollis subsp. mollis*		X	
Shrub (SG)	Proteaceae	*Petrophile canescens*	Conesticks	X	
Shrub (SG)	Proteaceae	*Petrophile pulchella*	Conesticks	X	
Shrub (SG)	Proteaceae	*Telopea speciosissima*	Waratah	X	X
Shrub (SG)	Rhamnaceae	*Pomaderris andromedifoli af. 'andromedifolia'*		X	
Shrub (SG)	Rutaceae	*Boronia microphylla*	Small-leaved Boronia	X	
Other (OG)	Pittosporaceae	*Billardiera scandens*	Hairy Apple Berry	X	
Grass & grasslike (GG)	Cyperaceae	*Caustis flexuosa*	Curly Wig		X
Grass & grasslike (GG)	Cyperaceae	*Eleocharis sphacelata*	Tall Spike Rush	X	
Grass & grasslike (GG)	Cyperaceae	*Gahnia microstachya*		X	
Grass & grasslike (GG)	Cyperaceae	*Gahnia sieberiana*	Red-fruit Saw-sedge	X	
Grass & grasslike (GG)	Cyperaceae	*Lepidosperma laterale*	Variable Sword-sedge	X	
Grass & grasslike (GG)	Cyperaceae	*Lepidosperma limicola*		X	

Growth Form Group	Family	Scientific Name	Common Name	Recorded in Surrounding Vegetation	BioNet Vegetation Classification
Grass & grasslike (GG)	Cyperaceae	*Schoenus spp.*		X	
Grass & grasslike (GG)	Juncaceae	*Juncus spp.*		X	
Grass & grasslike (GG)	Juncaceae	*Juncus usitatus*		X	
Grass & grasslike (GG)	Lomandraceae	*Lomandra cylindrica*		X	
Grass & grasslike (GG)	Lomandraceae	*Lomandra filiformis subsp. filiformis*		X	
Grass & grasslike (GG)	Lomandraceae	*Lomandra glauca*	Pale Mat-rush	X	X
Grass & grasslike (GG)	Lomandraceae	*Lomandra longifolia*	Spiny-headed Mat-rush	X	
Grass & grasslike (GG)	Lomandraceae	*Lomandra longifolia var. longifolia*	Spiny-headed Mat-rush	X	
Grass & grasslike (GG)	Lomandraceae	*Lomandra multiflora subsp. multiflora*	Many-flowered Mat-rush	X	
Grass & grasslike (GG)	Lomandraceae	*Lomandra obliqua*			X
Grass & grasslike (GG)	Poaceae	*Aristida ramosa*	Purple Wiregrass	X	
Grass & grasslike (GG)	Poaceae	*Austrostipa puberula*		X	
Grass & grasslike (GG)	Poaceae	*Austrostipa rudis*		X	
Grass & grasslike (GG)	Poaceae	*Austrostipa rudis subsp. nervosa*		X	
Grass & grasslike (GG)	Poaceae	*Cynodon dactylon*	Common Couch	X	
Grass & grasslike (GG)	Poaceae	*Echinopogon caespitosus*	Bushy Hedgehog-grass	X	
Grass & grasslike (GG)	Poaceae	*Elymus scaber*	Wheatgrass	X	
Grass & grasslike (GG)	Poaceae	*Entolasia stricta*	Wiry Panic	X	X
Grass & grasslike (GG)	Poaceae	*Microlaena stipoides*	Weeping Grass	X	
Grass & grasslike (GG)	Poaceae	*Poa sieberiana*	Snowgrass	X	
Grass & grasslike (GG)	Poaceae	*Rytidosperma pallidum*	Redanther Wallaby Grass	X	

Growth Form Group	Family	Scientific Name	Common Name	Recorded in Surrounding Vegetation	BioNet Vegetation Classification
Grass & grasslike (GG)	Poaceae	*Rytidosperma spp.*		X	
Grass & grasslike (GG)	Poaceae	*Rytidosperma tenuius*		X	
Grass & grasslike (GG)	Restionaceae	*Baloskion australe*		X	
Grass & grasslike (GG)	Restionaceae	*Baloskion gracile*		X	
Grass & grasslike (GG)	Restionaceae	*Empodisma minus*		X	
Grass & grasslike (GG)	Restionaceae	*Eurychorda complanata*		X	
Grass & grasslike (GG)	Restionaceae	*Lepyrodia scariosa*		X	
Grass & grasslike (GG)	Xyridaceae	*Xyris ustulata*	Yellow Flag	X	
Fern (EG)	Gleicheniaceae	*Gleichenia dicarpa*	Pouched Coral Fern	X	
Forb (FG)	Acanthaceae	*Brunoniella australis*	Blue Trumpet	X	
Forb (FG)	Apiaceae	*Daucus glochidiatus*	Native Carrot	X	
Forb (FG)	Apiaceae	*Hydrocotyle tripartita*	Pennywort	X	
Forb (FG)	Apiaceae	*Xanthosia pilosa*	Woolly Xanthosia	X	X
Forb (FG)	Asteraceae	*Arrhenechthites mixta*	Purple Fireweed	X	
Forb (FG)	Asteraceae	*Coronidium scorpioides*	Button Everlasting	X	
Forb (FG)	Asteraceae	*Craspedia variabilis*	Common Billy-buttons	X	
Forb (FG)	Asteraceae	*Euchiton sphaericus*	Star Cudweed	X	
Forb (FG)	Campanulaceae	*Wahlenbergia communis*	Tufted Bluebell	X	
Forb (FG)	Campanulaceae	*Wahlenbergia gracilis*	Sprawling Bluebell	X	
Forb (FG)	Campanulaceae	*Wahlenbergia spp.*	Bluebell	X	
Forb (FG)	Colchicaceae	*Burchardia umbellata*	Milkmaids	X	

Growth Form Group	Family	Scientific Name	Common Name	Recorded in Surrounding Vegetation	BioNet Vegetation Classification
Forb (FG)	Droseraceae	*Drosera peltata*		X	
Forb (FG)	Goodeniaceae	*Dampiera stricta*		X	X
Forb (FG)	Goodeniaceae	*Goodenia bellidifolia subsp. bellidifolia*		X	
Forb (FG)	Goodeniaceae	*Goodenia hederacea*	Ivy Goodenia	X	
Forb (FG)	Goodeniaceae	*Goodenia paniculata*		X	
Forb (FG)	Haemodoraceae	*Haemodorum planifolium*		X	
Forb (FG)	Haloragaceae	*Gonocarpus micranthus*		X	
Forb (FG)	Haloragaceae	*Gonocarpus tetragynus*	Poverty Raspwort	X	
Forb (FG)	Iridaceae	*Patersonia glabrata*	Leafy Purple-flag	X	
Forb (FG)	Iridaceae	*Patersonia sericea*	Silky Purple-Flag	X	X
Forb (FG)	Linaceae	*Linum marginale*	Native Flax	X	
Forb (FG)	Orchidaceae	*Diuris pardina*	Leopard Orchid	X	
Forb (FG)	Orchidaceae	*Microtis spp.*		X	
Forb (FG)	Orchidaceae	*Prasophyllum spp.*		X	
Forb (FG)	Orchidaceae	*Thelymitra ixioides*	Dotted Sun Orchid	X	
Forb (FG)	Orchidaceae	*Thelymitra spp.*		X	
Forb (FG)	Phormiaceae	*Dianella revoluta*	Blueberry Lily	X	
Forb (FG)	Phormiaceae	*Dianella revoluta var. revoluta*		X	
Forb (FG)	Phyllanthaceae	*Poranthera microphylla*	Small Poranthera	X	
Forb (FG)	Rubiaceae	*Opercularia hispida*	Hairy Stinkweed	X	
Forb (FG)	Rubiaceae	*Opercularia varia*	Variable Stinkweed	X	

Growth Form Group	Family	Scientific Name	Common Name	Recorded in Surrounding Vegetation	BioNet Vegetation Classification
Forb (FG)	Rubiaceae	*Pomax umbellata*	Pomax	X	
Forb (FG)	Stackhousiaceae	*Stackhousia viminea*	Slender Stackhousia	X	
Forb (FG)	Violaceae	*Hybanthus monopetalus*	Slender Violet-bush	X	
Forb (FG)	Violaceae	*Hybanthus vernonii*		X	
Forb (FG)	Violaceae	*Viola silicestris*		X	
Fern (EG)	Dennstaedtiaceae	*Pteridium esculentum*	Bracken	X	X

FIGURES

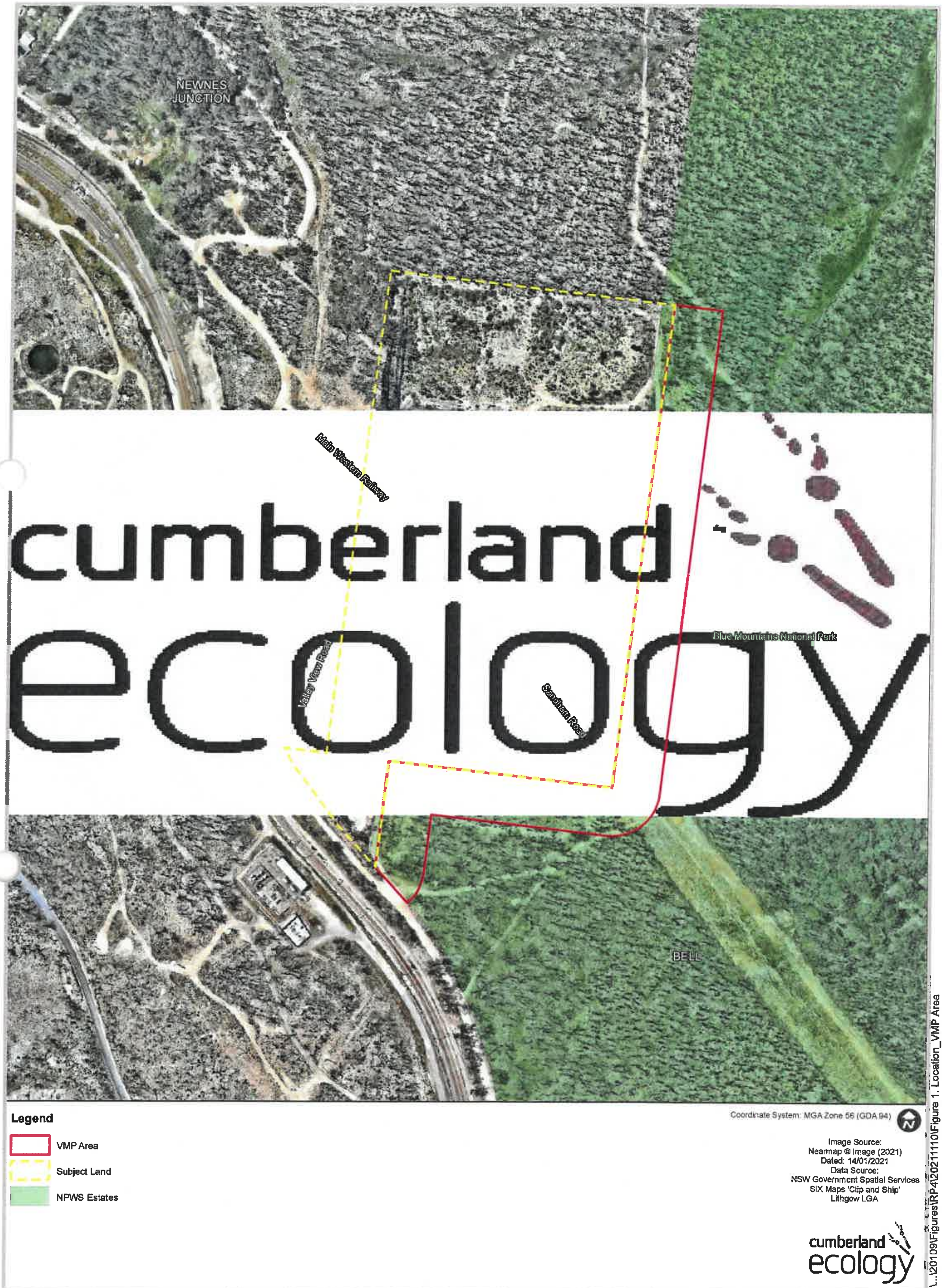


Figure 1. Location of the VMP Area

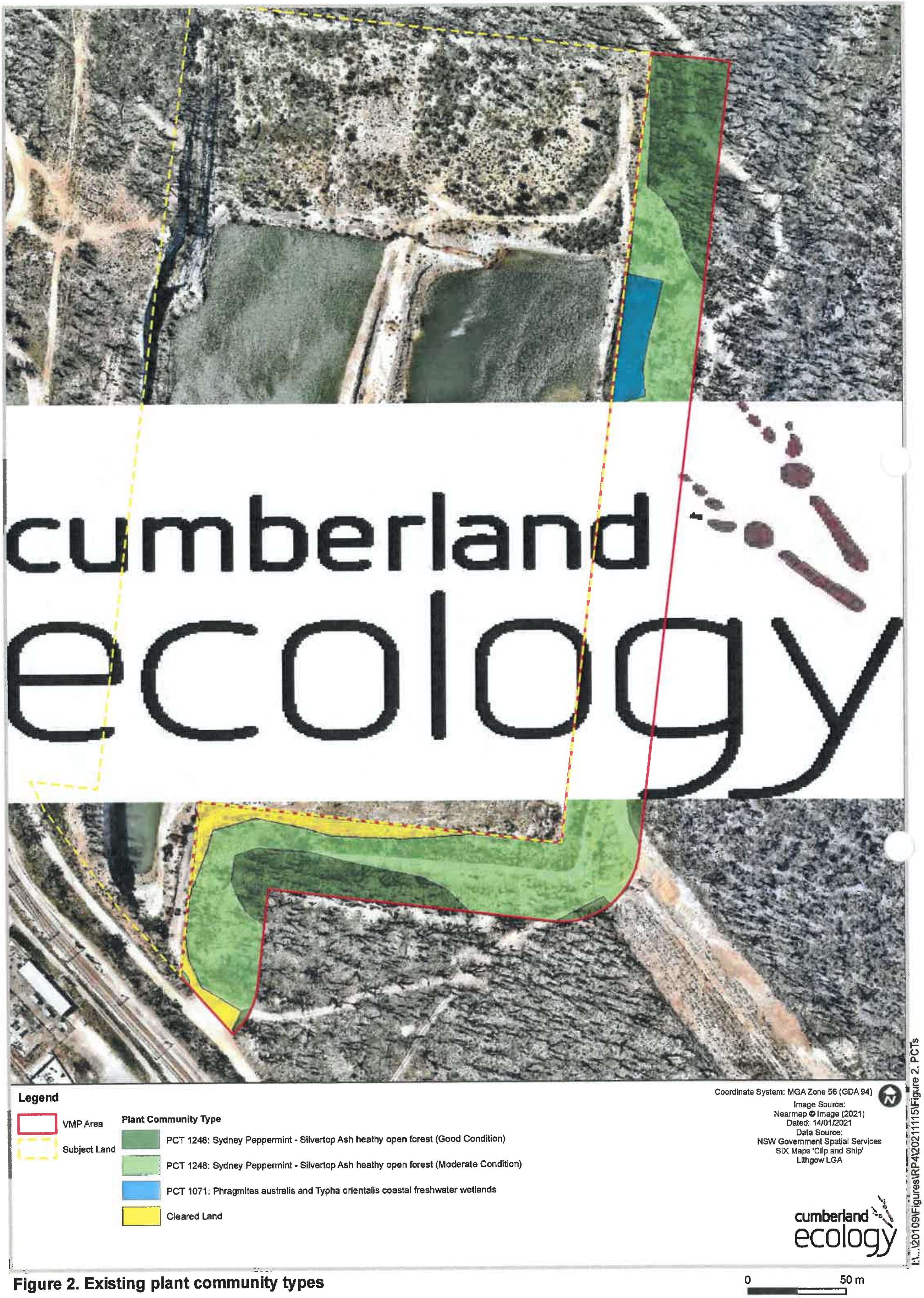
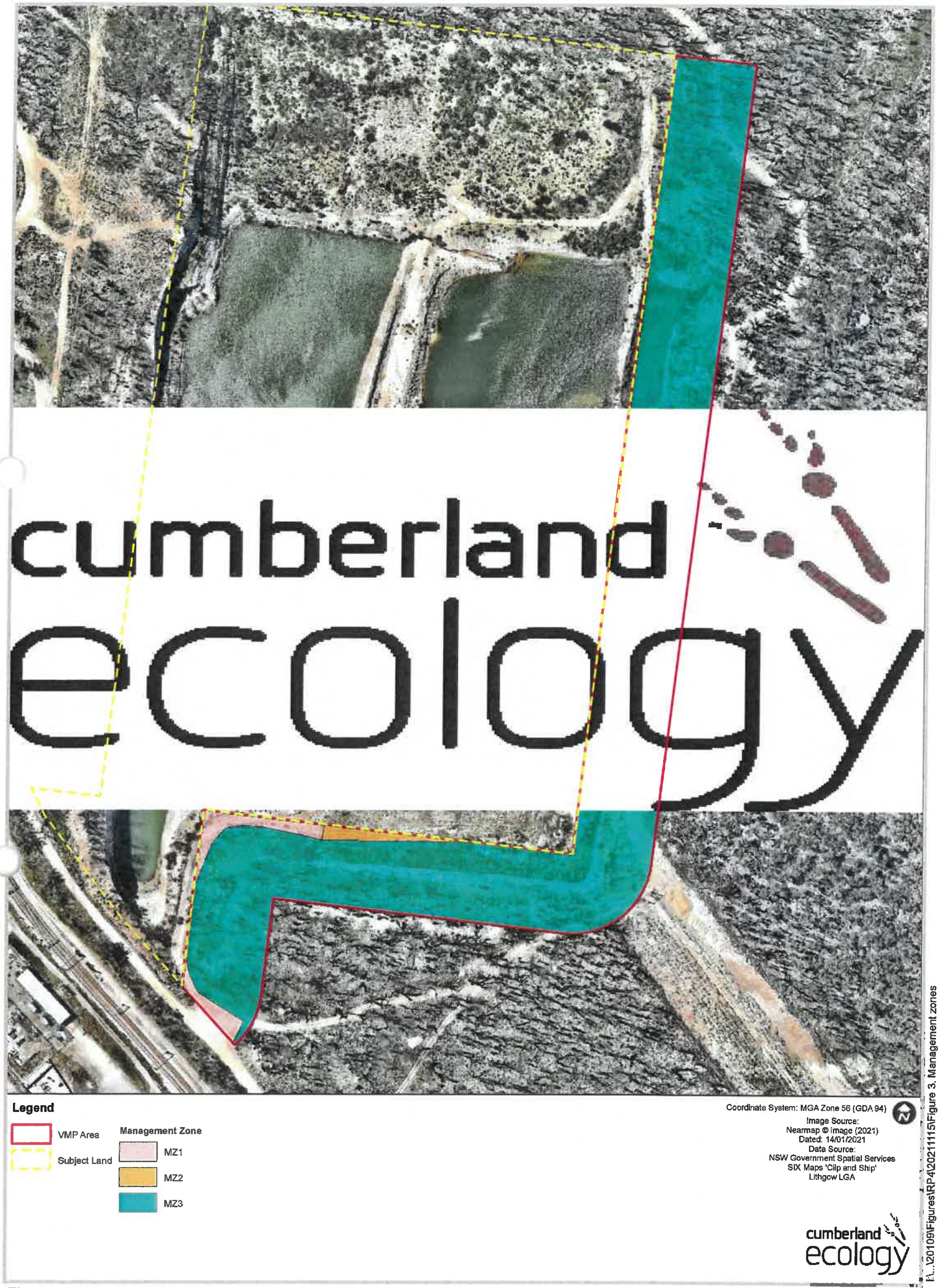


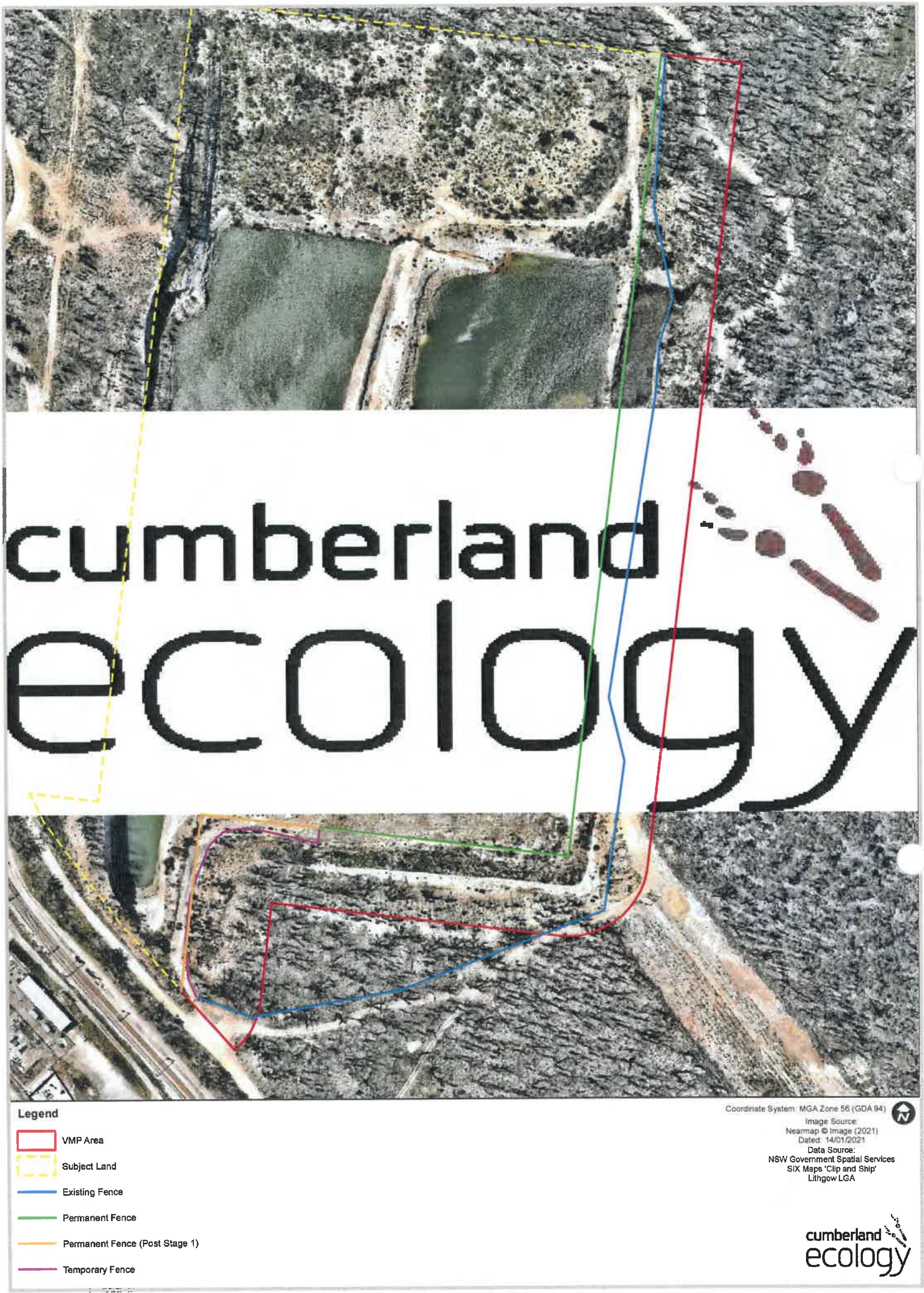
Figure 2. Existing plant community types



Coordinate System: MGA Zone 56 (GDA 94)
Image Source:
Nearmap © image (2021)
Dated: 14/01/2021
Data Source:
NSW Government Spatial Services
SIX Maps 'Clip and Ship'
Lithgow LGA

I:\...\20109\Figures\RP4\20211115\Figure 3. Management zones

Figure 3. Management zones



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SIX Maps 'Clip and Ship'
Lithgow LGA

I:\...\20109\Figures\RP4\20211110\Figure 4. Fencing plan

Figure 4. Fencing plan

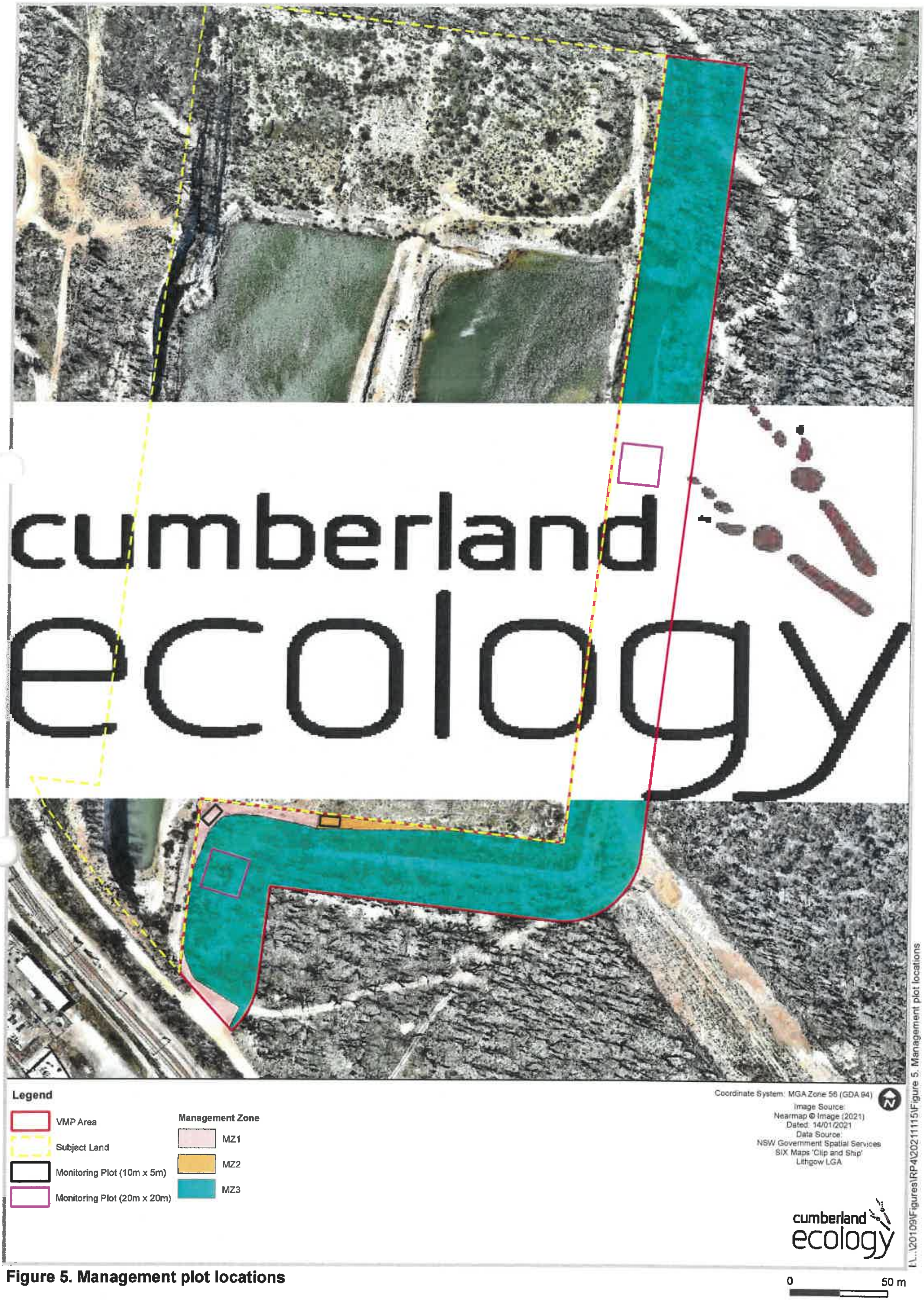

Figure 5. Management plot locations

Rehabilitation of the Former Bell Quarry - DA 294/19

Ecological Monitoring Plan

HWL Ebsworth Lawyers

16 November 2021

Final

cumberland ecology

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Report No. 20109RP3

Version	Date Issued	Amended by	Details
1	16 November 2021		Final issued for submission

Approved by:	**Dr David Robertson**
Position:	Director
Signed:	David Robertson
Date:	16 November, 2021

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Glossary

Term / Abbreviation	Definition
BAM	Biodiversity Assessment Method
BQRP	Bell Quarry Rehabilitation Project Pty Ltd
Council	Lithgow City Council
DA	Development Application
dbh	Diameter at Breast Height
DPE	NSW Department of Planning and Environment
EIS	Environmental Impact Statement
ENM	Excavated natural material
EP&A Act	NSW *Environmental Planning and Assessment Act 1979*
EPA	NSW Environment Protection Authority
EPL	Environment Protection Licence
GBMWHA	Greater Blue Mountains World Heritage Area
GDE	Groundwater dependent ecosystem
NSW	New South Wales
OEH	NSW Office of Environment and Heritage
the Project	The Bell Quarry Rehabilitation Project
SEARs	Secretary's Environmental Assessment Requirements
TARP	Trigger Action Response Plan
Subject land	Lot 23 DP 751631
VENM	Virgin excavated natural material
WRPP	Western Regional Planning Panel

1. Introduction

Cumberland Ecology has been requested by HWL Ebsworth Lawyers on behalf of Bell Quarry Rehabilitation Project Pty Ltd (BQRP) to prepare an ecological monitoring plan for the Bell Quarry Rehabilitation Project (the 'Project'). The Project sought designated and integrated development consent under Part 4 of the New South Wales (NSW) *Environmental Planning and Assessment Act 1979* (EP&A Act). The Development Application (DA) for the Project was refused by the Western Regional Planning Panel (WRPP) in April 2020. This ecological monitoring plan is required to address the following recommendation proposed by OEH (2019):

> *Recommendation 5. A detailed monitoring plan, incorporating a Trigger Action Response Plan, be developed for the project which addresses all potentially detrimental impacts (including surface and ground water levels and quality, pathogens, weeds and rehabilitation).*

1.1. Purpose

The purpose of this document is to provide a detailed ecological monitoring plan to monitor the potential detrimental impacts of the Project. This ecological monitoring plan includes monitoring of the following:

- Weed invasion;
- Pathogens; and
- Rehabilitation.

The plan also includes performance criteria for each of the above items, and a Trigger Action Response Plan (TARP).

The plan applies to the entirety of the study area as shown in **Figure 1**. Any works undertaken within the Blue Mountains National Park are required to be subject to a licence issued under the *National Parks and Wildlife Act 1974*.

A separate Water Management Plan will be developed to address management and monitoring requirements in relation to water resources (surface water and groundwater levels and quality).

1.2. Project Background

1.2.1. Site Background

Bell Quarry is located on Sandham Road, Dargan, approximately 10 km east of Lithgow, New South Wales (NSW) (the 'subject land') (**Figure 1**). The quarry was in operation under existing use rights between 1967 and 1994, and subsequently operated under a DA approval from Lithgow City Council (Council) and an Environment Protection Licence (EPL) issued by the NSW Environment Protection Authority (EPA) (GHD 2018b). Active operations with the quarry ceased and the EPL was surrendered to the EPA on 24 October 2014 (GHD 2018b). BQRP acquired the quarry site and subsequently undertook future land use planning for the subject land.

The subject land covers a total area of approximately 13.7 hectares (ha) and is divided by the Main Western Railway. The subject land is zoned E3 Environmental Management under *Lithgow Environmental Plan 2014*. It is located adjacent to the Greater Blue Mountains World Heritage Area (GBMWHA), and within the upper reaches of the Wollangambe River Catchment, which forms part of the broader Hawksbury-Nepean catchment.

1.2.2. Project Overview

BQRP is seeking to rehabilitate the subject land, with the final rehabilitated landform to be achieved via importation of virgin excavated natural material (VENM), excavated natural material (ENM) or comparable material (that meets an exemption pursuant to clauses 91 and 92 of the *Protection of the Environmental Operations (Waste) Regulation 2014)*, sourced from earthworks projects across Sydney and the local regional area.

The key features of the Project are identified by GHD (2021) as follows:

- Importation of approximately 1.2 million cubic metres of VENM, ENM or comparable material (that meets an exemption pursuant to clauses 91 and 92 of the *Protection of the Environmental Operations (Waste) Regulation 2014)*, sourced from earthworks projects across Sydney and the local regional area;
- Vehicle haulage at a rate of up to 140,000 tonnes per annum;
- Emplacement and compaction of soil material within the existing quarry voids;
- Shaping of fill to closely represent the pre-quarry landform and to allow surface water drainage across the final landform;
- Development of a water management system to control surface water discharges throughout the rehabilitation program and from the final landform including a lined contact water pond; and
- Revegetation of the site with locally endemic species to provide effective integration with the surrounding landscape.

1.2.3. Assessment History

1.2.3.1. Secretary's Environmental Assessment Requirements

Secretary's Environmental Assessment Requirements (SEARs) were issued for the Project on 18 November 2016 by the then NSW Department of Planning and Environment (DPE). The SEARs identified the following requirement in relation to biodiversity:

- *accurate predictions of any vegetation clearing on site or for any road upgrades;*
- *a detailed assessment of the potential impacts on any threatened species, populations, endangered ecological communities or their habitats, groundwater dependent ecosystems and any potential for offset requirements; and*
- *a detailed description of the measures to avoid, minimise, mitigate and offset biodiversity impacts.*

The SEARs were developed in consultation with other agencies, including WaterNSW, the Environment Protection Authority and the Department of Primary Industries. The detailed requirements recommended by WaterNSW included biodiversity requirements relating to groundwater dependent ecosystems (GDEs), watercourses, wetlands and riparian land, and stream rehabilitation. At the time the SEARs were issued, the Office of Environment and Heritage (OEH) were unable to provide input to the SEARs, and therefore DPE indicated a requirement for the proponent to consult directly with DPE. OEH subsequently issued requirements on 25 January 2017. These requirements included:

- *assessment of cumulative impacts,*
- *biodiversity [either via the BioBanking Assessment Methodology (BBAM) or a detailed biodiversity assessment, and*
- *impacts to OEH estate.*

1.2.3.2. Environmental Impact Statement

In 2018, BQRP submitted an Environmental Impact Statement (EIS) to support an application for designated and integrated development for the site under Part 4 of the EP&A Act. The EIS was prepared by GHD and included assessment of soil and water resources, biodiversity, traffic, air quality, noise and vibration, cultural heritage, and world heritage. The EIS included a number of supporting documents, including:

- Biodiversity Impact Assessment (GHD 2018a); and
- Water Resources Assessment (GHD 2018c).

1.2.3.3. Submissions and Responses

The DA and associated EIS were placed on public exhibition for 60 days between 19 January and 20 March 2020. Over 500 submissions were lodged, including submissions from NSW government agencies, local councils and the community. A Submissions Report was subsequently prepared by GHD (2019c) to respond to the issues raised in the submissions. The issues raised within the submissions related to the approval pathway, traffic, flora and fauna, water, contamination, social and economic, as well as general issues.

Following the lodgement of the Submissions Report further correspondences relating to environmental matters were issued by OEH (2019), EPA (2019a, c, b, 2020), Lithgow City Council, NSW Department of Planning, Industry and Environment (2019), National Parks and Wildlife Service (2019), and additional information provided by GHD (2019a, b).

1.2.3.4. Refusal

On 6 March 2020 Council issued an assessment report for the Project and recommended that Project be refused. A total of 12 reasons for refusal were provided in the assessment report. The Project was subsequently assessed by the WRPP. The WRPP made a determination to refuse the Project on 6 April 2020. A total of 11 reasons for the refusal were documented in the Determination and Statement of Reasons document issued by the WRPP.

The reasons for refusal primarily relate to environmental harm, including the following reason which is the subject of this review:

> *2. The Environment Protection Authority considers, based on its submissions to Council, that the proposal will have unacceptable environmental impacts on the Greater Blue Mountains World Heritage Area, arising from the following:*
>
> *i. it is likely that some of the soil leachates will adversely alter the natural characteristics and ionic balance of water draining into the Greater Blue Mountains World Heritage Area and the Colo River, Greater Blue Mountains World Heritage Area (GBMWHA).*

ii. *proposed discharges into a tributary of the Wollangambe River were identified that would impact on a swamp located on the tributary approximately 200m downstream of where the discharge is proposed. The tributary (and its connected swamp) is proposed to receive pumped out water from the quarry pits, any leachate from the material that is emplaced in the pits and overland flow once the area is rehabilitated. The tributary and swamp are in the GBMWHA.*

iii. *The Biodiversity Impact Assessment identified the Prickly Tea-tree - sedge wet heath swamp below the quarry discharge location as a Newnes Plateau Shrub Swamp (EEC under the TSC Act) and Temperate Highland Peat Swamps on Sandstone (EEC under the EPBC Act).*

iv. *The existence of the swamp in the headwaters of the drainage line downstream of Bell Quarry strongly suggests that there is a groundwater source which helps support/maintain the swamp in this location.*

v. *The Water Resources Assessment Section of the EIS has not clearly defined the downstream swamp as a Groundwater Dependent Ecosystem (GOE); it has not assessed the level of groundwater dependence for the swamp and the likely pathways (e.g. disruption of groundwater connections, reduction in groundwater quality) by which the project might impact on the swamp; and it does not consider issues surrounding water discharge rates or their effect on geomorphic stability for the swamp. It has therefore not appropriately assessed the risk the project will have on the THPS swamp.*

vi. *The dewatering of the quarry voids is likely to present a significant potential to destabilise sediments in the downstream swamp. If an erosional nick-point is established in the swamp, it could lead to the loss of the swamp in its entirety through erosion and gullying.*

2. Existing Biodiversity Values

This section summarises the existing environment identified within the Biodiversity Impact Assessment (GHD 2018a) prepared for the Project as well as incorporating findings from Cumberland Ecology (2021). The findings presented below include references to the project area and study area as shown in **Figure 1**.

2.1.1. Plant Community Types

The project area is described as comprising highly modified landforms with the majority of vegetation present being the result of previous rehabilitation activities. Some rehabilitation occurs outside of the project area, however much of remaining portions of the study area contain intact vegetation. The extent of plant community types (PCTs) identified within the project area and study area are outlined within **Table 1**.

Of the PCTs identified within the study area, only one is considered to conform to a threatened ecological community (TEC). Prickly Tea-tree – sedge wet heath on sandstone plateaux is considered to conform to Newnes Plateau Shrub Swamp in the Sydney Basin Bioregion which is listed as an endangered ecological community (EEC) under the NSW *Biodiversity Conservation Act 2016* (BC Act), as well as conforming to Temperate Highland Peat Swamps on Sandstone which is listed as an EEC under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Table 1 Plant community types within the project area and study area

PCT	Condition	Project Area (ha)	Study Area (ha)
1248: Sydney Peppermint - Silvertop Ash heathy open forest on sandstone ridges of the upper Blue Mountains, Sydney Basin Bioregion	Moderate/good-high	0.13	11.96^
1248: Sydney Peppermint - Silvertop Ash heathy open forest on sandstone ridges of the upper Blue Mountains, Sydney Basin Bioregion	Moderate/good-poor	2.48	5.43
1078: Prickly Tea-tree – sedge wet heath on sandstone plateaux, central and southern Sydney Basin Bioregion	Moderate/good	-	0.87^
*1071: Phragmites australis and Typha orientalis coastal freshwater wetlands of the Sydney Basin Bioregion	Moderate/good - poor	3.19	3.30
Cleared Land	Cleared	2.41	3.57
Total		**8.21**	**25.13**

** PCT identified is considered best-fit as the vegetation occurs within an artificial wetland*

^ Areas updated following surveys by Cumberland Ecology (2021).

2.1.2. Flora Species

Over 170 flora species from 47 families were recorded within the study area, of 90% of species are native and 10% exotic. One priority weed, *Cytisus scoparius* subsp. *scoparius* (English Broom), listed under the *Biosecurity Act 2015* for the Lithgow Local Government Area was recorded within the project area. This species is also classified as a Weed of National Significance. Other weeds recorded within the project area included Pampas Grass (*Cortaderia selloana*) and African Lovegrass (*Eragrostis curvula*).

No threatened flora species were recorded within the project area or study area. The following threatened flora species were identified as having potential habitat within the project area:

- *Boronia deanei (*Deane's Boronia) (EPBC Act Status: Vulnerable; BC Act Status: Vulnerable);
- *Personnia hindii* (EPBC Act Status: Not listed; BC Act Status: Endangered); and
- *Veronica blakelyi* (EPBC Act Status: Not listed; BC Act Status: Vulnerable).

Boronia deanei is noted as having potential habitat downstream of the project area. *Persoonia hindii* and *Veronica blakelyi* are noted as having potential habitat within the project area, with additional habitat located downstream of the project area.

Additional threatened flora species were considered to have broadly suitable habitat within the wider study area.

2.1.3. Fauna Habitat

The following broad fauna habitat type have been identified within the project area:

- Regenerating and planted vegetation;
- Intact native vegetation;
- Quarry voids (aquatic):
- Drainage line (aquatic); and
- Swamp (aquatic).

Habitat connectivity is limited within the project area, however extensive connectivity occurs in adjoining area, including within Blue Mountains National Park.

2.1.4. Fauna Species

A total of 57 native fauna species were recorded within the study area during the field survey, six frog species, 30 bird species, six dragonfly and damselfly species, four terrestrial mammal species, three bat species and eight reptile species. A further two bat species had possible call recordings. No introduced fauna species were detected.

One threatened fauna species, the Large Bent-winged Bat (*Miniopterus orianae oceanensis*) had a possible call recording within the study area. The Large Bent-winged Bat is listed as Vulnerable under the BC Act.

The following threatened fauna species were identified by GHD (2018a) as being potentially impacted by the Project:

- Giant Dragonfly (*Petalura australis*) (EPBC Act Status: Not Listed; BC Act Status: Endangered);

- Giant Burrowing Frog (*Heleioporus australiacus*) (EPBC Act Status: Vulnerable; BC Act Status: Vulnerable);
- Red-crowned Toadlet (*Pseudophryne australis*) (EPBC Act Status: Not Listed; BC Act Status: Vulnerable);
- Littlejohn's Tree Frog (*Litoria littlejohni*) (EPBC Act Status: Vulnerable; BC Act Status: Vulnerable); and
- Blue Mountains Water Skink (*Eulamprus leuraensis*) (EPBC Act Status: Endangered; BC Act Status: Endangered).

These species are noted as having potential habitat downstream of the project area along the drainage line and/or swamp.

A suite of other threatened fauna species were considered to have potential habitat within the project area or study area, however these were not assessed as impacted species.

2.1.5. Groundwater Dependent Ecosystems

Prickly Tea-tree – sedge wet heath on sandstone plateaux, located within the study area outside of the project area, has been identified as likely to be a GDE.

The following observations were made of the swamp vegetation (D. Martens pers. comm.) following a site inspection in December 2020:

- Surface water was observed flowing into the hanging swamp, which was then absorbed as groundwater into the shallow soil profile overlying sandstone (i.e. no surface flow through wetland);
- Shallow groundwater discharge was observed from the lowest portion of the hanging swamp at a similar rate to the observed surface water inflow rate;
- Limited evidence of channelised flow within the swamp; and
- Observations strongly suggest that hydrology of the hanging swamp is controlled by surface water inflows from upslope site discharge and side valley inflows.

2.1.6. Greater Blue Mountains World Heritage Area

Blue Mountains National Park, which forms part of the GBMWHA is located along the eastern and northern boundaries of the project area. Some areas immediately adjacent to the project area within the park have previously been disturbed through edge effects, clearing for boundary fence installation, historical quarrying and electricity easements.

3. Groundwater Dependent Ecosystem Monitoring

3.1. Threats to be Monitored

The threat to be monitored is the Prickly Tea-tree – sedge wet heath on sandstone plateaux, located within the study area outside of the project area, which has been identified as likely to be a GDE, that could be impacted by changes to surface or groundwater flows.

3.2. Data Collection

Monitoring of potential GDEs (i.e. swamp vegetation) will be undertaken at two permanent plots using the locations of the plots surveyed by Cumberland Ecology (detailed in report REF: 20109RP2). Monitoring of control sites is not proposed as there are no equivalent swamps immediately adjacent that are not potentially impacted by the quarry. Instead, data will be compared to baseline data from surveys by Cumberland Ecology in March 2021. Plot surveys will follow the BAM and include establishment of a 20 m x 50 m plot (or equivalent 10 m x 100 m plot) within which the following data will be collected:

- Composition for each growth form group by counting the number of native plant species recorded for each growth form group within a 20 m x 20 m plot;
- Structure of each growth form group as the sum of all the individual projected foliage cover estimates of all native plant species recorded within each growth form group within a 20 m x 20m plot;
- Cover of 'High Threat Exotic' weed species within a 20 m x 20m plot;
- Assessment of function attributes within a 20 m x 50 m plot, including:
    - Count of number of large trees;
    - Tree stem size classes, measured as 'diameter at breast height over bark' (DBH);
    - Regeneration based on the presence of living trees with stems <5 cm DBH;
    - The total length in metres of fallen logs over 10 cm in diameter;
- Assessment of litter cover within five 1 m x 1 m plots evenly spread within the 20 m x 50 m plot; and
- Number of trees with hollows that are visible from the ground within the 20 m x 50 m plot.

Each plot is to be monitored on an annual basis during the same season as previous monitoring (baseline monitoring was undertaken in autumn).

Following monitoring data is to be compiled in a spreadsheet summarising composition and structure for each growth form group and the function attributes.

3.3. Performance Indicators

Performance indicators for potential GDEs relate to noticing changes in indices (relative to previous monitoring years) that cannot be related to other natural causes such as drought or bushfire. As such rainfall records will need to be retained for the period of monitoring, and any other natural disturbance events (such as details of fire events) recorded.

The indices to be monitored include:

- Species richness of each growth form group; and
- Total cover for each growth form group;

As other function attributes such a litter cover, length of course woody debris and number of large trees (which are unlikely to be present) are less likely to be impacted by changes in surface or groundwater flow, these will be recorded, but do not have set performance indicators.

The performance indicator for potential GDEs is that species richness and/or species cover does not drop below 15% of the baseline value (i.e. that detected in surveys by Cumberland Ecology in March 2021) averaged across the two plots, which cannot be attributed to drought or other natural causes.

3.3.1. Trigger Action Response Plan

The Trigger Action Response Plan for GDEs is summarised in **Appendix A**.

4. Weed Monitoring

4.1. Threats to be Monitored

Weeds are a threat to the integrity of vegetation within the project area and adjacent bushland areas. They may change in distribution and abundance over time. There is potential for additional weeds to be introduced within the project area by human activities associated with the Project. Weeds also pose a significant threat to rehabilitation areas as they can out-compete native seedlings and reduce the success of revegetation measures.

A total of 20 weed species have been recorded within the study area. The target weed species for monitoring are the weed species that have been recorded within the study area as listed in **Table 2**.

Of the weed species recorded within the study area, the following have been identified under the NSW *Biosecurity Act 2015*:

- *Senecio madagascariensis* (Fireweed) – State Priority Weed (Asset Protection) and Regional Priority Weed (Containment);
- *Cytisus scoparius subsp. scoparius* (English Broom) – State Priority Weed (Asset Protection) and Regional Priority Weed (Asset Protection);

Eragrostis curvula (African Lovegrass) is also identified within the Central Tablelands Regional Strategic Weed Management Plan 2017-2022 (Central Tablelands LLS 2017) as a Regional Community Concern weed species.

Cytisus scoparius subsp. scoparius (English Broom) and *Senecio madagascariensis* (Fireweed) are also Weeds of National Significance.

There are a number of other environmental weeds throughout the study area, in particular within the project area. These include *Cortaderia selloana* (Pampas Grass), *Eragrostis curvula* (African Love Grass) *Centaurium erythraea* (Common Centaury) and *Plantago lanceolata* (Lamb's Tongues). These environmental weeds occur as relatively minor, localised infestations and are mainly concentrated in cleared land and poor condition vegetation in the former quarry. Other introduced species observed include common agricultural weeds such as *Trifolium subterraneum* (Subterranean Clover) and *Hypochoeris radicata* (Cat's Ear). The Western Australian species *Hakea laurina* (Pincushion Hakea) is present in some areas. Introduced plants were only very occasionally observed by GHD (2018a) in intact native vegetation outside the quarry.

Table 2 Target weed species for monitoring

Scientific Name	Common Name
Centaurium erythraea	Common Centaury
Conyza bilbaoana	
Conyza bonariensis	Flaxleaf Fleabane
Conyza sumatrensis	Tall fleabane
Cortaderia selloana	Pampas Grass
Cyperus eragrostis	Umbrella Sedge

Scientific Name	Common Name
Cytisus scoparius subsp. scoparius	English Broom
Eragrostis curvula	African Lovegrass
Erodium cicutarium	Common Crowfoot
Gamochaeta americana	Purple Cudweed
Hakea laurina	
Hypochoeris radicata	Catsear
Modiola caroliniana	Red-flowered Mallow
Petrorhagia dubia	
Plantago lanceolata	Lamb's Tongues
Senecio madagascariensis	Fireweed
Sida rhombifolia	Paddy's Lucerne
Solanum sp.	
Sonchus oleraceus	Common Sowthistle
Trifolium subterraneum	Subterranean Clover

4.2. Data Collection

4.2.1. Baseline Weed Survey

Random meander transects will be completed within the project area and wider study area to search for weed species, in particular Priority Weeds and Weeds of National Significance to identify baseline weed invasion. These transects will focus on areas of disturbance within the project area, as well as downstream areas in the study area, where additional weed species are likely to colonise. Where significant infestations of weeds (defined as any infestation of Priority Weeds and/or environmental weeds extending over an area of 20 x 20m or more) are found, a 20 x 20 m quadrat will be established and areas/numbers will be estimated within the quadrat and extrapolated to give overall population size estimates. On the completion of surveys, a baseline map of weed infestations will be prepared. This mapping and estimates of overall population size estimates will be used to inform the management actions and trigger control activities. The locations of these additional quadrats will be recorded and photographs taken. These quadrats will be incorporated into the weed monitoring program and visited in subsequent monitoring periods track the progress and efficacy of control activities.

4.2.2. Annual Weed Monitoring

Weed monitoring will be conducted annually within quadrats that are monitored as part of rehabilitation monitoring and the 20 x 20m quadrats surveyed as part of the baseline weed survey (***Section 4.2.1***.). From the quadrat data collected for vegetation rehabilitation monitoring (see **Chapter 6**) and the baseline weed survey the percentages of exotic weeds will be calculated, and the identity of the weeds present determined.

In addition to surveying within the quadrats, annual random meander transects will be completed in all areas within the project area.

The results of the annual monitoring will be reported in the Monitoring Report as outlined in **Chapter 7**.

4.3. Performance Indicators

Performance indicators for weed monitoring are shown in **Table 3** and include the following:

- A measurable decline in weed density and distribution;
- A measurable decline in weed diversity;
- A reduction in significant weed infestations; and
- Limited recruitment/invasion of new weed species.

Table 3 Performance indicators for weed monitoring

Indicator	5 Year Criteria	10-Year Criteria	15-Year Criteria
Weed density and distribution	25% reduction in baseline value	50% reduction in baseline value	75% reduction in baseline value
Weed diversity	Weed diversity not increased above baseline with limited new weed species recorded	Weed diversity not increased above baseline and downward trend in weed diversity, with limited new weed species recorded	Weed diversity reduced to minimal levels with some species eradicated and limited new species recorded.
Significant weed infestations	Observed reduction in abundance and distribution of significant weed infestations	Downward trend in abundance and distribution of significant weed infestations	No records of new significant weed infestations

4.3.1. Trigger Action Response Plan

In the event the weed control targets in **Table 3** are not being met, the action in response will be to increase weed treatment efforts. Further, in the event that new weed species are recorded, weed hygiene protocols will be reviewed and strengthened to ensure the weed seeds are not inadvertently brought onto site. This will include reviewing seed supply for rehabilitation to ensure that strictly only local provenance species are used, and that seed mixes do not include non-local native species. The disposal of weed material of species established in the site should also be reviewed to ensure this does not result in inadvertent weed spread through movement of soil or water. The Trigger Action Response Plan for weed control is summarised in **Appendix A**.

5. Pathogen Monitoring

5.1. Threats to be Monitored

Activities within the project area have the potential to introduce or spread pathogens such as Phytophthora (*Phytophthora cinnamomi*), Myrtle Rust (*Uredo rangelii*) and Chytrid Fungus (*Batrachochytrium dendrobatidis*) into adjacent native vegetation through vegetation and soil disturbance, through the movement of plant, machinery and vehicles, as well as through rehabilitation works. There is little available information about the distribution of these pathogens within the locality, and no evidence of these pathogens was observed during surveys by GHD (2018a). Phytophthora and Myrtle Rust may result in the dieback or modification of native vegetation and damage to fauna habitats. Chytrid Fungus affects both tadpoles and adult frogs and can cause 100% mortality in some populations once introduced into an area.

5.2. Monitoring Methods

5.2.1. Baseline Study

A baseline study of pathogens at the site will be conducted. This will involve a random meander transect will be completed in all areas within the project area to search for signs of dieback in species, or Myrtle Rust pustules on susceptible species.

In addition, soil sampling will be undertaken to detect *Phytophthora cinnamomi*. Soil sampling will focus on susceptible areas upstream of the swamp.

5.2.2. Fill Sample Testing

Fill must not be imported from areas known to contain Phytophthora, Myrtle Rust or Chytrid fungus. Samples of fill must be tested at the point of origin for these pathogens. No fill returning positive results for pathogens may be transported to project area.

5.2.3. Vegetation Health Monitoring

A random meander transect will be completed in all areas within the project area to search for signs of dieback in species, or Myrtle Rust pustules on susceptible species. These transects will focus on areas of disturbance plus downstream areas as these are where the project could introduce pathogens. In addition to random meander transects, vegetation health will be monitored during the monitoring of rehabilitation plots, detailed in ***Section 6.2.2.*** Photographs should be taken to support observations of plant health.

Visible symptoms of Phytophthora-based vegetation dieback are as follows (Royal Botanic Gardens Trust 2018):

- Wilting, yellowing and dieback of the plant;
- Rapid death of susceptible plants; and
- Greater loss of plants during dry weather.

Visible symptoms of myrtle rust are as follows (DPI 2015):

- Purple spots on leaves; sometimes growing large, merging and distorting leaves;
- Bright yellow pustules within purple spots, fading to grey as infection ages;

- Death of soft plant material; and
- Death of host plants in highly susceptible species.

An example of Myrtle Rust pustules is provided in **Photograph 1.**

Photograph 1 Example of Myrtle Rust pustules

A wide range of species are susceptible to Phytophthora-based vegetation dieback (DPIE 2020). A list of susceptible species from the project area is provided in **Table 4**. Species potentially susceptible belong to the same genera as susceptible species.

Table 4 Flora species known to be susceptible to Phytophthora or Myrtle Rust recorded within the study area

Species	Phytophthora susceptible	Myrtle Rust susceptible
Banksia ericifolia var. *ericifolia*	Yes	
Banksia spinulosa	Yes	
Baeckea linifolia		Yes
Cassinea aculeata	Yes	
Epacris paludosa	Yes	
Epacris pulchella	Yes	
Eucalyptus blaxlandii	Potential	Potential
Eucalyptus piperita	Potential	Potential

Species	Phytophthora susceptible	Myrtle Rust susceptible
Eucalyptus racemosa	Potential	Potential
Eucalyptus radiata	Potential	Yes
Eucalyptus sieberi	Potential	Yes
Grevillea laurifolia	Potential	
Grevillea rosmarinifolia subsp. *rosmarinifolia*	Yes	
Hakea dactyloides	Potential	
Hakea propinqua	Potential	
Leptospermum continentale	Potential	Yes
Leptospermum grandifolium	Potential	Potential
Leptospermum macrocarpum	Potential	Potential
Leptospermum polygalifolium	Potential	Yes
Leptospermum trinervium	Potential	Potential
Lomatia silaifolia	Potential	
Ozothamnus diosmifolius	Potential	
Patersonia sericea	Yes	
Persoonia chamaepitys	Potential	
Persoonia levis	Potential	
Petrophile canescens	Potential	
Petrophile pulchella	Yes	
Phyllanthus virgatus	Potential	
Pimelea linifolia subsp. *collina*	Yes	
Telopea speciosissima	Yes	
Xanthosia atkinsoniana	Potential	
Xanthosia dissecta	Yes	

5.2.4. Frog Surveys

Skin swabs and specialist analysis are required to diagnose the presence of Chytrid fungus. Surveys for the presence of this pathogen will instead involve searching for deceased and obviously affected frogs, as well as by comparing amphibian diversity and abundance to previous monitoring years.

Frog surveys are to be undertaken annually to determine if there in any detectable decline in from species richness, while also searching for deceased frogs. Frog surveys should be undertaken annually following rainfall and will target the downstream swamp areas.

5.2.4.1. Spotlighting and Call Playback

Spotlight surveys will be conducted using a hand-held spotlight while walking. Spotlighting should be undertaken along the length of the swamp as well as approximately 100 m past either end, along the associated drainage line. Spotlighting should be undertaken for a period of one hour by two personnel each night, over a total of four nights.

In conjunction with spotlighting surveys, call playback for the Giant Burrowing Frog and Red-crowned Toadlet will be undertaken. Call playback should be followed with quiet listening and spotlighting in the immediate vicinity. Call playback should be undertaken at two locations within the drainage line associated with the swamp. Call playback should be undertaken at each location for four nights.

5.2.4.2. Tadpole Searches

Diurnal tadpole searches will be undertaken within the approximately 100 m of drainage line at either end of the swamp. Two diurnal tadpole searches were undertaken using a dip net. Any tadpole captured will be identified and released.

5.3. Trigger Action Response Plan

The trigger for an action response is that signs of infection by Phytophthora (*Phytophthora cinnamomi*), Myrtle Rust (*Uredo rangelii*) or Chytrid fungus (*Batrachochytrium dendrobatidis*) are observed in flora or amphibian species. The Trigger Action Response Plan for pathogens is summarised further in **Appendix A**.

6. Rehabilitation Monitoring

6.1. Vegetation Communities to be Rehabilitated

6.1.1. Existing Vegetation Communities

The Biodiversity Assessment Report (2018a) indicates that the subject land contains a range of different Plant Community Types in varying conditions. These are summarised in **Table 5** below with an indication of their suitability for rehabilitation.

Table 5 Vegetation communities present in the subject land and their suitability for rehabilitation

PCT No	PCT Name	Condition Class	Rehabilitation suitability
1248	Sydney Peppermint Silvertop Ash heathy open forest on sandstone ridges of the upper Blue Mountains, Sydney Basin Bioregion	Moderate	Undisturbed areas that should be the benchmark of rehabilitation
1248	Sydney Peppermint Silvertop Ash heathy open forest on sandstone ridges of the upper Blue Mountains, Sydney Basin Bioregion	Poor	Current rehabilitation areas
1078	Prickly Tea-tree - sedge wet heath on sandstone plateaux, central and southern Sydney Basin Bioregion.	Moderate/good	Not directly impacted and not proposed for rehabilitation.
1071	*Phragmites australis* and *Typha orientalis* coastal freshwater wetlands of the Sydney Basin Bioregion)	Moderate	Quarry voids filled with water and not proposed for rehabilitation
-	Cleared land	n/a	Areas that will comprise future rehabilitation

With the exception of quarry voids that have filled with water that have formed wetlands broadly consistent with PCT 1071 (*Phragmites australis* and *Typha orientalis* coastal freshwater wetlands of the Sydney Basin Bioregion) areas that are undergoing rehabilitation are broadly consistent with PCT 1248. A more detailed description of each PCT suitable for rehabilitation or in the process of being rehabilitated is provided further below.

6.1.2. PCT 1248 Sydney Peppermint Silvertop Ash heathy open forest on sandstone ridges of the upper Blue Mountains, Sydney Basin Bioregion

6.1.2.1. Moderate Condition

This community is present as remnant or regrowth native vegetation with near-intact overstorey and mid-storey. The canopy is dominated by large stands of *Eucalyptus piperita* (Sydney Peppermint) and *Eucalyptus sieberi* (Silver-top Ash). The canopy has lower densities of *Eucalyptus oreades* (Blue Mountains Ash), *Eucalyptus globoidea* (White Stringybark) and *Eucalyptus sclerophylla* (Hard-leaved scribbly Gum). Characteristic mid-storey shrubs include *Leptospermum grandifolium* (Woolly Teatree) and *Leptospermum trinervium* (Slender Tea-tree). Smaller shrubs species include *Daviesia latifolia* (Bitter Pea) *Pomaderris andromedifolia* subsp. *andromedifolia, Grevillea laurifolia* (Laurel-leaf Grevillea) and *Lomatia silaifolia* (Crinkle Bush). The ground layer is sparse, but species rich and structurally variable with abundant leaf litter between understorey plants. Grasses in the ground layer include *Entolasia stricta* (Wiry Panic), *Austrostipa rudis* subsp. *nervosa* (a spear-grass), *Poa sieberiana* (Snow Grass), *Microlaena stipoides* (Weeping Grass) and a *Rytidosperma* sp. Other ground layer species include *Dianella revoluta* var. *revoluta* (Blue Flax Lily), *Lepidosperma laterale* (Variable Swordsedge) *Patersonia sericea* (Silky Purple-Flag) *Pteridium esculentum* (Bracken Fern) *Lomandra filiformis* subsp. *filiformis, Xanthosia pilosa* (Woolly Xanthosia) *Amperea xiphoclada, Opercularia varia,* (Variable Stinkweed), *Poranthera microphylla* (Small Poranthera), *Baloskion gracile, Hybanthus vernonii* and *Brunoniella australis* (Blue Trumpets).

This community in its intact form (moderate condition) represents the benchmark for the majority of rehabilitation areas except voids.

6.1.2.2. Poor Condition

This form of PCT 1248 is present as regrowth and as rehabilitated native vegetation comprising a derived shrub land and partially cleared woodland with sub-mature regrowth on rehabilitated portions of the quarry. Rehabilitated areas appear to include a mix of planted native species and natural regrowth from re-spread topsoil. A canopy layer is absent. The mid-storey forms a moderate to dense cover of sclerophyllous shrubs including *Acacia longifolia, Gahnia sieberiana* (Red-fruit Saw-sedge), *Leptospermum polygalifolium* (Tantoon) and *Leptospermum trinervium.* Occasional patches of saplings of *Eucalyptus* species are present. The shrub layer includes *Acacia terminalis* (Sunshine Wattle), *Cassinia aculeata* (Dolly Bush) *Daviesia latifolia. Hakea laurina, Leptospermum grandifolium, Petrophile pulchella* (Conesticks) and *Leptospermum macrocarpum.* The ground layer includes the grasses in the moderate condition form in addition to forbs including *Gonocarpus tetragynus* (Poverty Raspwort), *Lepyrodia scariosa, Lomandra longifolia* (Spiny-headed Mat-rush), *Goodenia paniculata, Amperea xiphoclada, Baloskion gracile* and *Coronidium scorpioides* (Button Everlasting). This form of PCT 1248 contains introduced weeds including *Cytisus scoparius* subsp. *scoparius* (English Broom), *Cortaderia selloana* (Pampas Grass), *Eragrostis curvula* (African Love Grass) *Hypochoeris radicata* (Cat's Ear) and *Hakea laurina* (Pincushion Hakea).

6.2. Monitoring Methods

6.2.1. Reference Condition Surveys

Plot-based floristic surveys will be undertaken in the intact (moderate) condition form of PCT 1248 to identify baseline condition. These plot should be surveyed following the Biodiversity Assessment Method (BAM) and including the establishment of 20 m x 50 m plots within which the following data will be collected:

- Composition for each growth form group by counting the number of native plant species recorded for each growth form group within a 20 m x 20 m plot;
- Structure of each growth form group as the sum of all the individual projected foliage cover estimates of all native plant species recorded within each growth form group within a 20 m x 20m plot;
- Cover of 'High Threat Exotic' weed species within a 20 m x 20m plot;

- Assessment of function attributes within a 20 m x 50 m plot, including:
    - Count of number of large trees;
    - Tree stem size classes, measured as 'diameter at breast height over bark' (DBH);
    - Regeneration based on the presence of living trees with stems <5 cm DBH;
    - The total length in metres of fallen logs over 10 cm in diameter;
- Assessment of litter cover within five 1 m x 1 m plots evenly spread within the 20 m x 50 m plot; and
- Number of trees with hollows that are visible from the ground within the 20 m x 50 m plot.

A minimum of three plots should be surveyed and will form the base line condition against which rehabilitated areas will be assessed. Following the completion of surveys the data should be entered into a spreadsheet and the average of the three plots for each variable above calculated.

6.2.2. Rehabilitation Monitoring

Rehabilitation monitoring is to be undertaken annually in the same season each year.

A total of three permanent monitoring plots are to be established in rehabilitation areas, including one within the existing poor condition PCT 1248 and two within newly established areas of PCT 1248. Each plot will be a 20 x 50 m plot surveyed following the BAM as detailed in ***Section 6.2.1.*** The plots should be spread out evenly across the subject land, to cover rehabilitated areas of different ages. A permanent photo monitoring point will be established at the start and end of the centre line of each 20 x 50m plot. A steel star picket would be suitable for marking photo points. At each photo point photographs will be taken pointing north, east, south and west.

6.3. Completion Criteria

During the rehabilitation process, it is expected that not all species present in reference areas will be able to establish as there are some 'recalcitrant species' that have particular germination requirements that are difficult to provide in the rehabilitation process. Further, some species may have particular mycorrhizal associations which may be difficult to restore when soil is disturbed. As such, species diversity is not expected to return the same level as that of reference sites. Further many structural features such a leaf litter and coarse woody debris will not return for many years until canopy trees become mature, unless features can be returned through salvage of course woody debris. Some variables such as large trees and hollow bearing trees will not develop more many years and beyond the project life of 15 years, and as such are not included in completion criteria. As such, progressive criteria are provided at five yearly intervals as rehabilitated areas progress in **Table 6**.

Table 6 Progressive Criteria for rehabilitation of each PCT

Variable	Percentage of Benchmark		
	5 Years	10 Years	15 Years
Species richness (each growth form group)	40%	50%	60%
Cover (trees)	0	10	50
Cover (shrubs)	5	25	50
Cover (grasses)	10	40	60
Cover (other)	10	40	60
Cover (High Threat Exotics)	60	40	10
Regeneration	present	present	present
Tree dbh 5-9 cm	0	5	25
Tree dbh 10-19 cm	0	5	10
tree dbh 20-29 cm	0	0	5
Length of fallen logs	0	0	10
Litter cover	5	25	50

The progressive targets presented above would be reset in the event of a bushfire (i.e. the year of a bushfire would become year zero), although it is expected that some variables such as species richness would re-establish rapidly after wildfire.

6.3.1. Trigger Action Response Plan

Where it is identified that rehabilitation is not progressing according to the progressive rehabilitation targets in **Table 5** it is best to intervene early, i.e. at the five and 10 year interval, as at later time intervals it will be more difficult to intervene if particular criteria are not met (for example if trees of certain size classes have not developed after 15 years they cannot be planted at that size). As such criteria that would trigger a response are for the 5 and 10 year intervals only. Trigger Action Response Criteria and the appropriate response is provided in **Appendix A**.

7. Reporting

7.1. Annual Reporting

An annual monitoring report is to be prepared for submission to EES to track and assess the performance of biodiversity management measures. The annual monitoring report is to detail the following:

- Methods used in monitoring, with reference to this plan, including figures showing the location of monitoring surveys;
- A summary of the findings with reference to performance criteria, progressive rehabilitation criteria, benchmark data and TARP criteria.
- Details of where TARP criteria are exceeded together with details of action responses implemented;
- Discussion of findings, together with comparison with previous monitoring events;
- Photographs of rehabilitation monitoring plots; and
- A summary of monitoring data in Appendices.

7.2. Review

Adequate monitoring, review and adaptive management are essential to ensure mitigation measures remain effective. As such this monitoring plan including performance criteria, completion criteria and trigger action responses is to be reviewed every five years and updated as required.

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APPENDIX A :

Trigger Action Response Plan

Table 7 Trigger Action Response Plan

Monitoring Parameter	Trigger	Action / Response
Groundwater Dependent Ecosystems		
Annual GDE monitoring undertaken	Annual GDE monitoring not undertaken	Conduct monitoring in the same season as baseline monitoring
Species richness for each growth-form group	Average reduction in species richness across both plots of > 15% that is not attributable to drought or other natural causes	
Total cover for each growth-form group	Average reduction in total cover across both plots of > 15% that is not attributable to drought or other natural causes	
Weeds		
Baseline weed survey conducted	Baseline weed survey not conducted	Conduct baseline weed survey immediately.
Annual weed monitoring conducted	Annual weed monitoring not conducted	Conduct annual weed monitoring immediately.
5 yearly performance criteria met	5-yearly performance measure not met	Increase frequency of management actions
		Review hygiene protocol and make necessary amendments
		Review seed supply for rehabilitation activities to ensure only native local provenance seeds included
Pathogens		
Baseline pathogen survey	Baseline pathogen survey and testing not conducted	Conduct baseline survey and pathogen testing
Soil testing prior to import of fill	Pathogens detected	Fill not permitted to be transported to site
Vegetation health monitoring conducted	Evidence of *Phytophthora cinnamomi* caused dieback, or Myrtle Rust infection	Soil/pathogen testing will be undertaken in the immediate vicinity to confirm the infection.

Monitoring Parameter	Trigger	Action / Response
		The area where signs of infection was observed must be quarantined with no access without complete sterilisation of boots, clothing and equipment immediately on leaving the area.
		Sediment control measures are to be put in place to ensure no soil or water leaves the infected area.
		DPIE is to be informed of the infection;
		Hygiene measures are to be reviewed to determine if additional measures can be put in place to prevent the entry of pathogens.
Rehabilitation (refer to completion criteria in Table 6 for progressive targets)		
Reference condition surveys	Reference condition surveys not undertaken	Undertake reference condition surveys immediately
Annual rehabilitation monitoring	Rehabilitation monitoring not undertaken annually	Undertake rehabilitation monitoring annually
Species richness (each growth form group)	Richness is below progressive target	Interplant species of the relevant growth form group
Cover (relevant growth form group)	Cover below progressive targets	Interplant species of the relevant growth form group within gaps
Cover (High Threat Exotics)	Weed cover above progressive targets	Undertake weed treatment and review weed hygiene
Tree DBH classes	Number of stems below progressive targets	Interplant trees within gaps
Length of fallen logs	Length of logs below progressive targets	Place salvaged timber in rehabilitated areas

FIGURES

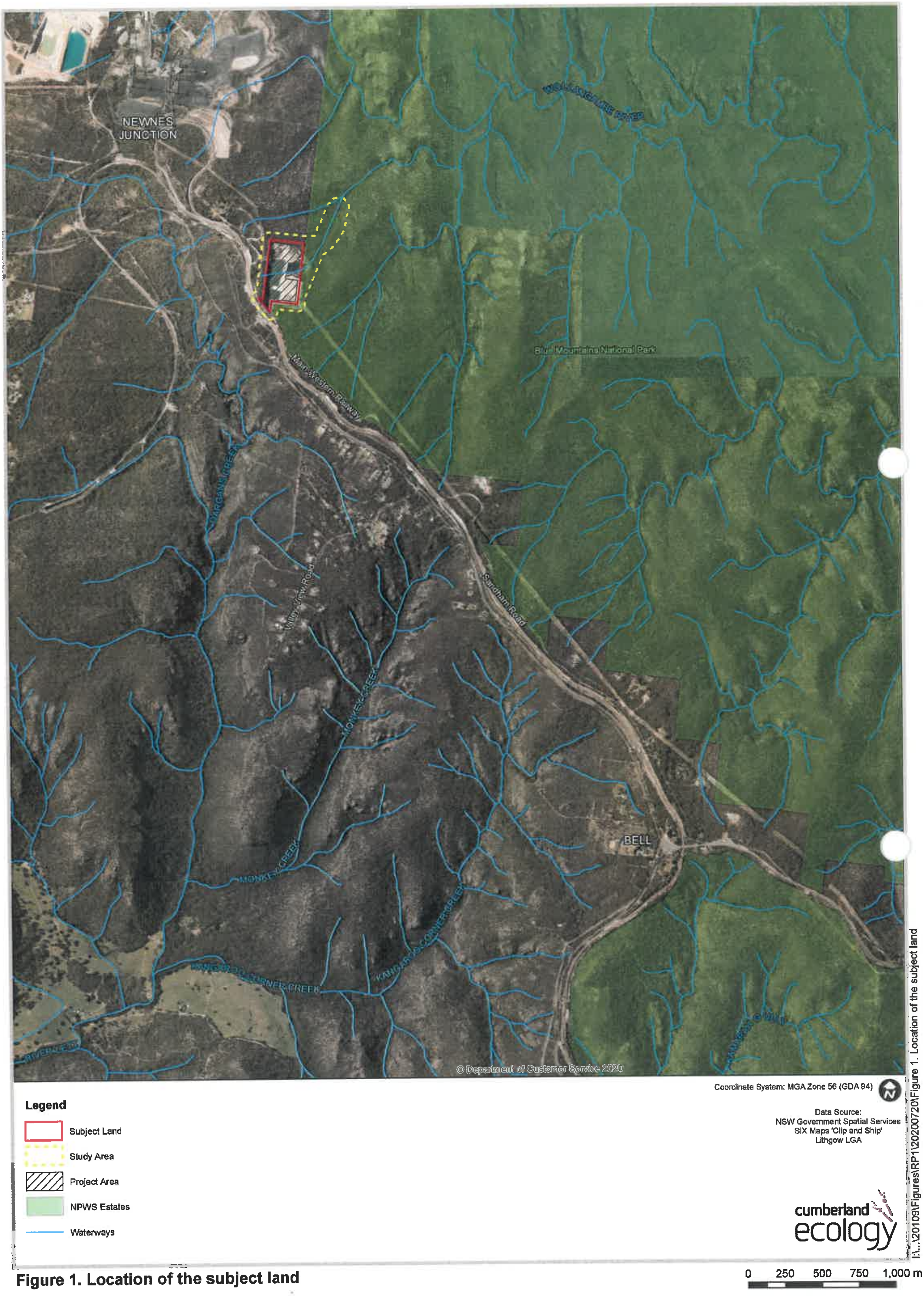

Figure 1. Location of the subject land

Appendix D

Hydrological Assessment

Hydrological Study

Proposed Rehabilitation of Bell Quarry

Final Report

P2007822JR03

November 2021

Prepared For HWL Ebsworth Lawyers

environmental science & engineering

Project Details

Report Title	Hydrological Study: Proposed Rehabilitation of Bell Quarry
Client	HWL Ebsworth Lawyers
File	P2007822JR03V02.docx
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Document History

Issue	Issue Date	Status	Description / Comment	Author	Reviewer	Approved
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Executive Summary

Overview

This report has been prepared in respect of a development application DA294/18 lodged with Lithgow City Council which seeks to rehabilitate the former Bell Quarry and develop a final land surface that more closely represents the pre-quarry landform (the **Proposal**) through the importation of material sourced across Sydney and the local regional area which meets:

1. The definition of Virgin Excavated Natural Material (**VENM**) as defined by the *Protection of the Environment Operations Act 1997* (NSW) ('*POEO* Act') from time to time;
2. The criteria of Excavated Natural Material (**ENM**) as set out in the Excavated Natural Material Order and Exemption 2014 issued by the NSW Environmental Protection Authority (NSW EPA) under clause 93 of the *Protection of the Environment Operations (Waste) Regulation 2014* (NSW) (*'POEO Waste Regulation'*); or
3. An exemption granted by the NSW EPA pursuant to clauses 91 and 92 of the *POEO Waste Regulation* and which specifically relates to the Land.

Scope

This report provides further environmental and hydrological data to support the Proposal. Specific objectives included:

1. Providing a detailed description of the existing hydrological environment, including surface and groundwater regimes, particularly at the hanging swamp located approximately 200 m downgradient of the Site (the **hanging swamp**).
2. Determining hydrological conditions, including surface and groundwater regimes, prior to historical quarrying activities, particularly at the hanging swamp.
3. Determine the surface water hydrologic regime after the final proposed landform is established.
4. Determine groundwater conditions during the filling stages of the project and after the final proposed landform is established.

Findings

Our findings are summarised as follows:

Surface Flow Regime

1. Flow gauging indicates that flows to the hanging swamp are directly related to the incidence of local rainfall (i.e. flows rely on surface flows from rainfall as opposed to base flows from groundwater). Local catchments have a rainfall rapid response with flows commencing not long after commencement of precipitation. This response is characteristic of the relatively shallow sandy soils and frequent bedrock outcropping within the catchment.

2. Flow gauging at the upstream and downstream extents of the hanging swamp indicated that inflows have been impacted by the quarry voids, with flow rates and volumes decreased through detention and evaporative losses within the existing quarry voids.

3. Flow gauging observations are supported by hydrological modelling that indicates the existing quarry voids have reduced inflows to the hanging swamp in the order of 65% for flows within the 50-90th percentile band, whereas less frequent higher intensity flows have increased due to the extent of cleared land within the quarry area.

4. Measured peak flows into the swamp of up to 40L/s and 638 L/s out of the swamp did not result in any observable erosion of the channel system or swamp, nor did they result in any geomorphic change. Based on the observed flow data, quarry dewatering rates up to say 100 L/s are not anticipated to result in any geomorphic change to the swamp or adjacent channel system. Higher rates may be acceptable.

5. Following completion of the final design surface, including retaining the lower void (pond 2), modelling indicates that there will be no adverse changes to the existing hydrological regime at the hanging swamp, and that return of flows towards those experienced under pre-quarrying conditions will occur.

6. Long-term runoff modelling indicates that the existing quarry has reduced average annual flow to the swamp in the order of 5 %, with inflows predominating during higher intensity runoff events. Existing swamp outflows are reduced by around 1.5 % compared to pre-quarry conditions. With the final rehabilitated surface in place, these historic impacts will be roughly halved to a 2.8% decrease in flow volume into the swamp and 0.8 % decrease in flow out of the swamp compared to pre-quarry conditions.

Surface Water Quality

7. The area downstream of the Site is a disturbed ecosystem due to historical catchment urban and quarrying activities, and construction of roads and clearing within the catchment.

8. Surface water quality was monitored within the existing quarry voids, the hanging swamp and inflows and outflows to the hanging swamp.

9. Surface water chemistry is generally within ANZG criteria for slightly to moderately disturbed freshwater ecosystems.

10. Water quality is broadly described as fresh with a low pH and low concentrations for most water quality parameters considered. Nutrient content is generally low, although higher nitrogen levels were found in the quarry ponds and the upstream gauge site. These do not appear to have impacted water quality within the swamp.

Existing Groundwater Regime

11. Groundwater within the site is located within a sandstone aquifer which maintains a generally downward flow gradient that does not flow directly to the hanging swamp.

12. Groundwater within the hanging swamp develops in response to direct rainfall and surface inflows arriving from the catchment which are developed partly within the Site but also within adjoining valley areas. As surface water inflows enter the swamp, these spread out and typically flow in an unchannelised manner over the swamp surface where due to the high sand content of swamp soils, there is a high degree of infiltration.

13. Infiltrated surface water within the hanging swamp causes a perched water table to develop which sits over the underlying sandstone bedrock. This water table is ephemeral and has the capacity to recharge the underlying permanent water table within the sandstone. Perched water within the swamp exits at the downstream portion of the swamp into a narrow formed channel.

14. The implications of these findings are that:

    a. Groundwater flows from the filled quarry voids does not contribute to groundwater flows within the swamp because these are controlled by surface water inflows and direct rainfall.

    b. Perched groundwater that occurs within the swamp will at times recharge deeper groundwater.

    c. Surface flows discharged from the Site during filling operations and following completion of the final landform will likely enter the swamp area and contribute to the hydrology and water chemistry of the perched water table.

Changes to Groundwater Regime

15. Modelling of pre-quarry groundwater levels indicates that the current quarry voids have significantly altered the pre-quarry groundwater levels by lowering the groundwater table by up to around 5 m in the quarry voids and increasing the

groundwater levels elsewhere in the model domain by around 0.5 – 2 m. Groundwater levels in the sandstone beneath the swamp have been increased by approximately 0.5 m due to the current quarry voids.

16. Modelling of the dewatered upper quarry void during the initial void filling stages indicates that local groundwater levels will be locally lowered compared to existing and pre-quarry conditions. In the sandstone beneath the hanging swamp, groundwater levels will be reduced by around 0.5 m, this being equivalent to pre-quarry conditions.

17. Modelling of the final design surface indicates that compared to pre-quarry conditions, groundwater levels will be increased upslope and decreased downslope of the lined and filled quarry void, although to a significantly lesser extent compared to the existing conditions. No material groundwater level changes occur in the sandstone beneath the swamp. Modelling shows that the final surface groundwater levels are the closest to the pre-quarry conditions compared to all other scenarios modelled as the drawdown extents are the smallest. This demonstrates that following completion of filling activities on the site, the groundwater regime will more closely align with the natural groundwater conditions that existed prior to quarrying occurring at the Site and is therefore an improvement over the situation that currently exists.

Groundwater Quality

18. Nitrogen levels were generally higher in deep wells within sandstone compared to the shallow wells within the swamp sediments.

19. Total phosphorous and heavy metal concentrations were generally lower in deep wells within sandstone compared to the shallow wells within the swamp sediments.

20. Total recoverable hydrocarbons were all below the detection limit except for at MW201 where they were observed on four occasions.

Contents

Tables

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1 Introduction

1.1 Overview

This report has been prepared in respect of a development application DA294/18 lodged with Lithgow City Council which seeks to rehabilitate the former Bell Quarry and develop a final land surface that more closely represents the pre-quarry landform (the **Proposal**) through the importation of material sourced across Sydney and the local regional area which meets:

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3. An exemption granted by the NSW EPA pursuant to clauses 91 and 92 of the *POEO Waste Regulation* and which specifically relates to the Land

The report provides findings in respect of hydrological investigations that have been undertaken in response to issues raised in the Statement of Facts and Contentions, filed 21 July 2021 (the **SOFACs**), in NSW Land & Environment Proceedings No 2021/00091361 (the **Proceedings**).

1.2 The Proposal

We understand that the Proposal, located at the former Bell Quarry at Sandham Road, Dargan (Lot 23 DP 751631) (the **Site**), consists broadly of the following:

1. Importation of around 1.0 million cubic metres of fill over a 15 year period to fill the two primary quarry voids comprising Pond 1 and Pond 2 (refer to Figure 1, Appendix A). Fill will be emplaced within and capped with a low permeability liner before the rehabilitated surface is prepared and revegetated.
2. The proposed imported fill is to be as per the description given above in Section 1.1.
3. Haulage of up to 140,000 tonnes of fill material per annum to the Site.
4. Dewatering of the existing upper quarry void (Pond 1) during the project filling phase.

1.3 Summary of Hydrological Issues

The SOFACs raise several contentions that are concerned with hydrological conditions at the Site and potential impacts of the Proposal. Concerns are raised in respect of both surface and groundwater resources. These contentions are broadly summarised as falling into several more general issues as described in Table 1.

Table 1: Overview of issues raised in SOFACs.

Issue	Contention(s)	Description of Issue	Response
Quarry void dewatering	1(ii), 2(v)-(vi), 7, 9(a) & (d), 11	This issue is concerned with the potential impact of dewatering Pond 1 (and previously Pond 2) during the filling operations on downstream watercourses and the hanging swamp several hundred metres downgradient of the site, including water quality and geomorphic stability.	Potential impacts of quarry void dewatering on the downslope hanging swamp are addressed by completed groundwater monitoring and modelling provided in Section 4.
Fill leachate generation	2(i)-(ii), 7, 11	This issue is concerned with the potential impact of leachate generated by fill placed in the quarry voids once it is released into the receiving environment. The issue covers impacts during the filling stages but also after the final landform has been establish.	Potential impacts of fill leachate generation are addressed in Section 6 of the Revised Water Resources Assessment (GHD, November 2021).
Final landform overland flow	2(ii), 7	This issue is concerned with the potential impact of changes to the overland flow regime arising from the final landform on downstream watercourses and swamp.	Potential impacts of changes to overland flow regimes on downslope watercourses and hanging swamp are addressed in Section 3.

1.4 Scope and Objectives

The scope of this report is to provide further environmental and hydrological data to support the Proposal. Specific objectives included:

1. Providing a detailed description of the existing hydrological environment, including surface and groundwater regimes, particularly at the hanging swamp located approximately 200 m downgradient of the Site (the **hanging swamp**).
2. Determining hydrological conditions, including surface and groundwater regimes, prior to historical quarrying activities, particularly at the swamp.
3. Determine the surface water hydrologic regime after the final proposed landform is established.
4. Determine groundwater conditions during the filling stages and after the final proposed landform is established.

2 Existing Environment

2.1 Overview

The Site is a former sandstone quarry located on the eastern side of Sandham Road, Bell, NSW. The Site lies within the Lithgow City Council Local Government Area (Figure 1). The Site contains two existing quarry voids, unsealed accesses and fences (Figure 2). A constructed wetland is located immediately downgradient of the Site, this built for water quality purposes during the quarrying activities (Figure 3). The Site also contains cleared areas (associated with former quarrying activities) and remnant bushland. Downslope some 200 m and east / north-east of the Site is an existing upland wetland or 'hanging swamp' (the **swamp**) (Figure 4). Map 1 (Appendix B) shows the Site in its local context.

Review of historical aerial photography of the Site shows that prior to quarrying commencing, the Site was largely covered by bushland and a number of unsealed accesses (circa. 1966) (Map 2). During quarrying, the active quarry and surrounding areas were stripped of most of its vegetation to allow for Site operations (circa 1998) (Map 3). Post quarrying (2021) (Map 4), the quarry voids have filled with water and previous processing and stockpiling areas have revegetated to some extent. Evidence of relatively recent bushfire at the site is noted in the vegetation downslope of the Site (Figure 4).

2.2 Topography and Slopes

The Site is located at the upper end and western side of a north-east / south-west running valley off the main ridgeline on which Bells Line of Road (Chifley Road) sits. Local elevation is variable, rising from approximately 1,000 mAHD at the downstream end of the hanging swamp to approximately 1,068 mAHD in the vicinity of Sandham Road and the western railway line from Lithgow to Sydney (Map 5).

Site slopes are variable, generally of the order of 0 – 10% at the top of ridgelines and in previously active quarry stockpiling and access areas, to near vertical along the edges of the quarry voids. Valley side slopes are generally between 10 – 20% downslope of the Site (Figure 5). Map 6 shows Site and local slopes.

2.3 Geology

Review of the Sydney 1:250,000 Geological Series Sheet S1 56-5 (NSW Department of Mines, 1966) shows that local geology consists of sandstones, shales and tuffs of the Narrabeen Sandstone Group (Figure 6).

2.4 Geomorphology

Regional geomorphology is characterised by the local geology, consisting of sandstone plateau crests with deeply incised canyon / gorge river valleys in between. Local surface and groundwater systems are generally either:

1. Diffuse or poorly defined and discontinuous surface flow paths on the sandstone plateaus with sand and organic deposits (Figure 7).
2. Gorge / canyon river valleys.
3. Transitional rivers between plateau and canyon systems exhibiting well defined channels with depositional zones controlled by bedrock outcropping.[1]

The plateau crests contain upland 'hanging swamps', which form from sand and organic material deposition in areas with localised changes in underlying geology and longitudinal slope.[2] These systems are described as having a high geomorphic fragility on account of the unchannelised unconsolidated soils of the system and impacts from upslope urbanisation which have changed flow regimes, caused erosion and introduced non-endemic species.[3]

The hanging swamp downslope of the Site maintains the following geomorphic characteristics:

1. The swamp has formed within a relatively narrow and evenly graded valley floor which accumulates a range of coarse sediments including bushfire charcoals (Figure 8). Based on our review of historical aerial photographs, it is likely that the swamp has accumulated sediments generated upslope during historical quarrying activities.
2. No defined channel is present within the swamp, although there is evidence of historic intermittent erosion and subsequent deposition events during periods of channelisation. These likely occurred drying heavy rainfall when vegetation cover was diminished or distressed (for example after a bushfire or during extended dry periods), or may have occurred during when the quarry was active and the effective catchment areas were higher (before the remediation works evident on the Site at the time of preparing this report).
3. Water inflow at the upstream end of the swamp arrives via a narrow channel approximately 0.5-1.0 m wide and up to 0.5 -1.0 m deep (see for example Figure 9). However, the channel form diminishes to nothing at the entry point to the swamp where surface flows are infiltrated into the sandy sediment (Figure 4 and Figure 8).
4. Water outflows, including shallow groundwater seepage and overland flows, are reconcentrated at the downstream end of the swamp, where a small approximately 1.0 m wide and 0.5 m deep channel re-emerges (see for example Figure 10).

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[1] Commonwealth Department of the Environment (2014) *Temperate Highland Peat Swamps on Sandstone: ecological characteristics, sensitivities to change, and monitoring and reporting techniques.*

[2] Ibid.

[3] Ibid.

2.5 Soils

Site soils are generally sandy (Figure 8). Review of Site soil mapping (Map 7) shows the following soils to be present at or near to the Site:

1. **Mount Sinai:** Located on the top of the ridgeline to the west of and upslope of the quarry on which Bells Line of Road and the main western railway are located. Consisting of shallow (typically < 0.05 m) stony quartz sand topsoils overlying up to 0.20 m of loamy sand then sandstone bedrock. Exposed 'pagoda' bedrock formations and outcrops are common.[4]

2. **Medlow Bath:** Located along local ridgelines and in the vicinity of the quarry voids. Consisting of up to 0.4 m of sand topsoil overlying up to 0.8 m of loamy to clayey sands grading to extremely weathered sandstone at depth then sandstone bedrock. Bedrock outcropping is common.[5]

3. **Wollangambe:** Located downslope of the quarry voids and in the vicinity of the hanging swamp. Consisting of up to 0.3 m of loamy sand topsoil overlying up to 0.7 m of clayey sand then sandstone bedrock. In localised areas of shale bedrock, up to 0.5 m of loamy sand overlies up to 0.7 m of sandy clay then shale bedrock.[6]

4. **Disturbed Terrain:** Located in the immediate vicinity of the former quarry area. Soils are largely sands with frequent outcropping of bedrock.[7]

To supplement the soil landscape data, fourteen (14) boreholes were completed at the Site and in the vicinity of the hanging swamp to confirm local profiles. Location of completed boreholes is given on Map 8, with boreholes logs provided in Appendix C. Table 2 provides a summary of the boreholes completed at the Site.

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[4] King (1993) *Wallerawang Soil Landscape Series Sheet 8931.*

[5] Ibid.

[6] Ibid.

[7] Ibid.

Table 2: Summary of Site borehole investigations.

Location	Topsoil	Sub-soil	Depth to Rock (m)
BH501	0 – 0.25 m silty sand	0.25 m sandy clay grading to extremely weathered sandstone	0.50
BH502	0 – 0.30 m silty sand	0.30 m sandy clay grading to extremely weathered sandstone.	0.60
BH503	0 – 0.20 m silty sand	0.40 m sandy clay grading to extremely weathered sandstone.	0.60
BH504	0 – 0.15 m silty sand	Extremely weathered sandstone grading to moderately weathered sandstone.	0.15
BH505	0 – 0.25 m silty sand	Extremely weathered sandstone grading to moderately weathered sandstone.	0.25
BH506	0 – 0.20 m silty sand	Extremely weathered sandstone grading to moderately weathered sandstone.	0.20
BH507	0 – 0.30 m gravelly sand	Extremely weathered sandstone.	0.30
BH508	0 – 0.30 m gravelly sand	0.20 m sandy clay grading to extremely weathered sandstone.	0.50
BH509	0 – 0.20 m silty sand	0.40 m sandy clay grading to extremely weathered sandstone.	0.60
BH510	0 – 0.20 m silty sand	0.30 m sandy clay grading to extremely weathered sandstone.	0.50
BH511	0 – 0.20 m silty sand	0.40 m sandy clay grading to extremely weathered sandstone.	0.60
BH512	0 – 0.60 m sand	Extremely weathered sandstone.	0.60
BH513	0 – 0.50 m gravelly sand fill	Extremely weathered sandstone.	0.50
BH514	0 – 0.30 m silty sand	0.50 m sandy clay grading to extremely weathered sandstone.	0.60

2.6 Creeks and Rivers

Directly downslope of the Site is an unnamed watercourse which forms part of the upper Wollangambe River catchment (Figure 1). Two flow monitoring stations have been installed on this watercourse at the upstream and downstream ends of the hanging swamp (Figure 9 and Figure 10). This watercourse runs north-eastwards prior to joining another unnamed watercourse to the north of the Site (Figure 11).

The resultant watercourse then joins another larger unnamed watercourse before flowing into the Wollangambe River, approximately 2.3 km downstream of the quarry void. Map 9 shows mapped 'hydrolines' in the vicinity of the Site.

2.7 Climate

2.7.1 Rainfall

Whilst the Site has no climate station, the Bureau of Meteorology (**BoM**) has three nearby open daily rainfall stations including:

1. Lithgow (Cooerwull) (063226)
2. Mt Boyce AWS (Blackheath) (063292)
3. Mt Wilson (Clarine) (063246)

The BoM also maintained a daily rainfall gauge at Newnes Junction Village (station 63139) between August 1959 and April 1968. This gauge was relatively close to the Site (approximately 1 – 2 km).

Map 10 shows the position of the BoM rainfall stations relative to the Site. Table 3 provides a summary of the BoM rainfall stations. Lithgow was considered the most representative and robust data set based on gauged flows at the Site when compared to the daily rainfall data at all three stations over the monitoring period.

Rainfall is generally summer / early autumn dominant, with median rainfall values suggesting that rain falls throughout the year.

Given the strong gradient in rainfall between Lithgow and Mount Wilson, Lithgow daily rainfall data were scaled up by 30% for the purposes of the MUSIC model (Section 3.3).

A comparison of daily rainfall totals at Lithgow (Cooerwull) and Newnes Junction for the period between July 1960 and April 1968 showed that the rainfall recorded at Newnes Junction was greater than that recorded for Lithgow for approximately 418 out of 657 rain days during this period and that total rainfall depth was approximately 33% higher at Newnes Junction than at Lithgow (Cooerwull). This correlates well with the adopted rainfall in the MUSIC modelling.

We understand that GHD have relied on a slightly different rainfall data, being point data for the site obtained from the SILO website, which comprises some 132 years extending between 1889 and 2021.[8] This data set is based on interpolated / modelled rainfall based on collected rainfall from a range of sources and was used by GHD for long-term water balance modelling. By comparison, the rainfall relied upon in this report for MUSIC hydrologic modelling uses a shorter [scaled] rainfall record including 1962 – 1971 and 2007 to the present day, these being available non-interpolated data. As shown in Figure 15, the differences between these data sets is negligible and both data sets are considered appropriate for their intended use.

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[8] https://www.longpaddock.qld.gov.au/silo/point-data.

Table 3: Summary of Bureau of Meteorology (BoM) stations and rainfall data.

Statistic	Lithgow	Mount Boyce	Mount Wilson	Newnes Junction	Adopted for Site
Station Number	063226	063292	063246	063139	-
Elevation (mAHD)	900	1080	1010	1080	-
Median annual rain (mm/year)	775.0	1020.0	1263.4	1128.6	970.0
Mean Annual rain (mm/year)	783.3	984.7	1272.7	1095.9	1045.0

2.7.2 Evaporation

The nearest climate station with appropriate monthly evaporation data is Bathurst Agricultural Station (BoM station number 063005, approximately 68 km to the west of the Site. Whilst the Richmond Airport is closer to the Site by approximately 20 km, the Bathurst climate station is considered more representative given its more similar elevation of approximately 710 mAHD (as opposed to Richmond at 19 mAHD). Mean annual evaporation used in the MUSIC model was 1,346 mm.

2.7.3 Evapotranspiration

Pan evaporation data (refer to Section 2.7.2) is used in the MUSIC modelling program to determine losses through evapotranspiration at the Site.

3 Surface Water Hydrology

3.1 Catchment Characteristics

Sub-catchments flowing to significant features (e.g. the voids, upstream and downstream ends of hanging swamp, *etc.*) were determined using available contour data (NSW Department of Financial Services and Information, 2017). Catchments were then split by surface characteristics for the purpose of MUSIC modelling to determine hydrological and water quality characteristics. Table 4 details catchments used in the MUSIC modelling, with the catchment plan provided in Map 12.

Adopted impervious and pervious areas by sub-catchment classification are provided in Table 5, noting that these were derived by iteration to obtain best fit to observed flows. Impervious area percentages adopted for forested areas upslope and downslope of the Site were 10% and 20% respectively reflecting occurrence of very shallow soils and frequent rock outcropping. Former quarry areas draining to voids were modelled as having a 40% impervious area to represent shallow soils and limited existing vegetation coverage. An impervious area of 100% is adopted for direct rainfall into the quarry voids.

Table 4: Summary of catchments used in hydrological and water quality modelling (existing conditions).

Catchment	Area by Surface Classification (ha)						Total Area (ha)
	Unsealed Road	Forest	Rural Residential	Rail Corridor	Former Quarry	Pond	
1	0.432	5.077	0.000	0.000	0.000	0.000	5.509
2	0.000	0.000	0.000	2.482	0.000	0.000	2.482
3	0.484	3.776	0.000	0.000	0.000	0.000	4.260
4	0.000	0.000	0.000	0.000	0.400	0.000	0.400
5	0.000	0.000	0.000	0.000	1.146	0.000	1.146
6	0.000	0.000	0.000	0.000	0.000	2.733	2.733
7	0.110	1.237	0.000	0.000	0.000	0.000	1.347
8	0.000	0.000	0.000	0.000	4.825	0.000	4.825
9	0.000	0.000	0.000	0.000	0.000	0.764	0.764
10	0.000	0.075	0.000	0.000	0.000	0.000	0.075
11	0.000	0.000	0.000	0.000	0.000	0.150	0.150
12	0.000	0.770	0.000	0.000	0.000	0.000	0.770
13	0.357	5.572	0.000	0.000	0.000	0.000	5.929
14	0.080	9.601	0.000	0.000	0.000	0.000	9.681
15	1.370	17.157	1.711	0.000	0.000	0.000	20.237
Total	2.833	43.265	1.711	2.482	6.370	3.647	60.307

Table 5: Adopted impervious / pervious areas by catchment type.

Catchment Classification	Impervious Area (%)	Pervious Area (%)
Unsealed Road	100	0
Forest (to Quarry Void)	10	90
Forest (downslope Quarry Void)	20	80
Rural Residential	25	75
Rail Corridor	1	99
Former Quarry	40	60
Pond (Direct Rainfall)	100	0

3.2 Flow Gauging

3.2.1 Purpose

Two stream gauges (Figure 9 and Figure 10) were set up at the upslope and downslope ends of the hanging swamp to determine flows and assess likely changes to hydrological conditions, should the Site be rehabilitated to remove the quarry voids. Map 11 shows the position of flow gauging sites and catchments draining to each gauge.

3.2.2 Method

Gauging methodology consisted of the following:

1. **Site selection:** Two locations on the watercourse downslope of the quarry were selected for flow gauging. Sites were chosen on the basis of a stable cross-section, presence of a downstream bed level control, and presence of a permanent pool located upstream of the bed level control within which instrumentation could be installed.

2. **Pressure transducer installation:** Two water pressure transducers were installed to continuously measure water level at the gauge site, with observations made at 15 minute intervals during the monitoring period between 20/4/2021 and 25/10/2021 (6 months), this being sufficient to characterise the existing hydrologic regime at the swamp A non-submerged transducer was installed to measure atmospheric pressure.

3. **Channel survey:** At each gauging station site, cross-section surveys were undertaken by a registered surveyor to determine channel form and estimate bed slope. Survey data are provided in Appendix E. Survey data enabled a stage-discharge relationship to be established at each gauge site.

4. **Correction for atmospheric pressure:** Gauged pressures were converted to water depths by correcting for atmospheric pressure variations.

5. **Conversion of depths to flow rates:** The stage-discharge relationship was used to produce a flow time series at each gauging location based on water level observations.

3.2.3 Findings

Results of flow monitoring and recorded rainfall (scaled) at Lithgow (Cooerwull) for the period from 20/4/2021 to 25/10/2021 are provided graphically for the upstream and downstream flow gauging stations in Figure 12 and Figure 13.

Results are summarised in Table 6, in terms of percentiles of flow rates, minimum, maximum and average flows across the monitoring period. Figure 16 shows the flow rates depicted as a cumulative frequency curve.

Table 6: Flow rate statistics – measured flows.

Statistic	Upstream Gauge (L/s)	Downstream Gauge (L/s)
Minimum	0.00	0.00
10th Percentile	0.13	0.85
20th Percentile	0.21	1.32
30th Percentile	0.31	1.81
40th Percentile	0.44	2.38
50th Percentile (Median)	0.62	2.91
60th Percentile	0.84	3.66
70th Percentile	1.14	4.87
80th Percentile	1.50	7.41
90th Percentile	2.18	11.79
91st Percentile	2.30	13.06
92nd Percentile	2.47	13.73
93rd Percentile	2.59	15.13
94th Percentile	2.78	17.36
95th Percentile	2.97	20.20
96th Percentile	3.39	23.28
97th Percentile	4.08	27.04
98th Percentile	5.22	39.78
99th Percentile	10.05	103.54
Maximum	42.83	638.23
Average	1.14	7.00

3.2.4 Discussion

Site flow regime is characterised as follows:

1. **Surface Flows Directly Relate to Incident Rainfall**: Flows to the hanging swamp appear to be directly related to incidence of local rainfall (i.e. flows rely on surface flows from rainfall as opposed to base flows from groundwater).
2. **Runoff Response to Rainfall is Rapid:** Local catchments have a relative rapid response with flows commencing not long after commencement of precipitation. Hydrographs are correspondingly short with relatively short rising limb to the peak and then a somewhat longer falling limb of the hydrograph denoting that flows continue for some time afterwards (Figure 14). This response is characteristic of the relatively shallow sandy catchment soils and frequent bedrock outcropping within the catchment.
3. **Quarry has Significantly Reduced Swamp Inflows:** Catchment areas to the upslope and downslope gauges are approximately 24.5ha and 60.4 ha respectively, with the upper catchment approximately 40% of the total catchment area downslope. By contrast, the observed median flow at the upstream gauge is approximately 21% of the flow at the downstream gauge. This indicates that the quarry voids and historical quarrying activities have considerably impacted hydrology at the swamp by decreasing inflow rates by approximately 50%.
4. **Average Flow Rates are Low:** Average flow rates into and out of the swamp were low for the given catchment areas, being 1.1 and 7.0 L/s for the upstream and downstream gauge respectively.
5. **Periods of Zero/Near Zero Flow Occur:** Low flows of < 1 L/s and < 5 L/s for the upstream and downstream gauges respectively occurred for approximately 60% of the time. For the upstream gauge, these flows represented slow release of surface water detained in the quarry voids. For the downstream gauge, these flows represented the release of shallow stored groundwater within the swamp sediments.
6. **Peak Flows Did Not Cause Erosion:** Peak flows into the swamp of up to 40L/s and 638 L/s out of the swamp were measured during the observation period. These did not result in any observable erosion of the channel system or swamp, nor did they result in any geomorphic change.
7. **Quarry Dewatering Rate:** Based on the observed flow data, quarry dewatering rates up to say 100 L/s are not anticipated to result in any geomorphic change to the swamp or adjacent channel system. Higher rates may be acceptable.

3.3 Flow Modelling

3.3.1 Purpose

Flow modelling was completed to:

1. Characterise long-term hydrological conditions under the current site conditions upstream and downstream of the hanging swamp.
2. Estimate hydrological conditions prior to quarrying activities upstream and downstream of the hanging swamp so that the impact of historical quarrying can be assessed.
3. Estimate hydrological conditions for the final design surface upstream and downstream of the hanging swamp.

3.3.2 Method

Methodology used included the following:

1. Development of a calibrated MUSIC (Model for Urban Stormwater Improvement Conceptualisation) model based on observed flow data (Section 3.2), recorded rainfall and Site observations of local conditions.
2. Catchment boundaries and catchment surface characteristics were determined based on Site aerial photos for existing conditions (Map 12). Boundaries were determined to key existing local features such as the hanging swamp (upstream and downstream ends), existing quarry voids and wetland, and the tributary watercourse to the north of the quarry which flows to the hanging swamp.
3. Soil properties based on soil data from subsurface investigations (Section 2.5) and BMT WBM (2015) guidelines for MUSIC modelling, adjusted to be more representative of local conditions.
4. Local daily rainfall for Lithgow (Cooerwull) was used, adjusted by a factor of 1.30 to allow for the rainfall gradient observed between Lithgow, Mount Boyce and Mount Wilson.
5. Model was rerun iteratively by adjusting soil parameters, impervious areas and properties of the quarry voids and calibrated against the recorded flow monitoring data.
6. Once the model was calibrated to the short-term flow monitoring data, a longer rainfall record was used to determine the long-term existing hydrological conditions. The rainfall record used included approximately 25 years of daily rainfall recorded at Lithgow (Cooerwull) for the years 1962 – 1971 and 2007 – October 2021, adjusted by a factor of 1.3 to represent the wetter conditions at the Site.

7. Following establishment of the longer-term existing conditions model, determine the pre-quarry hydrological conditions by removing the existing quarry voids from the model and amend catchment surface characteristics to match pre-quarry conditions.
8. The final design surface was modelled based on the final surface development plans, with these indicating a retention of the lower quarry void (pond 2).

3.3.3 Calibration

Model calibration consisted of:

1. Modifying catchment soils properties, with reference to soil testing undertaken.
2. Modifying catchment percentage impervious fractions based on existing development and rock exposures within the catchment.
3. Modifying quarry void parameters to represent capture of upslope catchment flows and overflows to downstream receiving environments.

A comparison of flow volumes and rates for selected storm events during the monitoring period is provided in Table 7, Table 8, Table 9 and Table 10 and demonstrates that the model is sufficient calibrated for predictive purposes. The following is noted:

1. In terms of modelled flow volumes:
    a. Modelled flow volumes closely match observed data indicating that the model is sufficiently calibrated for predictive purposes, with normalised root mean square of residuals around 18%. Some over or under prediction is expected for individual storm events, and variation between storm events, due to the spatial variation in rainfall between the Lithgow rain gauge and actual rain falling on the site.
    b. Average measured flows at the upstream gauge are lower than modelled flows, suggesting that not all of the detention properties of the existing quarry voids have been fully captured by the model.
    c. Average measured flows at the downstream gauging station are very similar to modelled flow volumes indicating a good model fit.
2. In terms of peak flow rates:
    a. Modelled flow rates are broadly consistent with observed data indicating that the model is sufficiently calibrated for predictive purposes, with normalised root mean square of residuals around 23%. Some over or under prediction is expected for individual storm events, and variation between storm events, due to the spatial variation in rainfall between the Lithgow rain gauge and actual rain falling on the site.

b. Peak measured flow rates at the upstream gauge are lower than modelled flows, suggesting that not all of the detention properties of the existing quarry voids have been fully captured by the model.

c. Peak measured flows at the downstream gauging station are lower than modelled flow volumes indicating flow absorption and attenuation within the hanging swamp.

d. Differences between measured and modelled peak flow rates are also expected because of temporal data differences between the Lithgow rain dataset [used for modelling], which consisted of daily data with values recorded at 9am, and the flow gauging data which was collected at 15 minute intervals.

e. Hydrological algorithms internal to the MUSIC model may not precisely mimic the rainfall-runoff response behaviour of the Site and surrounding areas.

Table 7: Comparison of measured and modelled event runoff volumes at upstream gauging station (ML).

Rainfall Event	Measured (ML)	Modelled (ML)
6/5/2021-7/5/2021	1.26	1.78
3/6/2021-4/6/2021	0.26	0.01
16/7/2021-18/7/2021	0.94	2.46
24/8/2021-25/8/2021	2.82	11.23
15/10/2021-17/10/2021	0.38	0.77
Average	1.132	3.25

Table 8: Comparison of measured and modelled event runoff volumes at downstream gauging station (ML).

Rainfall Event	Measured (ML)	Modelled (ML)
6/5/2021-7/5/2021	13.6	4.99
3/6/2021-4/6/2021	1.41	1.18
16/7/2021-18/7/2021	4.37	6.8
24/8/2021-25/8/2021	24.33	30.18
15/10/2021-17/10/2021	3.24	2.19
Average	9.39	9.068

Table 9: Comparison of measured and modelled peak flows upstream gauging station (L/s).

Rainfall Event	Measured (L/s)	Modelled (L/s)
6/5/2021-7/5/2021	18.4	15.5
3/6/2021-4/6/2021	3.1	0.01
16/7/2021-18/7/2021	6.8	15.5
24/8/2021-25/8/2021	42.8	94.3
15/10/2021-17/10/2021	3.2	5
Average	14.86	26.062

Table 10: Comparison of measured and modelled peak flows at downstream gauging station (L/s).

Rainfall Event	Measured (L/s)	Modelled (L/s)
6/5/2021-7/5/2021	246.8	43
3/6/2021-4/6/2021	14.4	7
16/7/2021-18/7/2021	37.6	36.4
24/8/2021-25/8/2021	340.5	214.1
15/10/2021-17/10/2021	32.4	12.2
Average	134.34	62.54

3.3.4 Existing Hydrology

Rainfall data used for MUSIC model predictive purposes included approximately 25 years of daily rainfall recorded at Lithgow (Cooerwull) for the years 1962 – 1971 and 2007 – October 2021 [scaled by a factor of 1.30]. Evaporation data used in the MUSIC model was monthly average data for Bathurst. Results for daily flow volumes and peak flow rates are provided in Table 11 and Table 12. The following is observed from these data:

1. Surface runoff into and out of the hanging swamp is low for approximately 80 % of the modelled period, this characteristic of a runoff regime which is dominated by quick responses to incident rainfall and is reflective of the small contributing upslope catchment.

2. For some 50% of the modelled period there is essentially no or low surface runoff through the swamp. This is broadly consistent with the observed gauging data.

Table 11: Modelled existing conditions hydrology (daily flow volume).

Statistic	Upstream Gauge (kL/d)	Downstream Gauge (kL/d)
Minimum	0.00	0.00
10th Percentile	0.00	0.00
20th Percentile	0.00	0.00
30th Percentile	0.00	0.00
40th Percentile	0.14	0.02
50th Percentile	0.38	3.82
60th Percentile	1.40	32.44
70th Percentile	6.45	155.65
80th Percentile	59.40	448.27
90th Percentile	341.16	1,262.52
91st Percentile	411.13	1,481.09
92nd Percentile	504.27	1,676.36
93rd Percentile	630.84	1,914.57
94th Percentile	812.23	2,259.97
95th Percentile	1,036.98	2,661.04
96th Percentile	1,411.46	3,335.43
97th Percentile	1,973.32	4,646.49
98th Percentile	3,038.09	7,024.40
99th Percentile	5,330.82	12,966.48
Maximum	31,675.55	76,212.63

Table 12: Modelled existing conditions hydrology (peak flow rate).

Statistic	Upstream Gauge (L/s)	Downstream Gauge (L/s)
Minimum	0.00	0.00
10th Percentile	0.00	0.00
20th Percentile	0.00	0.00
30th Percentile	0.00	0.00
40th Percentile	0.00	0.00
50th Percentile	0.00	0.06
60th Percentile	0.02	0.44
70th Percentile	0.07	1.73
80th Percentile	0.69	5.17
90th Percentile	3.95	15.07
91st Percentile	4.76	17.14
92nd Percentile	5.84	19.40
93rd Percentile	7.30	22.16
94th Percentile	9.40	26.16
95th Percentile	12.00	30.80
96th Percentile	16.34	38.60
97th Percentile	22.84	53.78
98th Percentile	35.16	81.30
99th Percentile	61.70	150.08
Maximum	366.62	882.09

3.3.5 Pre-quarry Hydrology

The existing conditions MUSIC model was modified as follows to simulate pre-quarry hydrologic conditions:

1. Quarry voids were removed from the model.
2. Quarry and direct rainfall to void catchments were changed to forest catchments with 10% impervious area as per other forested catchments draining to the quarry voids.

Results of the modelling are produced in Table 13 and Table 14. The following observations are made in respect of these data.

1. Under pre-quarry conditions no flow conditions existed for around 50 % of the modelled period, this being similar to existing hydrological conditions.

2. For the 50-90th flow percentile bands, these representing the majority of the active flow period, existing flow volumes into the hanging swamp from the Site are on average 65 % lower than under pre-quarry conditions (reductions range from 8-89%). Existing flow rates into the hanging swamp from the Site are on average 69% lower than under pre-quarry conditions (reductions range from 15-100%).

3. For the less frequent 95-99th percentile bands, flow volumes and rates have increased by approximately 26% over pre-quarry conditions.

4. Modelling demonstrates that historical quarrying activities have considerably altered the natural hydrologic regime of the hanging swamp. Significant flow reductions have occurred for more frequent runoff events (< 90th percentile flows), but increased flow rate and volume have occurred for less frequent (> 90th percentile flows) and more intense runoff events.

Table 13: Modelled pre-quarry conditions hydrology (daily flow volume).

Statistic	Upstream Gauge (kL/d)	Downstream Gauge (kL/d)
Minimum	0.00	0.00
10th Percentile	0.00	0.00
20th Percentile	0.00	0.00
30th Percentile	0.00	0.00
40th Percentile	0.01	0.02
50th Percentile	1.56	3.82
60th Percentile	12.32	32.44
70th Percentile	51.31	155.65
80th Percentile	145.33	448.27
90th Percentile	398.90	1,262.52
91st Percentile	447.98	1,403.15
92nd Percentile	496.94	1,603.15
93rd Percentile	564.15	1,801.16
94th Percentile	654.48	2,142.15
95th Percentile	773.34	2,516.27
96th Percentile	984.15	3,255.98
97th Percentile	1,416.40	4,452.51
98th Percentile	2,726.74	7,156.04
99th Percentile	5,311.15	13,766.66
Maximum	30,347.97	74,885.05

Table 14: Modelled pre-quarry conditions hydrology (peak flow rate).

Statistic	Upstream Gauge (L/s)	Downstream Gauge (L/s)
No flow	0.00	0.00
10th Percentile	0.00	0.00
20th Percentile	0.00	0.00
30th Percentile	0.00	0.00
40th Percentile	0.00	0.00
50th Percentile	0.02	0.04
60th Percentile	0.14	0.38
70th Percentile	0.59	1.80
80th Percentile	1.68	5.19
90th Percentile	4.62	14.61
91st Percentile	5.18	16.24
92nd Percentile	5.75	18.55
93rd Percentile	6.53	20.85
94th Percentile	7.58	24.79
95th Percentile	8.95	29.12
96th Percentile	11.39	37.68
97th Percentile	16.39	51.53
98th Percentile	31.56	82.82
99th Percentile	61.47	159.34
Maximum	351.25	866.73

3.3.6 Final Surface Hydrology

The existing conditions MUSIC model was modified as follows to simulate the final design surface hydrologic conditions:

1. The upper quarry void (pond 1) was removed from the model.
2. Quarry and direct rainfall to the upper void catchment was changed to forest with 10% impervious area as per other forested catchments draining to the quarry voids.

1. Results of the modelling are produced in Table 15,Surface flows into the hanging swamp are similar to existing hydrological conditions, although mid range flows are move towards pre-quarry conditions due to the closure of the upper void (pond 1).
2. Surface flows leaving the hanging swamp are essentially unchanged compared to existing or pre-quarry conditions.

3. Modelling demonstrates that the proposed final surface will not detrimentally impact on the surface flow hydrological regime within the hanging swamp downslope of the Site. The closure of the upper void will go some way towards remediating historical changes in flow regime at the swamp.

Table 15 Table 16 and Table 17. The following observations are made in respect of these data:

4. Surface flows into the hanging swamp are similar to existing hydrological conditions, although mid range flows are move towards pre-quarry conditions due to the closure of the upper void (pond 1).

5. Surface flows leaving the hanging swamp are essentially unchanged compared to existing or pre-quarry conditions.

6. Modelling demonstrates that the proposed final surface will not detrimentally impact on the surface flow hydrological regime within the hanging swamp downslope of the Site. The closure of the upper void will go some way towards remediating historical changes in flow regime at the swamp.

Table 15: Modelled final surface conditions hydrology (daily flow volume).

Statistic	Upstream Gauge (kL/d)	Downstream Gauge (kL/d)
Minimum	0.00	0.00
10th Percentile	0.00	0.00
20th Percentile	0.00	0.00
30th Percentile	0.00	0.01
40th Percentile	0.10	0.29
50th Percentile	0.35	5.63
60th Percentile	1.45	48.71
70th Percentile	8.58	161.52
80th Percentile	89.91	444.80
90th Percentile	415.58	1277.43
91st Percentile	477.45	1433.87
92nd Percentile	555.12	1585.37
93rd Percentile	637.02	1804.65
94th Percentile	777.46	2123.35
95th Percentile	938.83	2529.98
96th Percentile	1221.93	3239.58
97th Percentile	1649.09	4243.34
98th Percentile	2722.84	7128.25
99th Percentile	5133.79	13691.75
Maximum	30844.92	75381.99

Table 16: Modelled final surface conditions hydrology (peak flow rate).

Statistic	Upstream Gauge (L/s)	Downstream Gauge (L/s)
No flow	0.00	0.00
10th Percentile	0.00	0.00
20th Percentile	0.00	0.00
30th Percentile	0.00	0.00
40th Percentile	0.00	0.00
50th Percentile	0.00	0.07
60th Percentile	0.02	0.56
70th Percentile	0.10	1.87
80th Percentile	1.04	5.15
90th Percentile	4.81	14.79
91st Percentile	5.53	16.60
92nd Percentile	6.43	18.35
93rd Percentile	7.37	20.89
94th Percentile	9.00	24.58
95th Percentile	10.87	29.28
96th Percentile	14.14	37.50
97th Percentile	19.09	49.11
98th Percentile	31.51	82.50
99th Percentile	59.42	158.47
Maximum	357.00	872.48

3.3.7 Existing, Pre-quarry and Final Surface Comparison

A comparison of average annual flows into and out of the hanging swamp is provided in Table 17. These data indicate that the existing quarry has reduced average annual flow to the swamp in the order of 5 %, with inflows predominating during higher intensity runoff events. Existing swamp outflows are reduced by around 1.5 % compared to pre-quarry conditions. With the final rehabilitated surface in place, these historic impacts will be roughly halved to 2.8% decrease in flow volume into the swamp and 0.8 % decrease in flow out of the swamp compared to pre-quarry conditions.

Table 17: Comparison of annual average swamp flows for existing, pre-quarry and final surface conditions.

Catchment State	Upstream Gauge (ML/yr)	Downstream Gauge (ML/yr)
Existing Conditions	86.4	249.0
Pre-Quarry Conditions	90.9	253.0
Final Rehabilitated Conditions	88.4	251.0

3.4 Surface Water Quality

3.4.1 Method

Sampling of surface water quality occurred at the following locations:

1. Each of the quarry voids (pond 1 and pond 2) on 5/10/2021, 13/10/2021, 19/10/2021 and 25/10/2021 (Quarry).
2. Each flow gauging site including upstream and downstream gauges on 5/10/2021, 13/10/2021, 19/10/2021 and 25/10/2021 (Swamp).
3. Left bank tributary joining upslope of the downstream gauging site (SW01) on 5/10/2021, 13/10/2021, 19/10/2021 and 25/10/2021 (Tributary). This is a less disturbed catchment than that containing the quarry voids.
4. Within the hanging swamp upstream of the tributary joining the downstream gauge (SW02) on 5/10/2021, 13/10/2021, 19/10/2021 and 25/10/2021 (Swamp).

Surface water quality testing locations are provided in Map 13. Parameters measured are listed in Table 18.

3.4.2 Findings

Water quality sampling laboratory reports are provided in Appendix F A summary of all surface water quality sampling compared to trigger values for upland rivers given in Australian and New Zealand Environment and Conservation Council (2018) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (95th percentile protection for slightly to moderately disturbed ecosystems) s provided in Table 18 below.[9]

Table 18: Surface water quality data averages against trigger values for highland rivers.

Parameter	Quarry (Ponds 1 & 2)	Swamp (U/S, D/S gauges + SW02)	Tributary (SW01)	ANZG (2018) Guidelines Trigger Value[10]
pH	6.7	5.0	4.6	6.5 - 7.5
Temperature (°C)	16.8	16.9	13.7	-
Electrical Conductivity (µS/cm)	26.9	28.1	32.3	350
Dissolved Oxygen (%)	80.2	59.0	11.7	< 90
Total nitrogen (mg/L)	0.29	0.13	0.05	< 0.25
Total Kjeldahl nitrogen (TKN) (mg/L)	0.35	0.13	0.05	-

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[9] https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/water-quality-toxicants.

[10] Values for pH, Electrical Conductivity, Dissolved Oxygen, Total Nitrogen, Total Nitrate and Total Phosphorous from Australian and New Zealand Environment and Conservation Council (2000) *National Water Quality Management Strategy – Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, Ch 3.

Parameter	Quarry (Ponds 1 & 2)	Swamp (U/S, D/S gauges + SW02)	Tributary (SW01)	ANZG (2018) Guidelines Trigger Value[10]
Total nitrogen as NO_x (mg/L)	0.003	0.004	0.009	< 0.015
Ammonia (mg/L)	0.009	0.011	0.010	< 0.013
Total Phosphorus (mg/L)	0.003	< 0.003	< 0.003	< 0.020
Total Sodium (mg/L)	4.00	4.34	5.20	-
Total Potassium (mg/L)	0.99	0.57	< 0.25	-
Total Calcium (mg/L)	0.84	0.45	< 0.25	-
Total Magnesium (mg/L)	0.54	0.34	0.73	-
Hardness (mg/L)	4.30	2.51	3.61	-
Total Alkalinity (mg/L)	8.00	5.29	3.13	-
Sulphate (mg/L)	1.13	2.58	2.75	-
Chloride (mg/L)	4.75	5.41	6.75	-
Total Silicon (mg/L)	< 1.50	1.83	2.70	-
Total Arsenic (µg/L)	0.56	< 0.50	< 0.50	< 13
Total Cadmium (µg/L)	< 0.05	< 0.05	< 0.05	< 0.2
Total Chromium (µg/L)	< 0.50	< 0.50	< 0.50	< 1.0
Total Copper (µg/L)	0.56	0.63	< 0.50	< 1.4
Total Lead (µg/L)	< 0.50	0.75	< 0.50	< 3.4
Total Mercury (µg/L)	< 0.025	< 0.025	< 0.025	< 0.6
Total Nickel (µg/L)	< 0.50	< 0.50	< 0.50	< 11
Total Zinc (µg/L)	1.63	2.25	1.00	< 8.0
Total Recoverable Hydrocarbons (TRH C6 – C10) (µg/L)	< 5	< 5	< 5	-
Total Recoverable Hydrocarbons (TRH C10 – C14) (µg/L)	< 25	28.9	< 25	-
Total Recoverable Hydrocarbons (TRH C15 – C28) (µg/L)	< 50	56.7	< 50	-
Total Recoverable Hydrocarbons (TRH C29 – C36) (µg/L)	< 50	< 50	< 50	-

A detailed summary of testing data is provided for TN, TP, alkalinity, copper and zinc in Table 19 below.

Table 19: Detailed surface water quality statistical summaries.

Site	No. of Samples	Minimum	Maximum	Standard Deviation	Average
Total Nitrogen (mg/L)					
Pond 1	4	0.20	0.30	0.10	0.30
Pond 2	4	0.30	0.40	0.10	0.30
U/S Gauge	4	0.10	0.40	0.20	0.30
D/S Gauge	4	0.10	0.10	0.00	0.10
Tributary (SW01)	4	0.10	0.10	0.00	0.10
Hanging Swamp (SW02)	4	0.10	0.10	0.00	0.10
Total Phosphorus (mg/L)					
Pond 1	4	<0.025	<0.025	0.00	<0.025
Pond 2	4	<0.025	<0.025	<0.025	<0.025
U/S Gauge	4	<0.025	<0.025	<0.025	<0.025
D/S Gauge	4	<0.025	<0.025	<0.025	<0.025
Tributary (SW01)	4	<0.025	<0.025	<0.025	<0.025
Hanging Swamp (SW02)	4	<0.025	<0.025	<0.025	<0.025
Alkalinity (mg/L)					
Pond 1	4	5.0	14.0	4.2	9.0
Pond 2	4	5.0	10.0	2.4	7.0
U/S Gauge	4	6.0	10.0	2.1	7.8
D/S Gauge	4	2.5	9.0	3.3	4.1
Tributary (SW01)	4	2.5	5.0	1.3	3.1
Hanging Swamp (SW02)	4	2.5	6.0	1.8	4.0
Copper (µg/L)					
Pond 1	4	< 0.5	1.0	0.3	0.6
Pond 2	4	< 0.5	< 0.5	0.0	< 0.5
U/S Gauge	4	< 0.5	< 0.5	0.0	< 0.5
D/S Gauge	4	< 0.5	1.0	0.3	0.6
Tributary (SW01)	4	< 0.5	< 0.5	0.0	< 0.5
Hanging Swamp (SW02)	4	< 0.5	1.0	0.3	0.8
Zinc (µg/L)					
Pond 1	4	< 0.5	3.0	1.3	1.9
Pond 2	4	< 0.5	3.0	1.1	1.4
U/S Gauge	4	1.0	6.0	2.1	3.5
D/S Gauge	4	< 0.5	2.0	0.9	1.3
Tributary (SW01)	4	< 0.5	2.0	0.7	1.0
Hanging Swamp (SW02)	4	2.0	2.0	0.0	2.0

3.4.3 Discussion

The following observations are made:

1. Several parameters tested are below the reportable concentration limit.
2. Surface waters are fresh and slightly acidic.
3. Nutrient content is generally low, although higher nitrogen levels were found in the quarry ponds and the upstream gauge site. These do not appear to have impacted water quality within the swamp.
4. Heavy metals and hydrocarbon concentrations were low or below the detection limit.
5. The area downstream of the Site is classified as a disturbed ecosystem due to historical catchment urban and quarrying activities, and construction of roads and clearing within the catchment. Surface water chemistry is generally within ANZG criteria for slightly to moderately disturbed freshwater ecosystems.

4 Hydrogeology

4.1 Hydrogeological Context

The site is located in the Blue Mountains within the upper reaches of an unnamed tributary of the Wollangambe River which, ultimately discharges into the Colo and then the Hawkesbury Rivers. A topographic divide less than 200m to the southwest of the Site is the boundary between the Wollangambe River and Coxs River catchments. The Coxs River flows south of the Blue Mountains into Warragamba Dam and the Nepean River.

Site geology is dominated by sandstone with shallow residual soils and therefore groundwater predominately occurs within this sandstone aquifer. Occasional shallow, perched aquifers where groundwater conditions are controlled dominated by rainfall and run-off would occur in areas where catchment flows are concentrated in areas with shallow gradients.

The Site is at high elevation with no downstream water bodies to control groundwater levels. Groundwater levels are therefore dominated by recharge and aquifer properties, maintaining a pressure gradient downward into deeper sandstone. Locally, the presence of the quarry voids on the site has likely impacted the surrounding groundwater regime by lowering groundwater levels on the upslope sides and raising it on the downslope sides.

Following filling of the quarry, groundwater levels are expected to more accurately align with groundwater levels that occurred prior to quarrying activities. This will bring the hydrogeological system back closer to the pre-quarrying conditions.

The hanging swamp immediately downstream of the Site, variously identified as a 'prickly tea-tree -sedge wet heath swamp', 'temperate highland peat swamp on sandstone', and a 'hanging swamp', does not receive flows from deeper groundwater in the sandstone aquifer and is reliant on rainfall and catchment run-off. This section assesses the level of connection of the swamp to groundwater and determine what, if any, changes to the hydrological regime of the swamp may occur as a result of the proposed development.

4.2 Other Groundwater Investigations

Green[11] performed a regional assessment of the multi-layered sandstone aquifers beneath the Blue Mountains. They found that shallow and intermediate aquifers were likely critical to spring flow and to stream base flow, but that the deep regional aquifer

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[11] Green R. T., Russell G., Williams M., Cendón D. I. (2010), 'Assessment of Multi-Layered Sandstone Aquifers in the Sydney Basin, Blue Mountains', *Groundwater 2010 the challenge of sustainable management*, National Convention Centre, Canberra, 31 October – 4 November.

appeared to be flowing towards the deep incised valley rivers with some discharge likely into the Hawkesbury-Nepean River or further east towards the coast.

4.3 Relevant Literature

The Australian Government[12] commissioned a report titled *'Temperate Highland Peat Swamps on Sandstone: ecological characteristics, sensitivities to change and monitoring and reporting techniques'* which defines three types of peat swamp on sandstone. The swamp downstream from the Site is most accurately characterised as a 'headwater swamp' as defined by this report because it is located close to a catchment divide where the topographic gradient is low. Characteristics of a 'headwater swamp' according to this report and relevant to this study include:

1. The dominant water source of the swamp is recharge through rainfall and run-off.
2. Water quality in the swamps is controlled by catchment run-off.
3. Swamps are often perched above the water table.
4. If a connection between groundwater and a swamp exists, which is unlikely, it is likely to be ephemeral as it would rely on the presence of a perched aquifer, most likely present after rainfall.

4.4 Groundwater Monitoring

4.4.1 Overview

Continuous groundwater level monitoring at 15-minute intervals via data-logging pressure transducer was commenced on 20th April 2021. Eight wells in total were monitored and these are shown in Map 14. To determine the groundwater regime more accurately within the swamp, both shallow (MW301B, MW302A, & MW302B) and deep (MW 301A, & MW401) wells were installed to understand the interaction between the shallow, perched aquifer, and the deeper sandstone aquifer. The shallow wells were screened in the top 1 – 2 m of the surface, in the swamp alluvium above the sandstone. The deep wells were screened in the sandstone at least 4m below the surface. Well construction is summarised in Table 20. Monitoring well construction logs are provided in Appendix D.

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[12] Australian Government (2014), *Temperate Highland Peat Swamps on Sandstone: ecological characteristics, sensitivities to change, and monitoring and reporting techniques*, Knowledge report, prepared by Jacobs SKM for the Department of the Environment, Commonwealth of Australia'.

Table 20: Groundwater monitoring well construction summary.

Well	Surface Elevation (mAHD)	Depth (mBGL)	Installed by	Type
MB02	1043.8	28.95	GHD	Deep
MB03	1038.193	24.5	GHD	Deep
MW201	1067.166	44.49	MA	Deep
MW301A	1014.583	5.84	MA	Deep
MW301B	1014.186	1.94	MA	Shallow
MW302A	1008.158	2.47	MA	Shallow
MW302B	1007.572	1.67	MA	Shallow
MW401	1022.024	12.02	MA	Deep

4.4.2 Statistical Summary

Groundwater monitoring data statistics are provided in Table 21.

Table 21: Summary of groundwater monitoring data.

Well ID	Monitoring Period		Groundwater Levels				
	Start	End[1]	Min (mAHD)	Median (mAHD)	Mean (mAHD)	Max (mAHD)	Range (m)
MB02	20/04/2021	25/10/2021	1029.01	1029.86	1029.85	1030.05	1.04
MB03	20/04/2021	25/10/2021	1027.04	1027.23	1027.24	1027.47	0.43
MW201	20/04/2021	25/10/2021	1042.48	1043.21	1043.15	1043.58	1.10
MW301A	29/04/2021	25/10/2021	1012.45	1013.15	1013.17	1013.50	1.05
MW301B	29/04/2021	25/10/2021	1014.08	1014.17	1014.17	1014.21	0.13
MW302A	29/04/2021	25/10/2021	1007.85	1007.92	1007.93	1008.15	0.30
MW302B	29/04/2021	25/10/2021	1007.43	1007.58	1007.58	1007.62	0.19
MW401	8/07/2021	25/10/2021	1019.59	1019.88	1019.87	1020.12	0.53

Notes:

1. At the time of writing, monitoring is ongoing – the end date reflects the last data collection date.

4.4.3 Commentary

Graphs of continuous monitoring data for wells MW301A and MW301B, and MB02 and MB03 with daily rainfall data (Lithgow Cooerwull - 63226) are provided in Figure 17 and Figure 18 respectively. Figure 17 shows a clear and consistent downward head gradient of 1 m from MW301B (shallow) to MW301A (deep). This demonstrates that surface water and shallow groundwater within the swamp recharges the deeper sandstone aquifer.

Figure 17 also shows the different reaction that the shallow and deep groundwater systems have in response to rainfall. In the shallow system (MW301B) rainfall has an almost instantaneous impact on groundwater levels but only until the groundwater reaches a maximum level, only ever varying by about 0.1 m. This is reasonable as the shallow alluvium would 'fill up' to the surface level during rainfall and once the infiltration capacity of the swamp is reached, and any excess rainfall and run-off would flow downhill across the surface of the swamp as sheet flow. In contrast, the deeper system (MW301A) shows a similarly rapid response to rainfall however the magnitude of the response is greater with monitored levels varying by about 0.3 m. This indicates that the deeper sandstone beneath the swamp receives increased amounts of groundwater recharge from the swamp above almost immediately following a rainfall event.

Figure 18 on the other hand shows a much slower reaction to rainfall in the deeper sandstone aquifer. While both wells exhibit increases in groundwater levels following rainfall events, the time from the trough to the peak is in the order of 3 or 4 days, much slower than the near immediate responses demonstrated in MW301A and MW301B (Figure 17). The correlation between rainfall and groundwater levels is also much less distinct than exhibited by MW301A and MW301B.

4.5 Conceptual Groundwater Model of Swamp

Based on the detailed groundwater investigations, a conceptual hydrogeological model for the downstream swamp has been prepared and is provided in Figure 19. The following comments are provided to assist in interpretation:

1. Groundwater within the swamp develops in response to direct rainfall and surface inflows arriving from the catchment which are developed both within the Site but also within adjoining valley areas.

2. As surface water inflows enter the swamp, these spread out and typically flow in an unchannelised manner over the swamp surface where due to the high sand content of swamp soils, there is a high degree of infiltration.

3. Infiltrated surface water causes a perched water table to develop which sits over the underlying sandstone bedrock. This water table is ephemeral and has the capacity to recharge the underlying permanent water table.

4. Perched water within the swamp exits at the downstream portion of the swamp into a narrow formed channel.

5. The swamp surface does not appear to have been the subject of any current significant erosion, although there is evidence that historical erosive events have occurred.

The following implications arise out of the preliminary investigation findings:

1. Groundwater flows from the filled quarry voids does not contribute to groundwater flows within the swamp because these are controlled by surface water inflows and direct rainfall.

2. Perched groundwater that occurs within the swamp will at times recharge deeper groundwater. This is evidenced by the hydraulic gradient between nested wells

MW301A (deep) and MW301B (shallow) where the groundwater head in MW301A is consistently around 1 m lower than that in MW301B demonstrating groundwater flow downwards into the sandstone from the overlying swamp (Section 4.4.3). At times there may be a continuous water connection between the ephemeral aquifer within the swamp and groundwater within deeper sandstone , and at other times the two water bodies may be disconnected.

3. Surface flows discharged from the Site during filling operations and following completion of the final landform will likely enter the swamp area and contribute to the hydrology and water chemistry of the perched water table.

4.6 Groundwater Modelling

4.6.1 Purpose

A groundwater model was prepared to:

1. Simulate existing groundwater conditions based on monitoring data.
1. Hind-cast groundwater conditions prior to quarry operations at the site.
2. Forecast groundwater conditions during the proposed filling operations when the upper quarry void is dewatered to enable filling.
3. Forecast groundwater conditions once the proposed filling is complete and the final surface is formed.

4.6.2 Method

A MODFLOW-NWT groundwater model of the existing conditions was prepared in the GMS 10.4.1 (2018) graphical user interface. The model grid was set up with 6 layers with the top of layer 1 representing the ground surface. Layer 1 had varying thicknesses to represent the full depth of the current excavation pits on the site, and the shallow alluvium found in the swamp. The remaining layers were vertically distributed below layer 1 to an elevation of 800 mAHD. Model extents were set to the surrounding ridgelines which were assumed to be groundwater divides. Material properties were applied to the model layers to represent the underlying sandstone, residual soils, and the quarry voids (hydraulic conductivity = 9999m/day).

The following boundary conditions were applied to the model:

1. Upstream and downstream constant head boundaries at estimated groundwater levels.
2. Recharge rates based on the different land uses and levels of vegetation.
3. A uniform annual evapotranspiration rate of 630 mm (BoM, 2016) and varying extinction depths based on the vegetation cover.

4. Drains below the swamp to represent an incised channel where the water is drained from the alluvium.

Once the existing conditions model was calibrated, it was modified to represent the following predictive models:

1. Pre-quarry conditions:
    a. Surface elevations modified to assumed elevations prior to quarrying based on existing lidar contours and historic aerial imagery.
    b. Material property extents, recharge zones, and evapotranspiration extinction depth zones modified as necessary.
2. Filling stage conditions:
    a. Main quarry void completely de-watered using a drain boundary condition set at the base of the void.
3. Final surface conditions:
    a. Main quarry pit horizontal hydraulic conductivity set to 10^{-9} m/s and vertical hydraulic conductivity set to 10^{-14} m/s to represent the proposed lining.
    b. Recharge rate over the fill area lowered to 0.8 mm/year to simulate the effect of the capping material.
    c. Recharge zones, and evapotranspiration extinction depth zones modified as necessary.

All other model parameters including material properties, recharge rates, evapotranspiration rates, and boundary conditions were kept constant. MODFLOW-NWT run settings were also kept constant between model runs.

4.6.3 Calibration

The existing conditions model was calibrated to the means of the groundwater level data collected by MA (see Section 4.4.2). To achieve calibration, hydraulic conductivities, recharge rates, and evapotranspiration depths were adjusted within realistic ranges until a normalised residual mean squared (NRMS) under 5% was achieved. The calibrated model parameters are summarised in Table 22.

Table 22: Calibrated existing groundwater conditions MODFLOW model parameters.

Category	Units	Calibrated Value
Hydraulic Conductivities		
Sandstone (Kh, Kv)	m/day	0.0098, 0.00098
Residual Soils (Kh, Kv)	m/day	0.500, 0.167
Quarry Void (Kh, Kv)	m/day	9999, 9999
Recharge Rates		
Cleared Areas	mm/year	39.2
Forested Areas	mm/year	27.4
Quarry Void	mm/year	7.8
Railway Corridor	mm/year	7.8
Swamp	mm/year	94.0
Evapotranspiration Extinction Depths		
Cleared Areas	m	1.0
Forested Areas	m	2.0
Quarry Void	m	0.1
Railway Corridor	m	0.2
Swamp	m	1.0

With the parameters above and the model set up as described in Section 4.6.2, a calibration of 3.8% NRMS with a mass balance error of -0.07%, and a mean residual of -1.12 m was achieved, indicating a slight under-prediction in groundwater levels across the model. A graph of the calibration outcome is provided in Figure 20.

4.6.4 Model Confidence Level Classification

In accordance with the Australian Groundwater Modelling Guidelines (2012), the model is considered to generally represent a 'Class 2' model confidence level classification, suitable for impact assessment.

A 'Class 2' classification is justified based on the following:

1. Calibration statistics are generally acceptable.
2. Mass balance error is less than 1% of total.
3. Geotechnical data coverage is reasonable in the vicinity of the proposed development.

4. Model parameters are generally consistent with conceptualisation.

4.6.5 Existing Groundwater Conditions

A map of existing groundwater levels in the model surface layer is provided at Map 15. It shows that groundwater levels in the site are significantly impacted by the quarry voids which lower groundwater in the southwest corner of the site. Groundwater levels outside the site and downslope towards the swamp are also impacted to some extent by the existing quarry voids.

A section through the model showing the groundwater level and groundwater equipotential contours is provided in Figure 21. The equipotential contours shown in Figure 21 demonstrate that groundwater flow within the model is generally downward with groundwater flows from the quarry voids not interacting with the swamp, this correlating with the conceptual model. The equipotential contours also show that groundwater gradients beneath the swamp are downward, in correlation with the data collected (wells MW301A and MW301B, Table 21).

4.6.6 Pre-quarry Groundwater Conditions

A map of modelled pre-quarry groundwater levels is provided at Map 16 and a drawdown plot to existing conditions is provided at Map 17. We note that drawdown is calculated as earlier groundwater level minus later groundwater level and therefore a negative drawdown represents an increase in groundwater levels.

The pre-quarry groundwater levels and drawdown to existing conditions shows that the current quarry voids significantly altered the pre-quarry groundwater levels by lowering the groundwater table by up to 5 m in the quarry voids and increasing the groundwater levels elsewhere in the model domain by around 0.5 – 2 m. Groundwater levels in the sandstone beneath the swamp show an increase by approximately 0.5 m due to the current quarry voids, therefore decreasing the pressure gradient from the swamp to the sandstone aquifer and decreasing the amount of recharge from the swamp to the sandstone aquifer by a small amount.

4.6.7 Filling Stage Groundwater Conditions

A map of filling stage groundwater levels is provided at Map 18 and drawdown plots from existing and pre-quarry conditions are provided in Map 19 and Map 20 respectively.

Map 19 shows that dewatering the main quarry void will lower local groundwater levels adjacent to the Site compared to existing conditions and groundwater in the sandstone below the swamp is likely to experience minor lowering of up to about 0.5 m, compared to the existing conditions, this being approximately the level experienced in the swamp in pre-quarry conditions.

Map 20 shows that dewatering the upper quarry void lowers local groundwater levels compared to pre-quarry conditions. The presence of water in the lower quarry void mitigates the potential impact of dewatering of the upper void with groundwater levels below the swamp being at similar levels to pre-quarry conditions.

We note that the modelled filling stage scenario is a worst-case situation where the whole upper quarry void has been modelled as dewatered. It is more likely that dewatering will be staged to allow the staged fill of the pit, and no dewatering will be necessary once filling has surpassed the elevation of the local groundwater table.

4.6.8 Final Surface Groundwater Conditions

A map of the final surface groundwater levels is provided at Map 21 and drawdown plots from existing and pre-quarry conditions are provided in Map 22 and Map 23 respectively.

Map 22 shows that once the main quarry void is lined and filled, groundwater levels increase upslope and decrease downslope compared to existing conditions. This is expected as the low permeability void liner would cause groundwater to mound up behind it as it flows downslope, reducing the flow of water to downslope areas. Groundwater levels in the sandstone beneath the swamp will be lowered by up to about 0.5 m compared to existing conditions, this being approximately the level experienced in the swamp in pre-quarry conditions.

Map 23 shows that compared to pre-quarry conditions, groundwater levels have increased upslope and decreased downslope of the lined and filled quarry void, although to a significantly lesser extent compared to the existing conditions (Map 22). Map 23 shows that no material groundwater level changes occurs in the sandstone beneath the swamp. Map 23 also shows that the final surface groundwater levels are the closest to the pre-quarry conditions compared to all other scenarios modelled as the drawdown extents are the smallest. This demonstrates that following completion of filling activities on the site, the groundwater regime will more closely align with the natural groundwater conditions that existed prior to quarrying occurring at the Site and is therefore an improvement over the situation that currently exists.

4.7 Groundwater Quality

4.7.1 Method

Groundwater samples were taken on five occasions in the preparation of this study. Samples were taken using fresh bio-balers for each well and the first three bio-baler's water collected were discarded before bottling. Water samples were immediately sealed in laboratory provided sampling bottles and stored in an esky with ice for transportation to a NATA certified laboratory to be analysed.

On the 25/10/2021, a low-flow pump was used to sample MW201, the deep monitoring well upslope of the main quarry void. For this sampling event, three well volumes were discarded before bottling.

Standard field observations (pH, temperature, electrical conductivity, dissolved oxygen) were measured on 25/10/2021.

Refer to Appendix F for complete laboratory results for all dates and samples collected.

4.7.2 Findings

Statistical summary of the groundwater quality monitoring results for deep and shallow wells are provided in Table 23 below.

Table 23: Groundwater water quality data averages.

Parameter	Deep Wells			Shallow Well (swamp)		
	Average (mg/L)	Maximum (mg/L)	Std. Dev (mg/L)	Average (mg/L)	Maximum (mg/L)	Std. Dev (mg/L)
pH[1]	4.64	5.00	0.24	4.47	4.48	0.01
Temperature (°C)[1]	13.3	14.2	0.9	13.0	13.1	0.1
Electrical Conductivity (µS/cm)[1]	33.6	44.0	7.0	27.6	31.4	3.8
Dissolved Oxygen (%)[1]	32.9	45.9	8.6	24.0	28.1	4.1
Total nitrogen (mg/L)	1.2	15	3	0.2	0.7	0.2
Total Kjeldahl nitrogen (TKN) (mg/L)	0.2	0.4	0.1	0.4	0.7	0.3
Total nitrogen as NO_x (mg/L)	0.5	1.8	0.6	<0.005	<0.005	0
Ammonia (mg/L)	<0.005	<0.005	0	<0.005	0.1	0
Total Phosphorus (mg/L)	<0.05	<0.05	0	0.2	1.1	0.3
Total Alkalinity (mg/L)	5.5	11	2.6	6.8	32	7.6
Sulphate (mg/L)	2.4	5	0.9	2.1	3	0.3
Chloride (mg/L)	4.9	7	0.9	4.6	6	0.7
Total Arsenic (µg/L)	<1	<1	0	5.7	24	7.3
Total Cadmium (µg/L)	<0.1	<0.1	0	0.2	0.7	0.2
Total Chromium (µg/L)	3.5	18	5.1	14.8	48	12.8
Total Copper (µg/L)	17	86	23.8	93.7	650	186.7
Total Lead (µg/L)	<1	4	0.9	46.1	210	61.5
Total Mercury (µg/L)	<0.05	0.1	0	<0.05	0.1	0
Total Nickel (µg/L)	4.4	24	5.7	4.3	11	3.9
Total Zinc (µg/L)	35.7	240	53.3	41.7	200	60.1
Water Hardness (mg/L)	3.1	7.3	1.9	2.1	7.5	1.6
TRH C6 – C9 (µg/L)	<10	<10	0	<10	<10	0
TRH C10 – C14 (µg/L)	<50	120	23.5	<50	<50	0
TRH C15 – C28 (µg/L)	<100	490	105	<100	<100	0
TRH C29 – C36 (µg/L)	<100	120	14.3	<100	<100	0

Notes:

1. Based on field measurements taken 25/10/2021.
2. TRH = Total Recoverable Hydrocarbons.

4.7.3 Summary Comments

The groundwater quality monitoring found that:

1. Nitrogen observations are generally higher in the deep wells compared to the shallow wells mostly due to elevated total nitrogen and NOx readings in MB03.
2. Total phosphorous observations are higher in the shallow wells compared to the deep wells.
3. Heavy metals are generally higher in the shallow groundwater wells than in the deeper groundwater wells.
4. Total recoverable hydrocarbons (TRHs) were all below the detection limit except for at MW201 where they were observed on four occasions.

5 Resources

Australian Government (2014), *Temperate Highland Peat Swamps on Sandstone: ecological characteristics, sensitivities to change, and monitoring and reporting techniques*, Knowledge report, prepared by Jacobs SKM for the Department of the Environment, Commonwealth of Australia'.

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Green R. T., Russell G., Williams M., Cendón D. I. (2010), 'Assessment of Multi-Layered Sandstone Aquifers in the Sydney Basin, Blue Mountains', *Groundwater 2010 the challenge of sustainable management*, National Convention Centre, Canberra, 31 October – 4 November.

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Appendix A – Figures

Figure 1: Site overview and location of relevant features.

Figure 2: Former quarry site with Pond 2 on left and Pond 1 at centre of photo.

Figure 3: Existing Pond 2 (at right) and wetland (at left).

Figure 4: Hanging swamp downstream of quarry indicating recent bushfire activity.

Figure 5: Overlooking Site from western edge of quarry void showing existing site topography.

Figure 6: Local sandstone bedrock profile in Pond 1 (side wall of existing void).

Figure 7: Inflow to hanging swamp showing infiltration of surface flows and absence of defined channel.

Figure 8: Typical sandy local topsoils (charcoal from recent local bushfire).

Figure 9: Flow monitoring station at upstream end of hanging swamp.

Figure 10: Flow monitoring station at downstream end of hanging swamp.

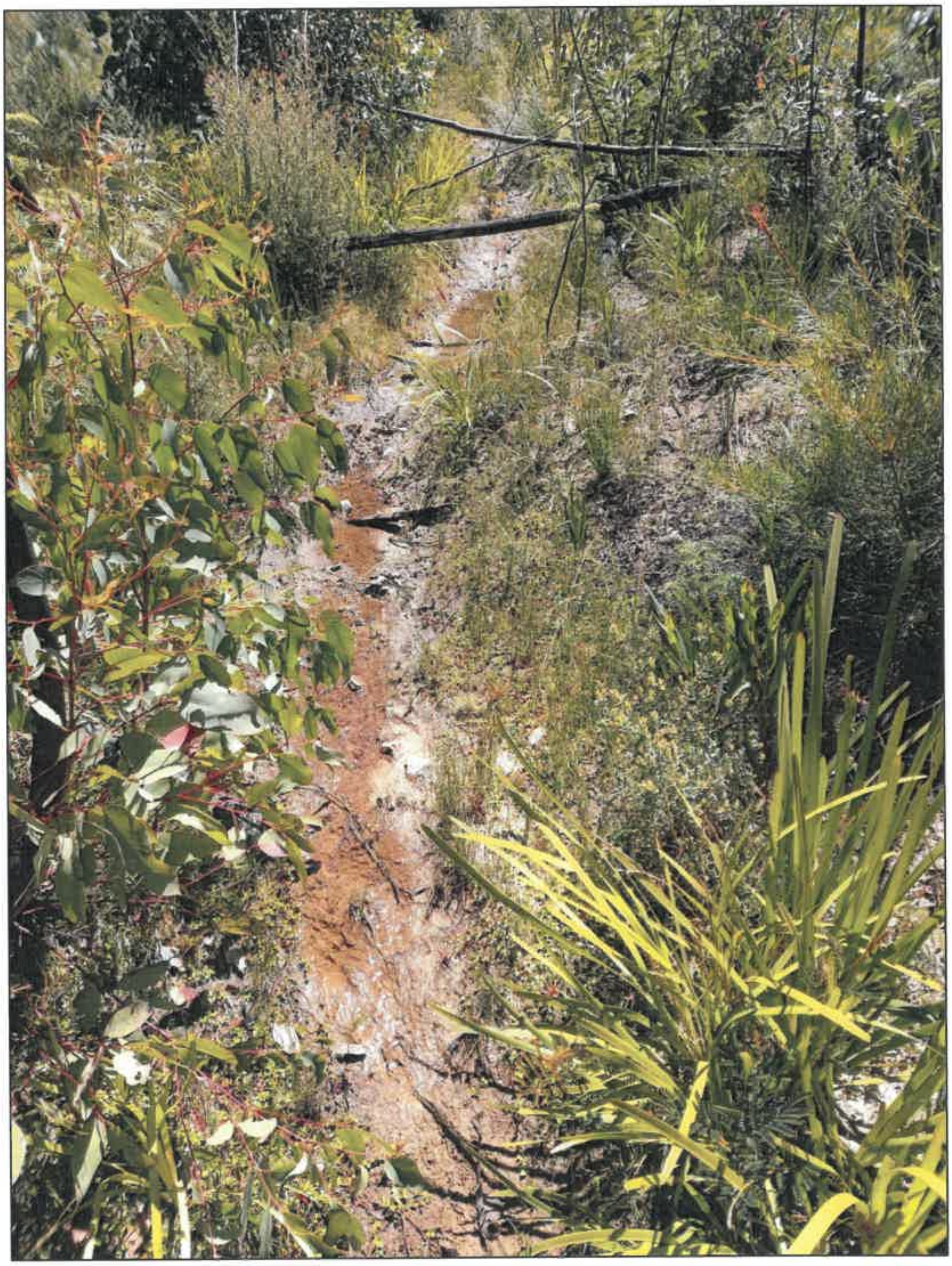


Figure 11: Left bank tributary entering at downstream end of hanging swamp.

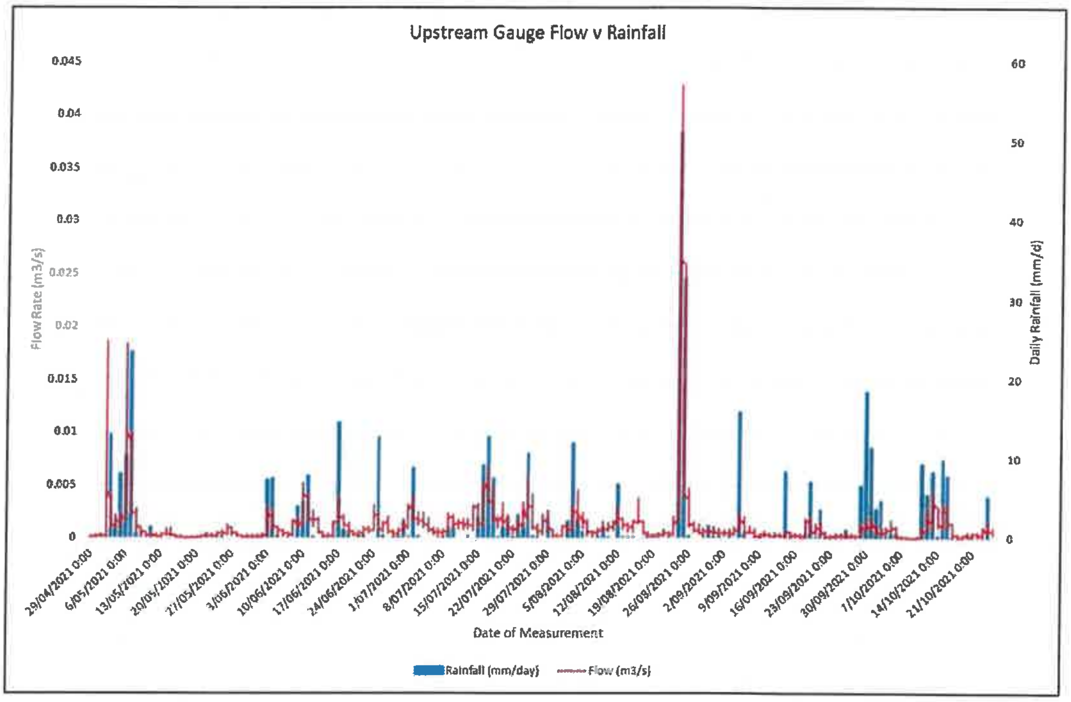


Figure 12: Measured flow vs rainfall (scaled) for Upstream Gauge.

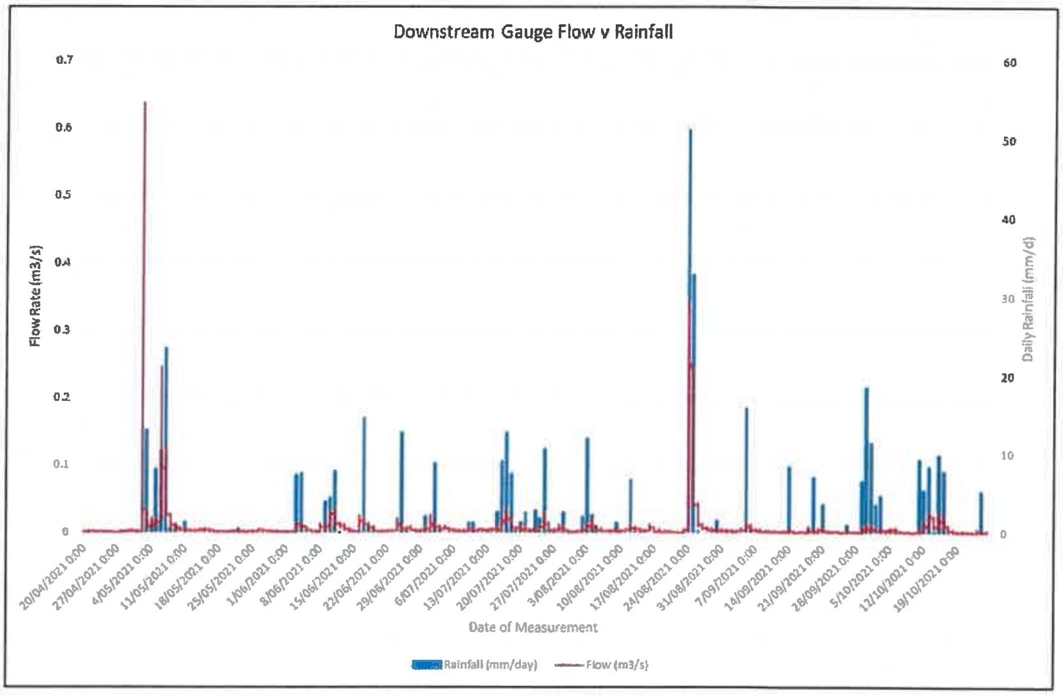


Figure 13: Measured flow vs rainfall (scaled) for Downstream Gauge.

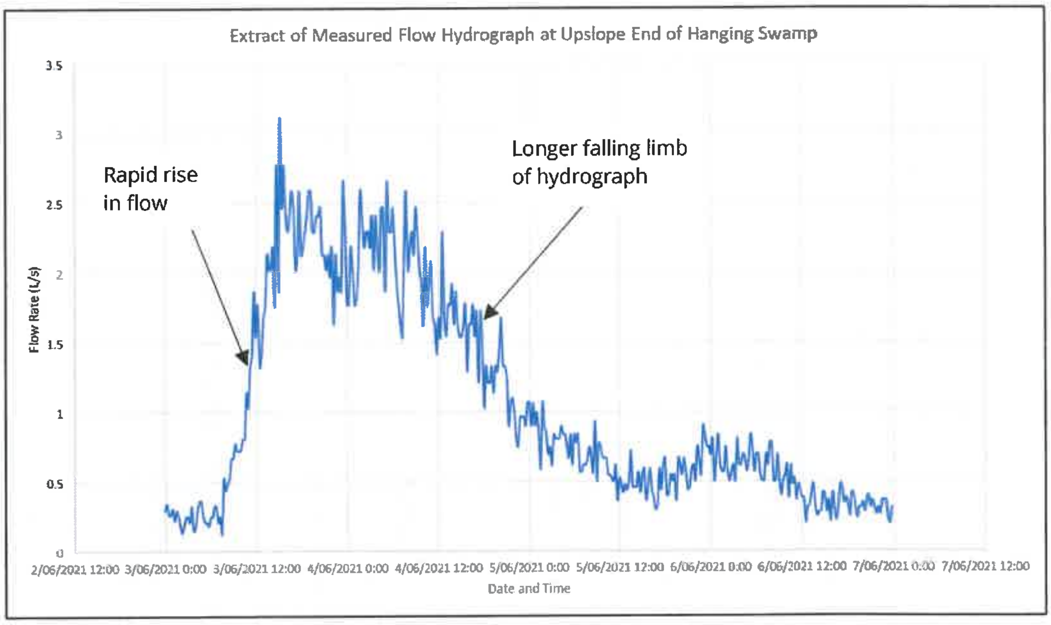


Figure 14: Extract from measured flow hydrograph at upstream.

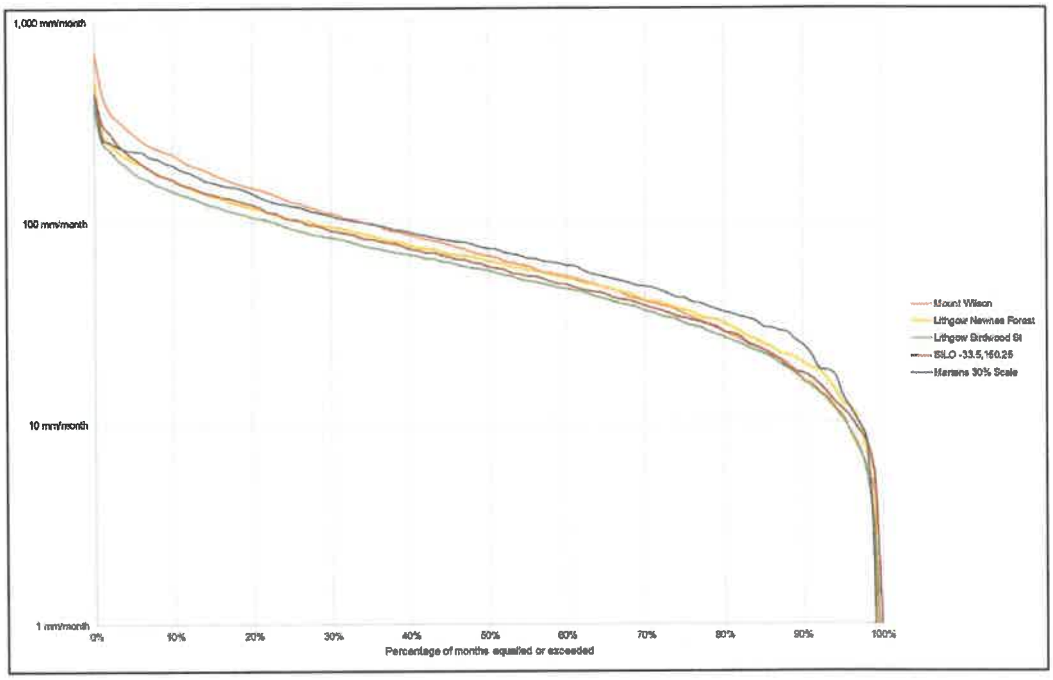


Figure 15: Cumulative frequency curve for comparative rainfall data sets

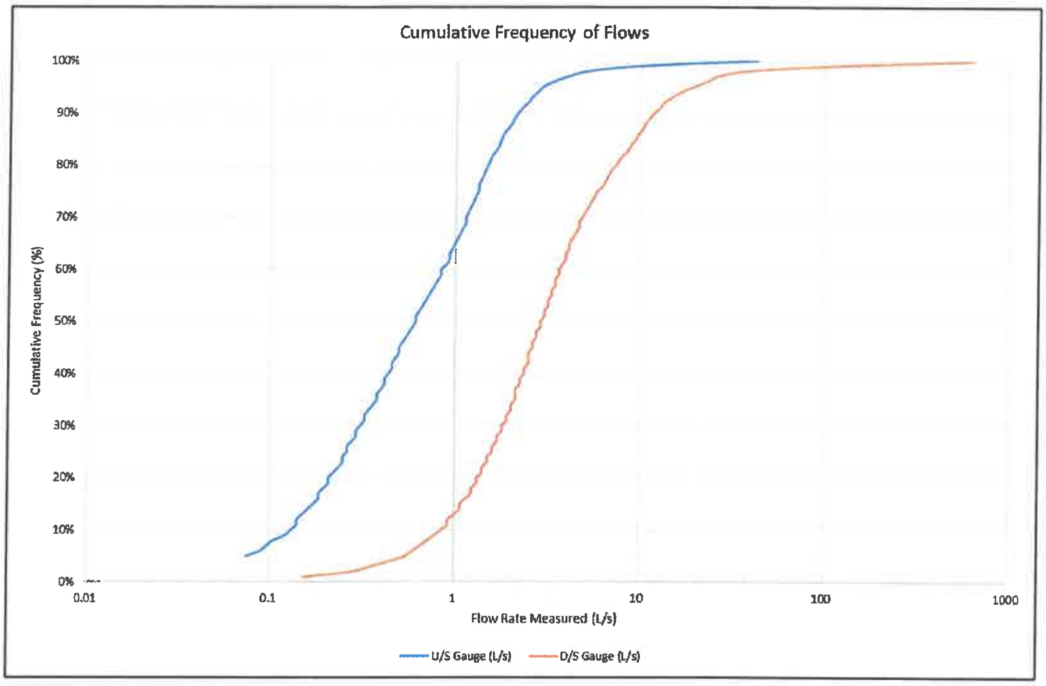


Figure 16: Cumulative frequency of measured flows at flow monitoring stations.

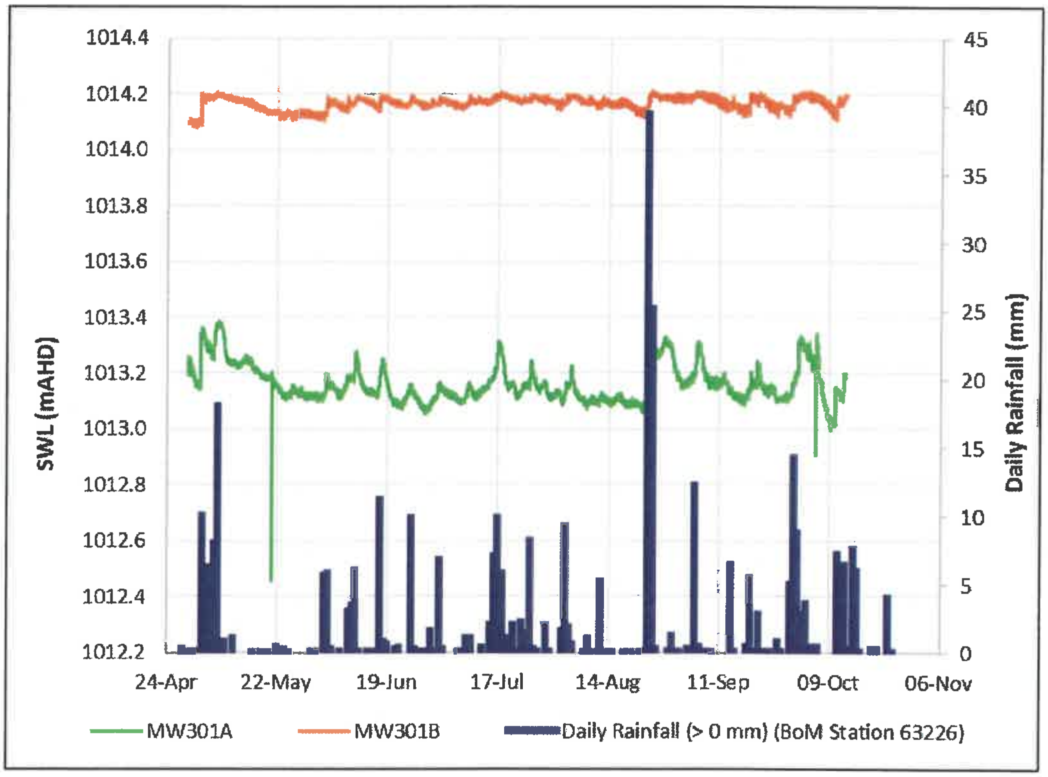


Figure 17: Continuous groundwater monitoring data for nested wells MW301A and MW301B.

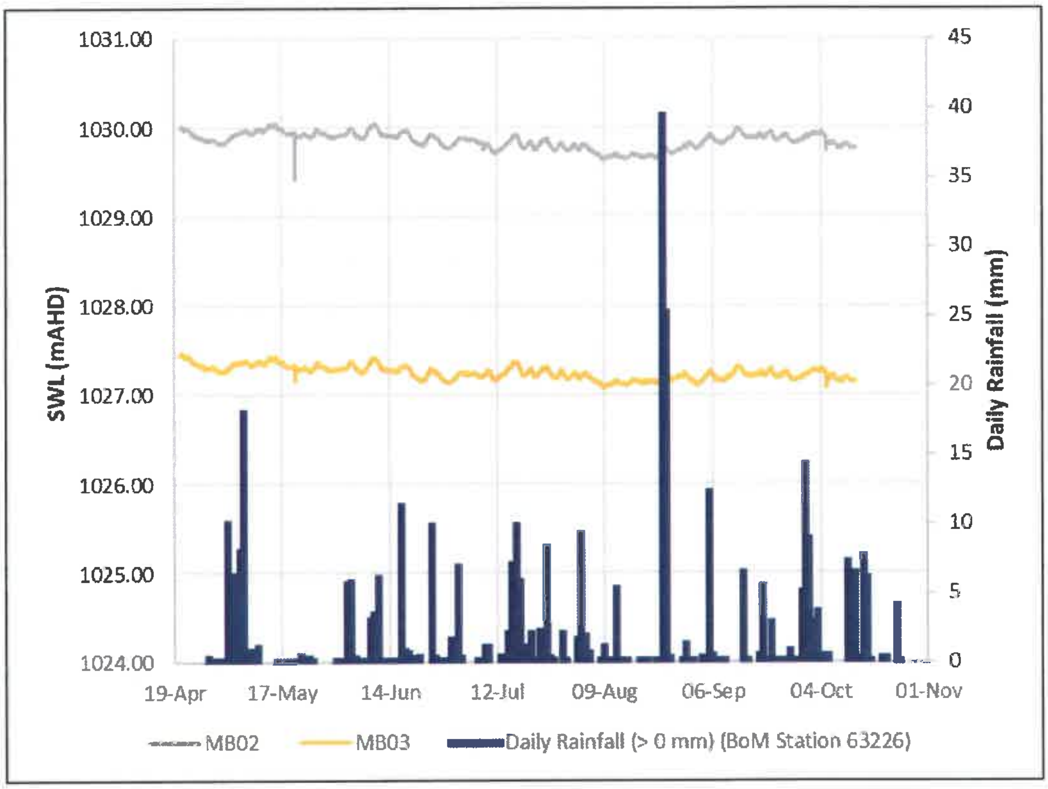


Figure 18: Continuous groundwater monitoring data for deep wells MB02 and MB03.

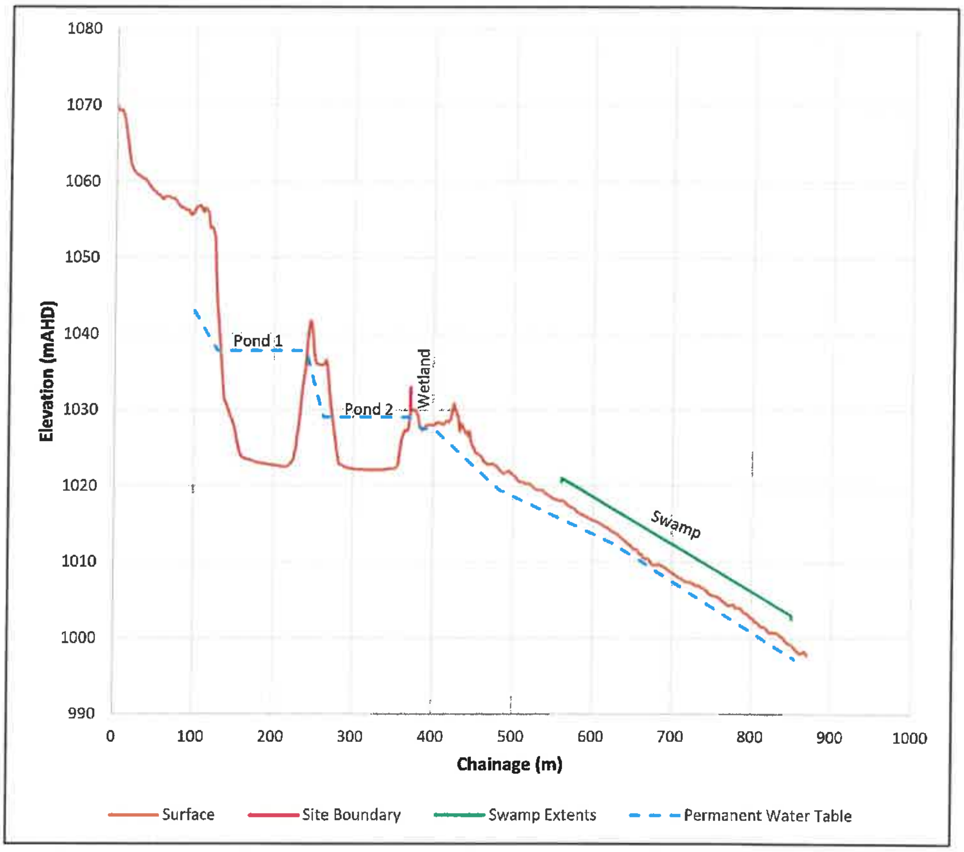


Figure 19: Conceptual hydrogeological section through Site and swamp.

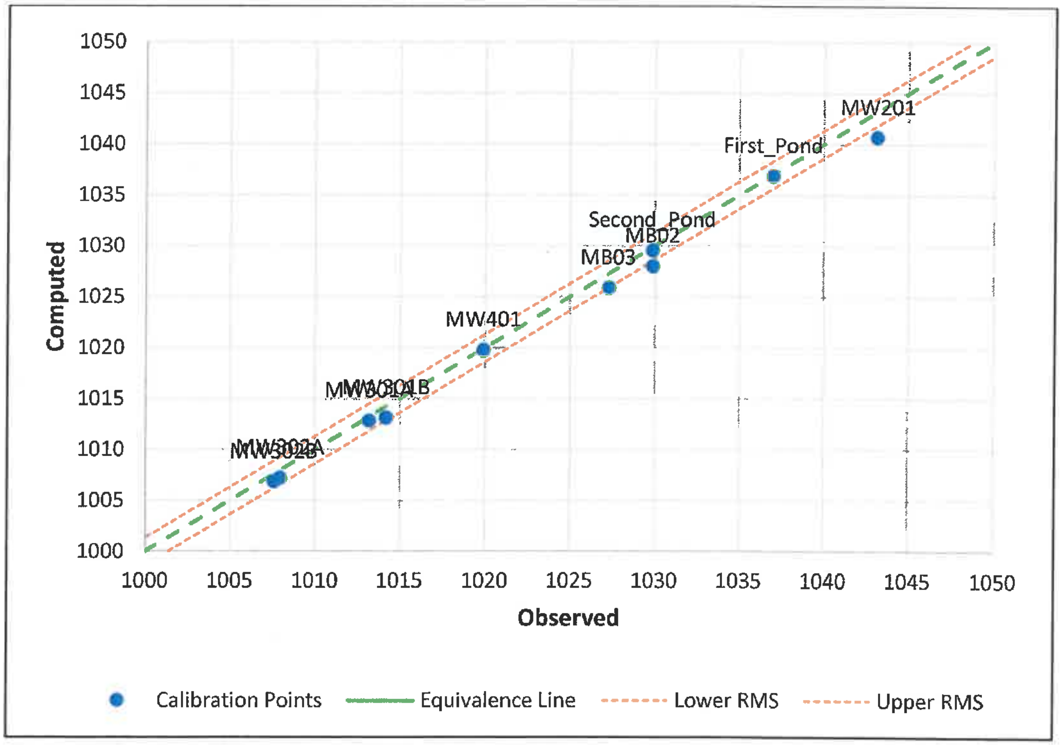


Figure 20: Existing conditions groundwater model calibration result.

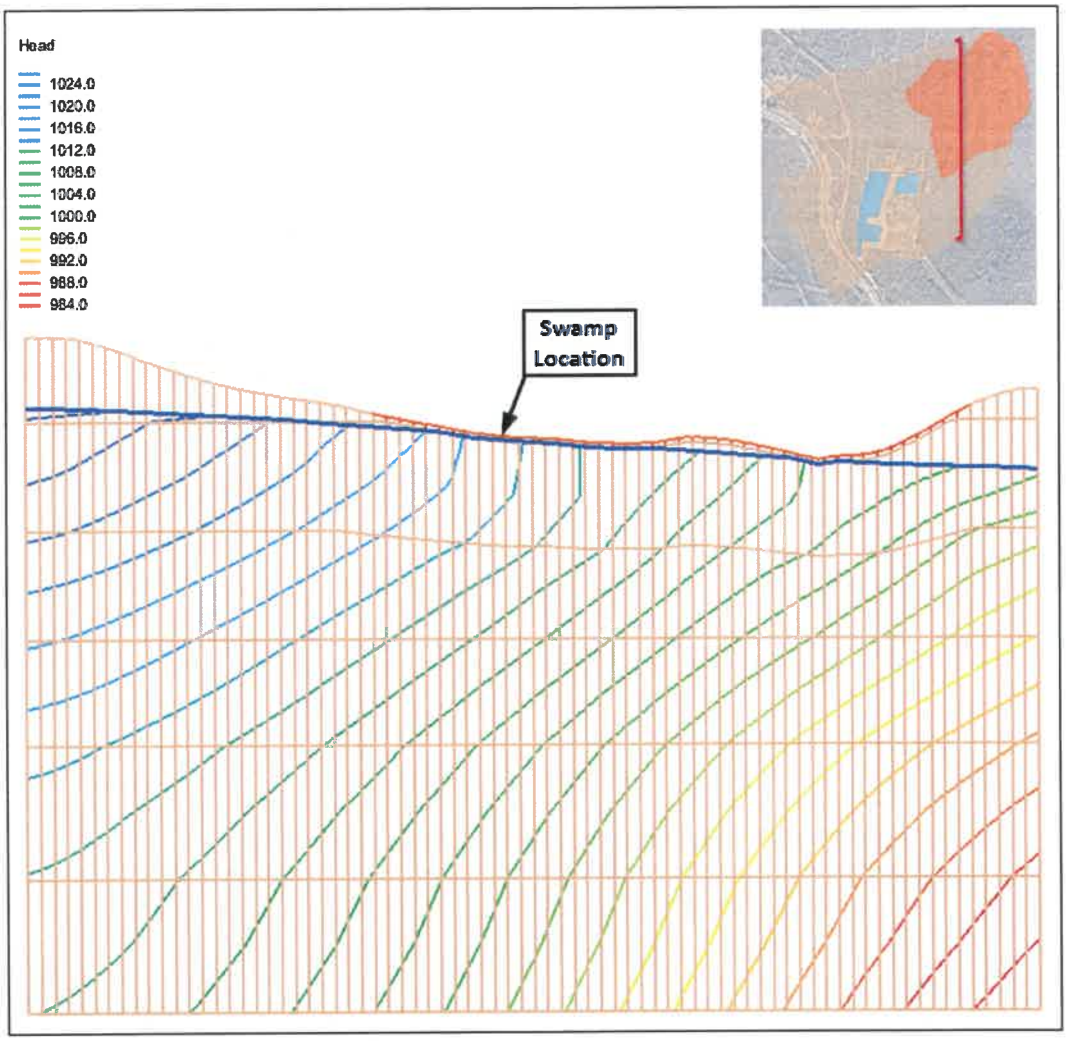
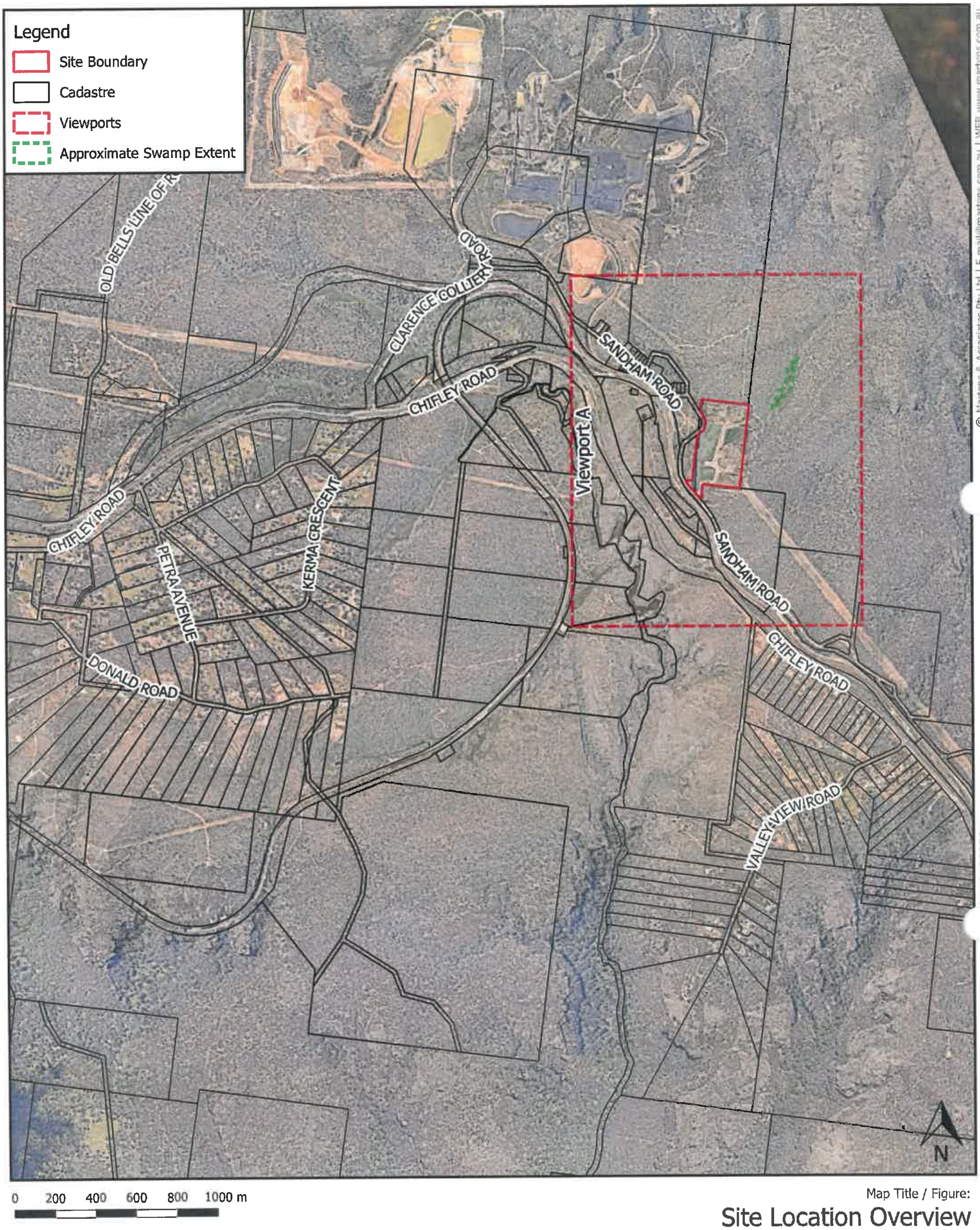


Figure 21: Groundwater model section through swamp.

Appendix B – Maps



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Notes:
- Aerial from Nearmap (2021).
- Cadastre from NSW DFSI (2020).

Map Title / Figure:

Site Location Overview

Map 01	Map
Sandham Road, Dargan, NSW	Site
Bell Quarry Rehabilitation	Project
Hydrological Study	Sub-Project
Bell Quarry Rehabilitation Project Pty Ltd	Client
19/11/2021	Date

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Viewport A

Notes:
- Aerial taken in 1966 and acquired from NSW DFSI (2021).

Map Title / Figure:

Site Aerial Photography Prior to Quarrying (1966)

Map 02	Map
Sandham Road, Dargan, NSW	Site
Bell Quarry Rehabilitation	Project
Hydrological Study	Sub-Project
Bell Quarry Rehabilitation Project Pty Ltd	Client
19/11/2021	Date

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1:7500 @ A4

Viewport A

Notes:
- Aerial taken in 1998 and acquired from NSW DFSI (2021).

Map Title / Figure:

Site Aerial During Quarrying (1998)

Map 03	Map
Sandham Road, Dargan, NSW	Site
Bell Quarry Rehabilitation	Project
Hydrological Study	Sub-Project
Bell Quarry Rehabilitation Project Pty Ltd	Client
19/11/2021	Date

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Viewport A

Notes:
- Aerial from Nearmap (2021).

Map Title / Figure:

Current Site Aerial (2021)

Map 04	Map
Sandham Road, Dargan, NSW	Site
Bell Quarry Rehabilitation	Project
Hydrological Study	Sub-Project
Bell Quarry Rehabilitation Project Pty Ltd	Client
19/11/2021	Date

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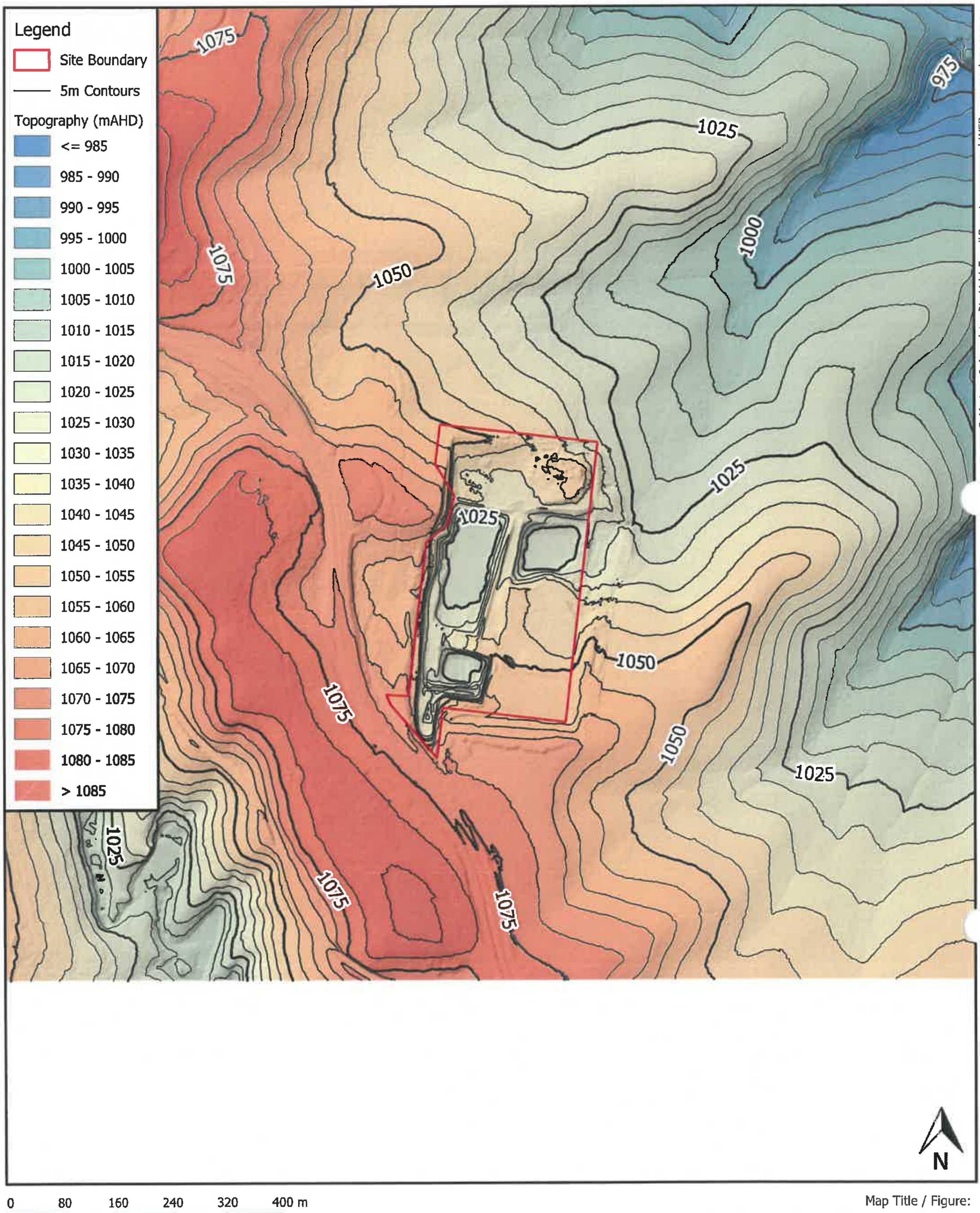

Project No: P2007822 Map Set: MS03-R EPSG: 28356

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Viewport A

Notes:
- Topography based on 2m LIDAR from NSW DFSI (2020) and site survey.

Map Title / Figure:

Topography

Map 05	Map
Sandham Road, Dargan, NSW	Site
Bell Quarry Rehabilitation	Project
Hydrological Study	Sub-Project
Bell Quarry Rehabilitation Project Pty Ltd	Client
19/11/2021	Date

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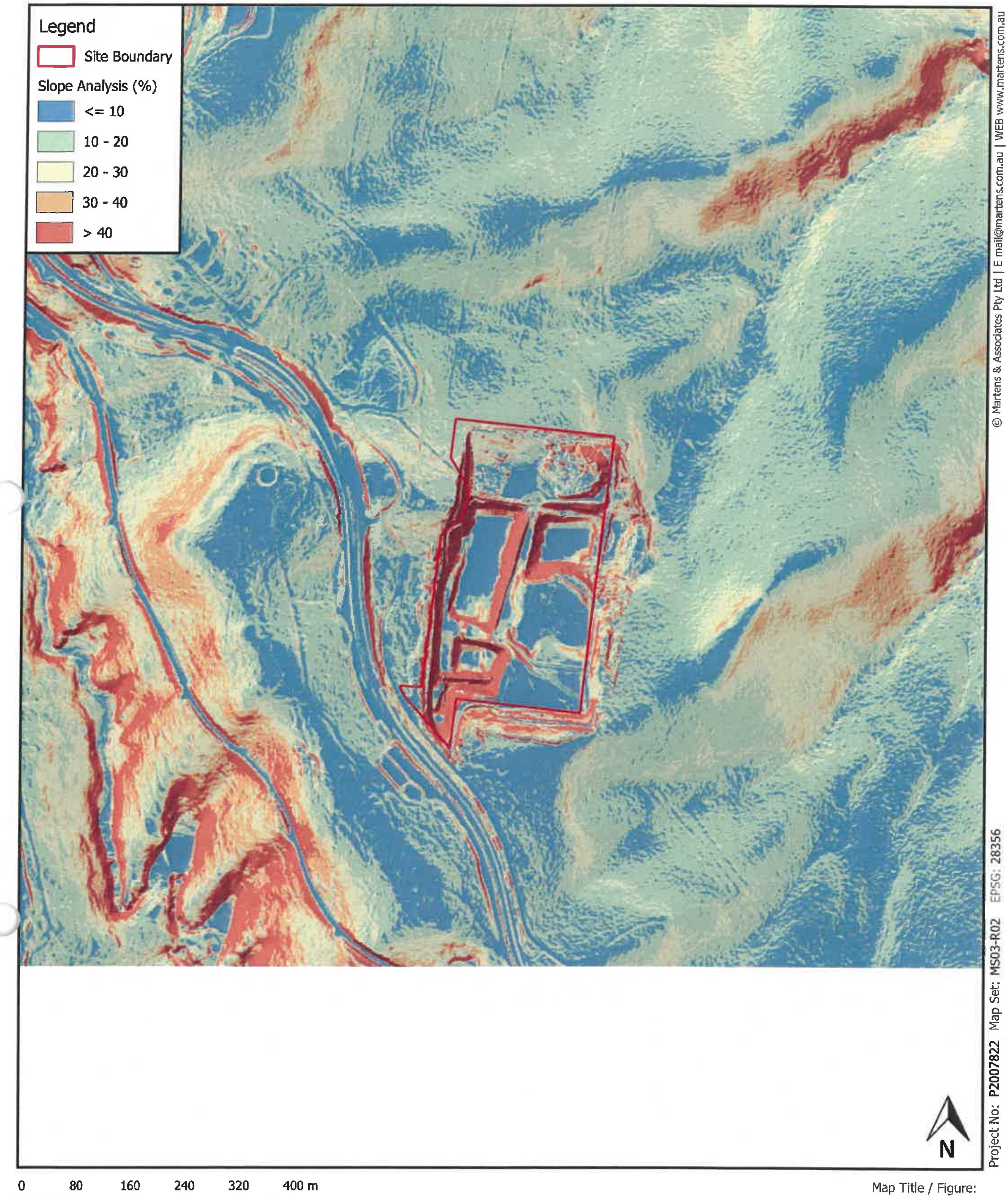

1:7500 @ A4

Viewport A

Notes:
- Slope analysis based on 2m LIDAR from NSW DFSI (2020) and site survey.

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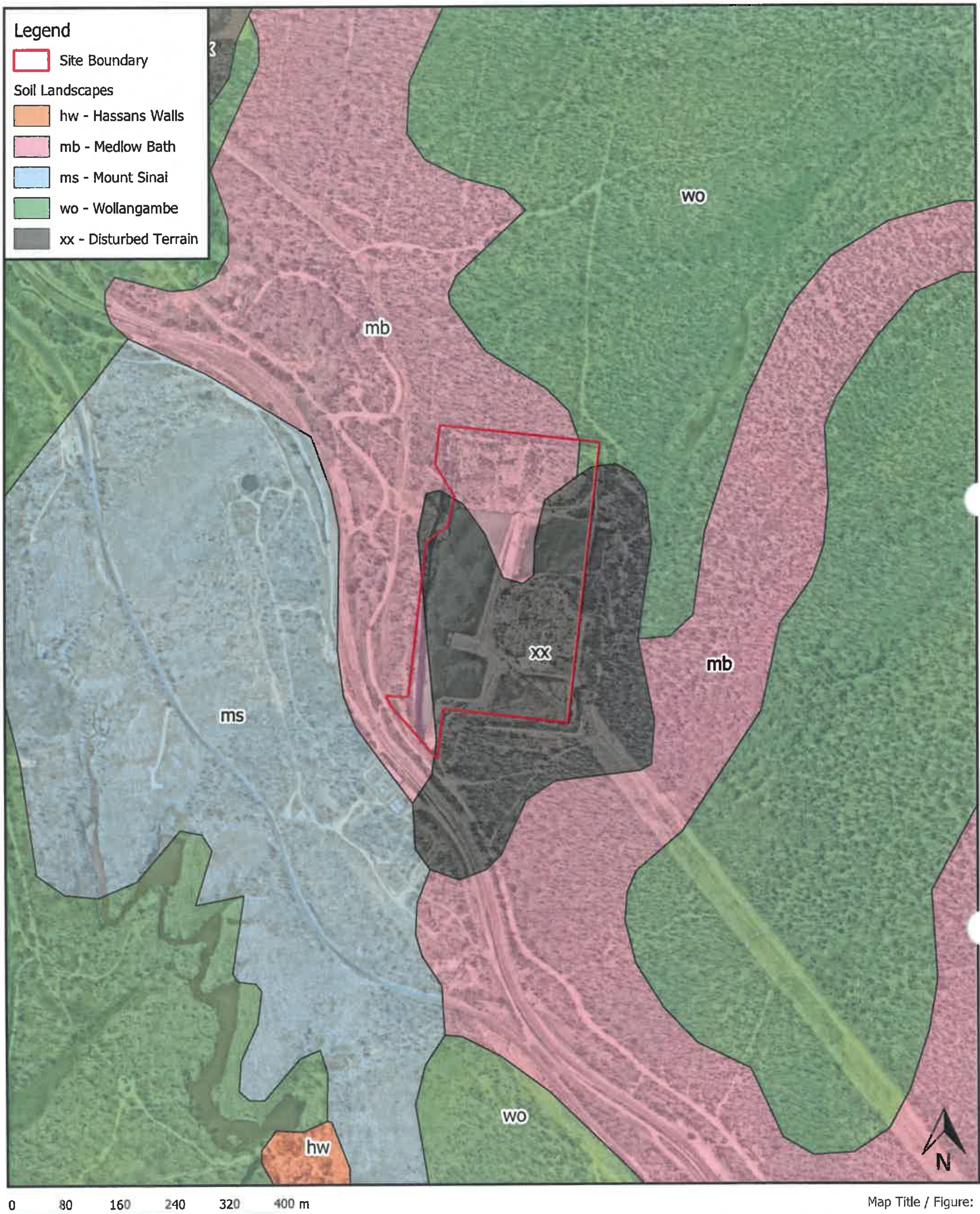
Map Title / Figure:

Slopes

Map 06	Map
Sandham Road, Dargan, NSW	Site
Bell Quarry Rehabilitation	Project
Hydrological Study	Sub-Project
Bell Quarry Rehabilitation Project Pty Ltd	Client
19/11/2021	Date

Project No: P2007822 Map Set: MS03-R02 EPSG: 28356



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Viewport A

Notes:
- Soil landscapes data from NSW DPIE (2021).

Map Title / Figure:

Soil Landscapes

Map 07	Map
Sandham Road, Dargan, NSW	Site
Bell Quarry Rehabilitation	Project
Hydrological Study	Sub-Project
Bell Quarry Rehabilitation Project Pty Ltd	Client
19/11/2021	Date

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Viewport A

Notes:
- Aerial from Nearmap (2021).

Map Title / Figure:

Borehole Soil Testing Plan

Map 08	Map
Sandham Road, Dargan, NSW	Site
Bell Quarry Rehabilitation	Project
Hydrological Study	Sub-Project
Bell Quarry Rehabilitation Project Pty Ltd	Client
19/11/2021	Date

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Map Title / Figure:

Creeks and Rivers

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Viewport A

Notes:
- Aerial from Nearmap (2021).
- Hydrolines from NSW DFSI (2020) and adjusted where necessary as indicated.

Map 09	Map
Sandham Road, Dargan, NSW	Site
Bell Quarry Rehabilitation	Project
Hydrological Study	Sub-Project
Bell Quarry Rehabilitation Project Pty Ltd	Client
19/11/2021	Date

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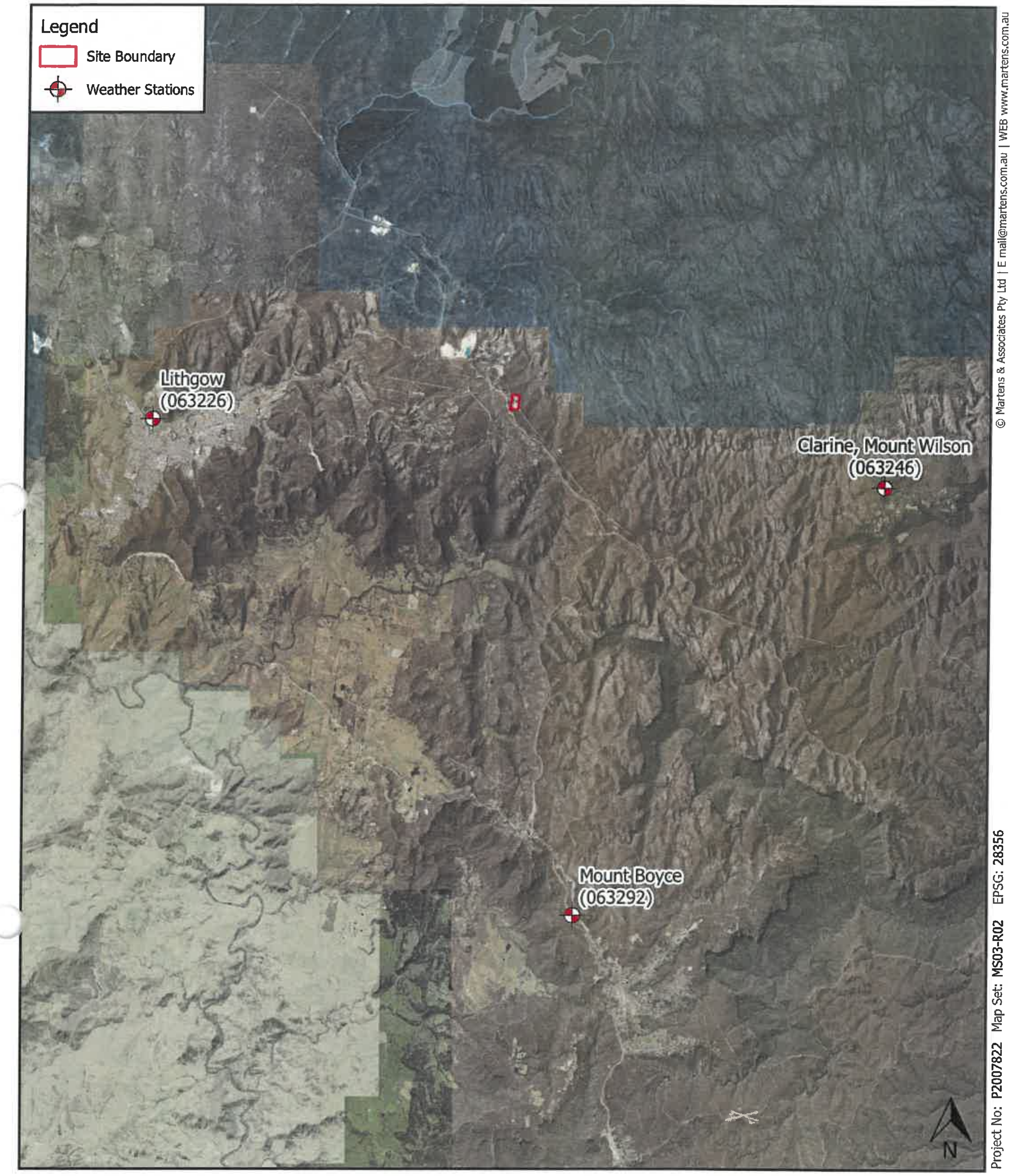

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Viewport B

Notes:
- Aerial from NSW SIXMaps (2021).
- Weather observation station locations from BoM (2021).

Map Title / Figure:

Nearby Weather Observation Stations

Map 10	Map
Sandham Road, Dargan, NSW	Site
Bell Quarry Rehabilitation	Project
Hydrological Study	Sub-Project
Bell Quarry Rehabilitation Project Pty Ltd	Client
19/11/2021	Date

Project No: P2007822 Map Set: MS03-R02 EPSG: 28356

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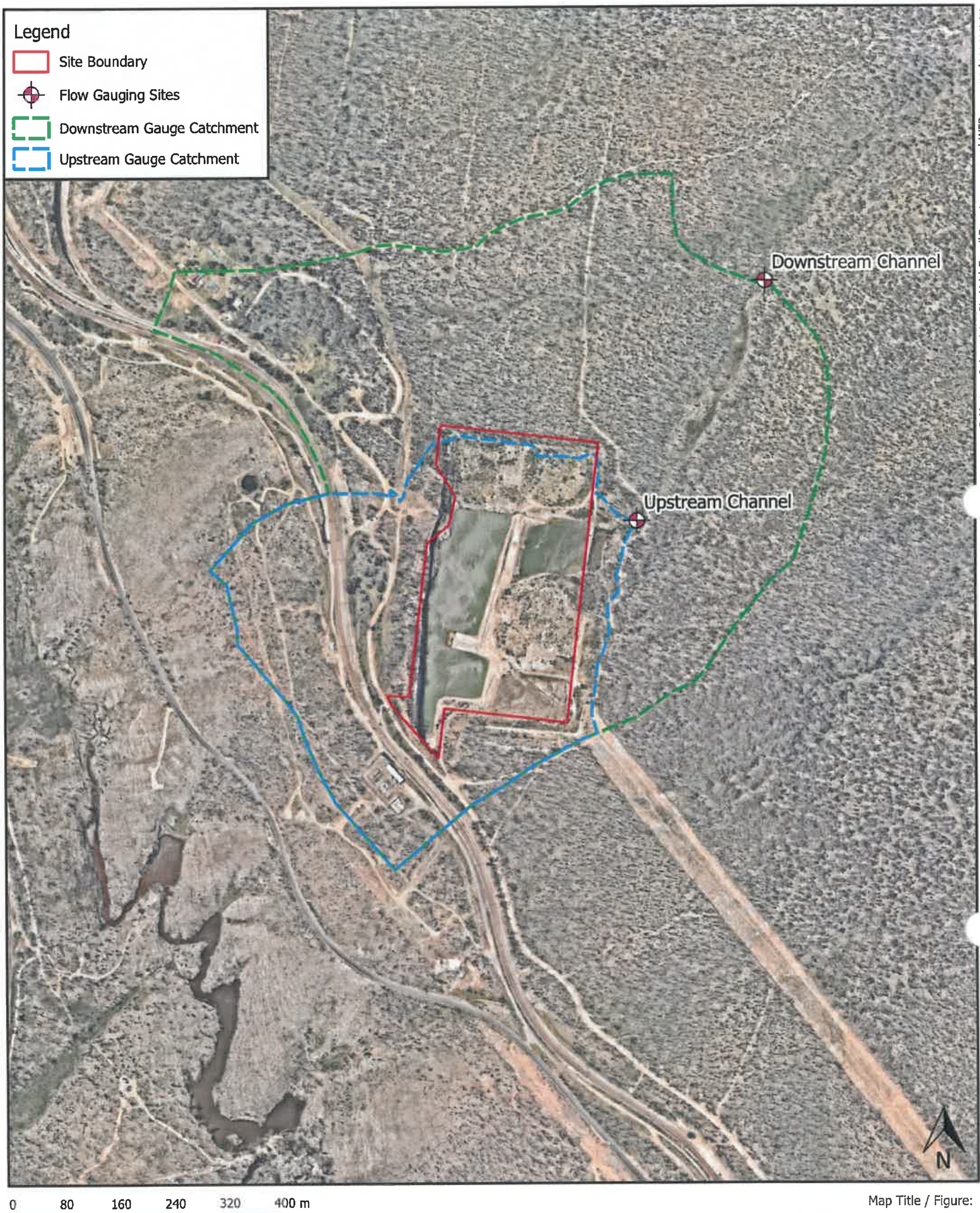

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Project No: P2007822 Map Set: MS03-K EPSG: 28356

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Viewport A

Notes:
- Aerial from Nearmap (2021).
- Catchment analysis based on 2m LIDAR from NSW DFSI (2020).

Map Title / Figure:

Flow Gauging Sites and Catchments

Map 11	Map
Sandham Road, Dargan, NSW	Site
Bell Quarry Rehabilitation	Project
Hydrological Study	Sub-Project
Bell Quarry Rehabilitation Project Pty Ltd	Client
19/11/2021	Date

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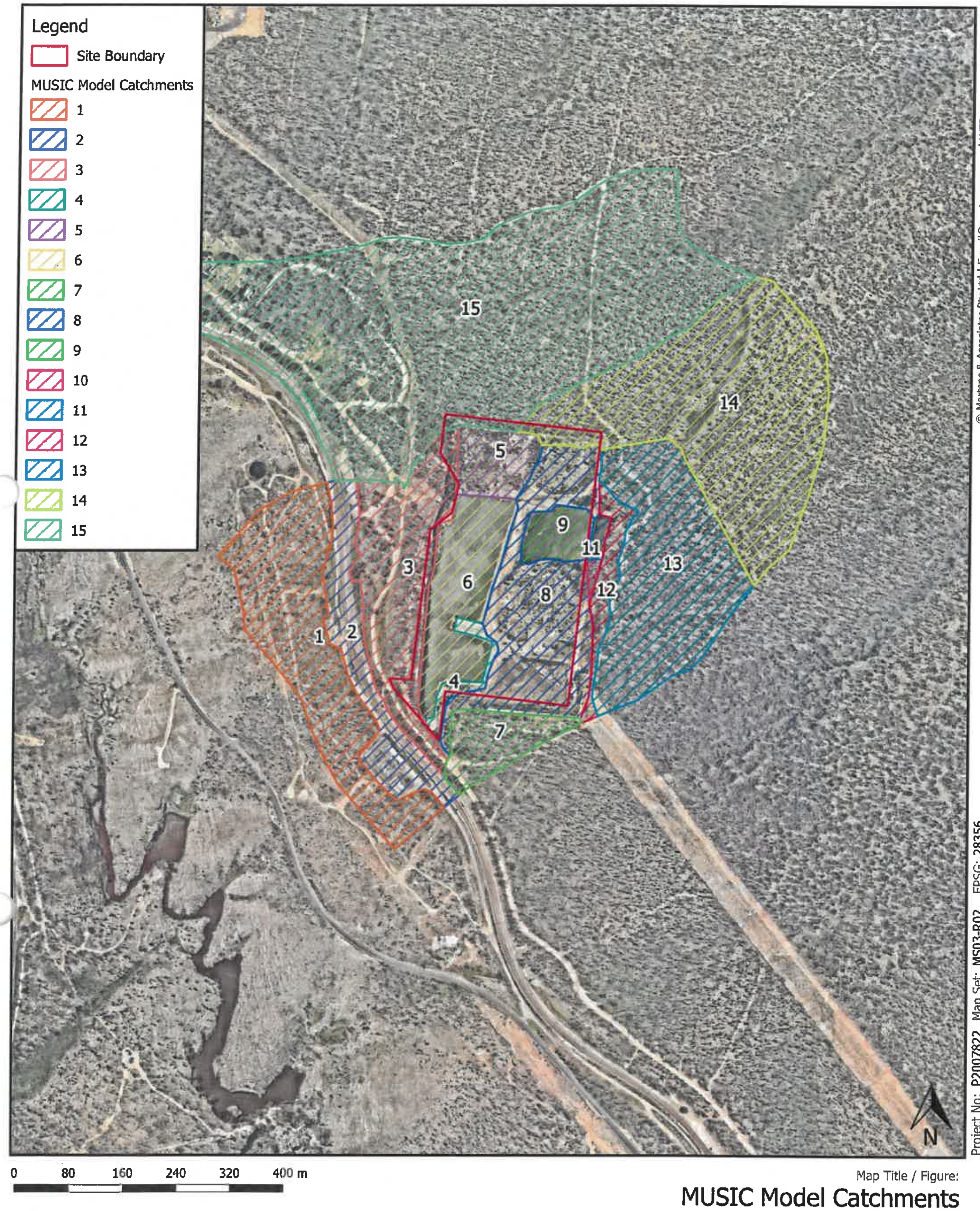

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Viewport A

Notes:
- Aerial from Nearmap (2021).

Map Title / Figure:

MUSIC Model Catchments

Map 12	Map
Sandham Road, Dargan, NSW	Site
Bell Quarry Rehabilitation	Project
Hydrological Study	Sub-Project
Bell Quarry Rehabilitation Project Pty Ltd	Client
19/11/2021	Date

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1:7500 @ A4

Viewport A

Notes:
- Aerial from Nearmap (2021).

Map Title / Figure:

Surface Water Testing Plan

Map 13	Map
Sandham Road, Dargan, NSW	Site
Bell Quarry Rehabilitation	Project
Hydrological Study	Sub-Project
Bell Quarry Rehabilitation Project Pty Ltd	Client
19/11/2021	Date

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Viewport A

Notes:
- Aerial from Nearmap (2021).
- Groundwater well locations surveyed by Geosurv 22/07/2021.

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Map Title / Figure:

Existing Groundwater Wells

Map 14	Map
Sandham Road, Dargan, NSW	Site
Bell Quarry Rehabilitation	Project
Hydrological Study	Sub-Project
Bell Quarry Rehabilitation Project Pty Ltd	Client
19/11/2021	Date

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Viewport A

Notes:
- Aerial from Nearmap (2021).
- Contours are in mAHD.

Map Title / Figure:

Existing Groundwater Levels (Calibrated)

Map 15	Map
Sandham Road, Dargan, NSW	Site
Bell Quarry Rehabilitation	Project
Hydrological Study	Sub-Project
Bell Quarry Rehabilitation Project Pty Ltd	Client
19/11/2021	Date

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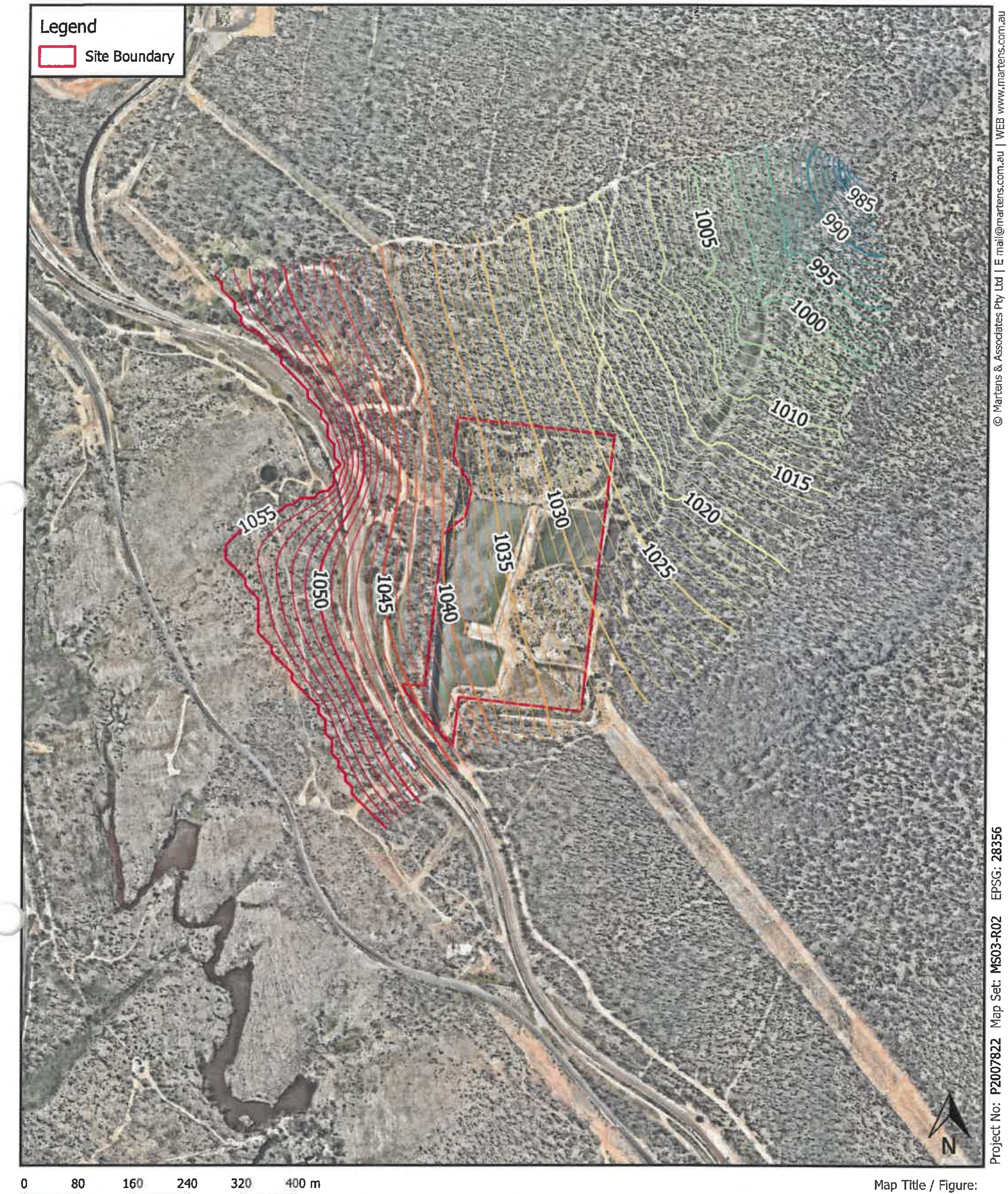

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Project No: P2007822 Map Set: MS03-R02 EPSG: 28356

1:7500 @ A4

Viewport A

Notes:
- Aerial from Nearmap (2021).
- Contours are in mAHD.

Map Title / Figure:

Pre-Quarry Groundwater Levels (Modelled)

Map 16	Map
Sandham Road, Dargan, NSW	Site
Bell Quarry Rehabilitation	Project
Hydrological Study	Sub-Project
Bell Quarry Rehabilitation Project Pty Ltd	Client
19/11/2021	Date

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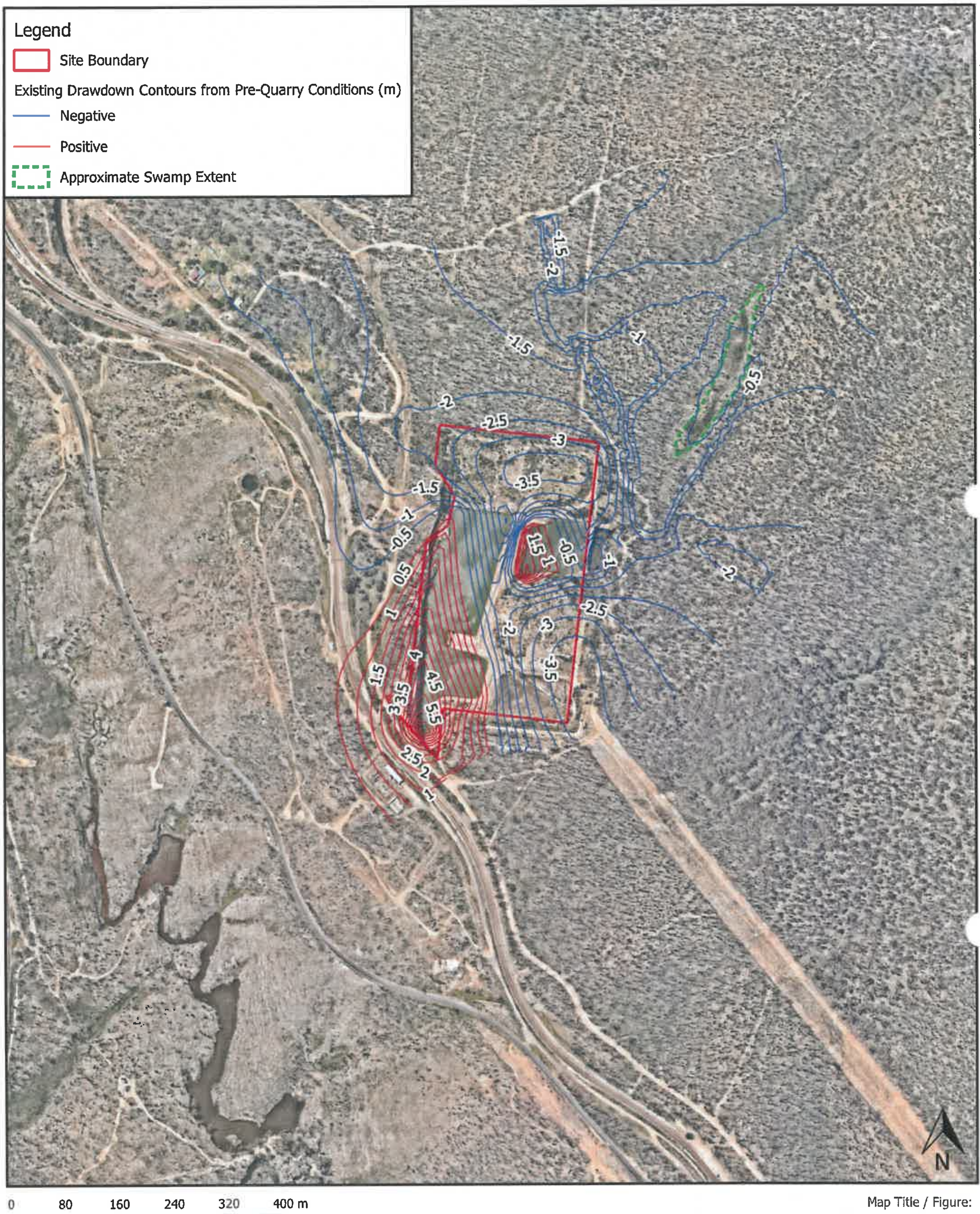

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Viewport A

Notes:
- Aerial from Nearmap (2021).
- Drawdown is calculated as the later groundwater level minus the earlier, hence a negative drawdown value represents an increase in groundwater levels.

Map Title / Figure:

Existing Groundwater Drawdown from Pre-Quarry Conditions

Map 17	Map
Sandham Road, Dargan, NSW	Site
Bell Quarry Rehabilitation	Project
Hydrological Study	Sub-Project
Bell Quarry Rehabilitation Project Pty Ltd	Client
19/11/2021	Date

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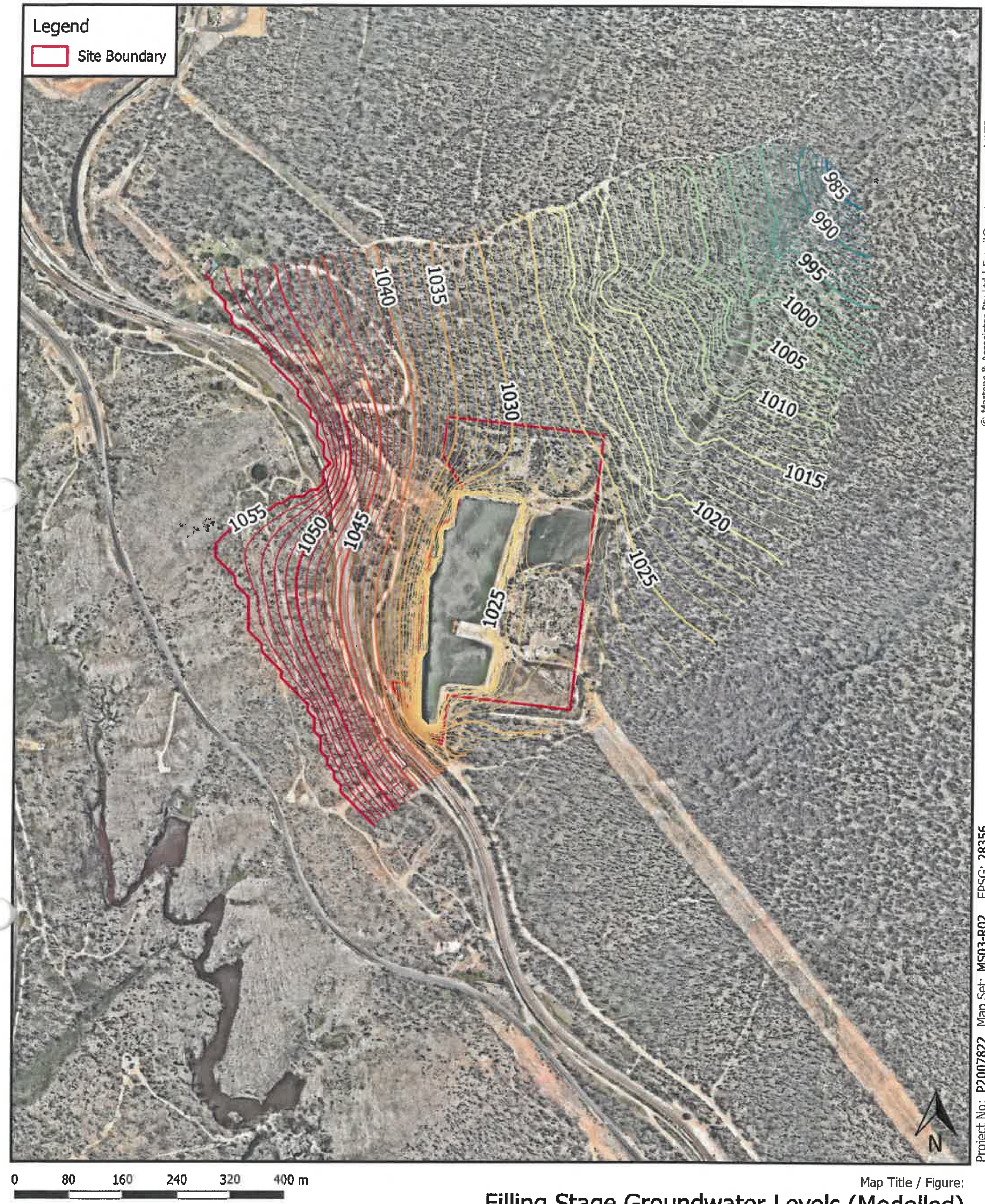

Project No: P2007822 Map Set: MS03-R02 EPSG: 28356

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Viewport A

Notes:
- Aerial from Nearmap (2021).
- Contours are in mAHD.

Map Title / Figure:

Filling Stage Groundwater Levels (Modelled)

Map 18	Map
Sandham Road, Dargan, NSW	Site
Bell Quarry Rehabilitation	Project
Hydrological Study	Sub-Project
Bell Quarry Rehabilitation Project Pty Ltd	Client
19/11/2021	Date

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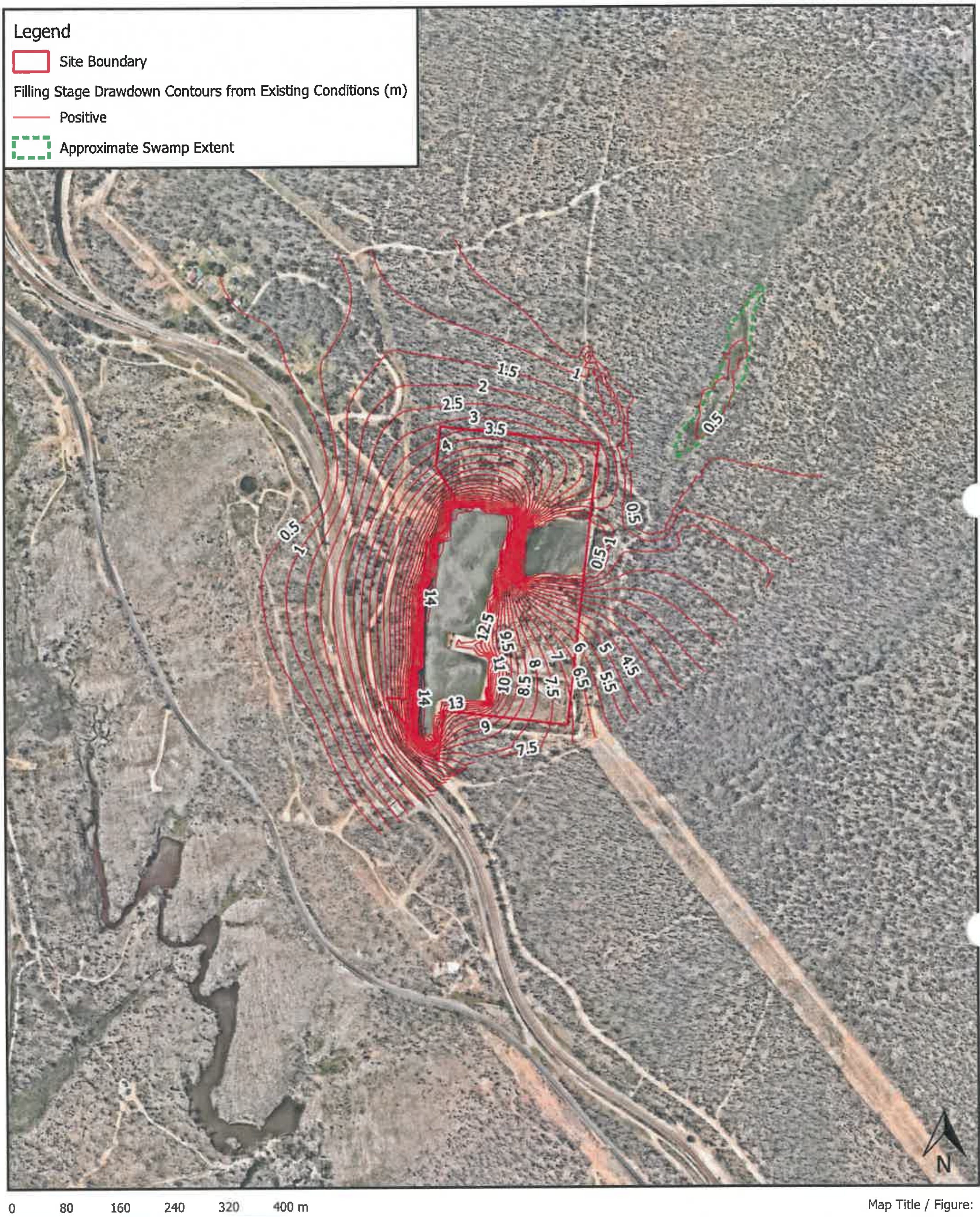

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Viewport A

Notes:
- Aerial from Nearmap (2021).
- Drawdown is calculated as the later groundwater level minus the earlier, hence a negative drawdown value represents an increase in groundwater levels.

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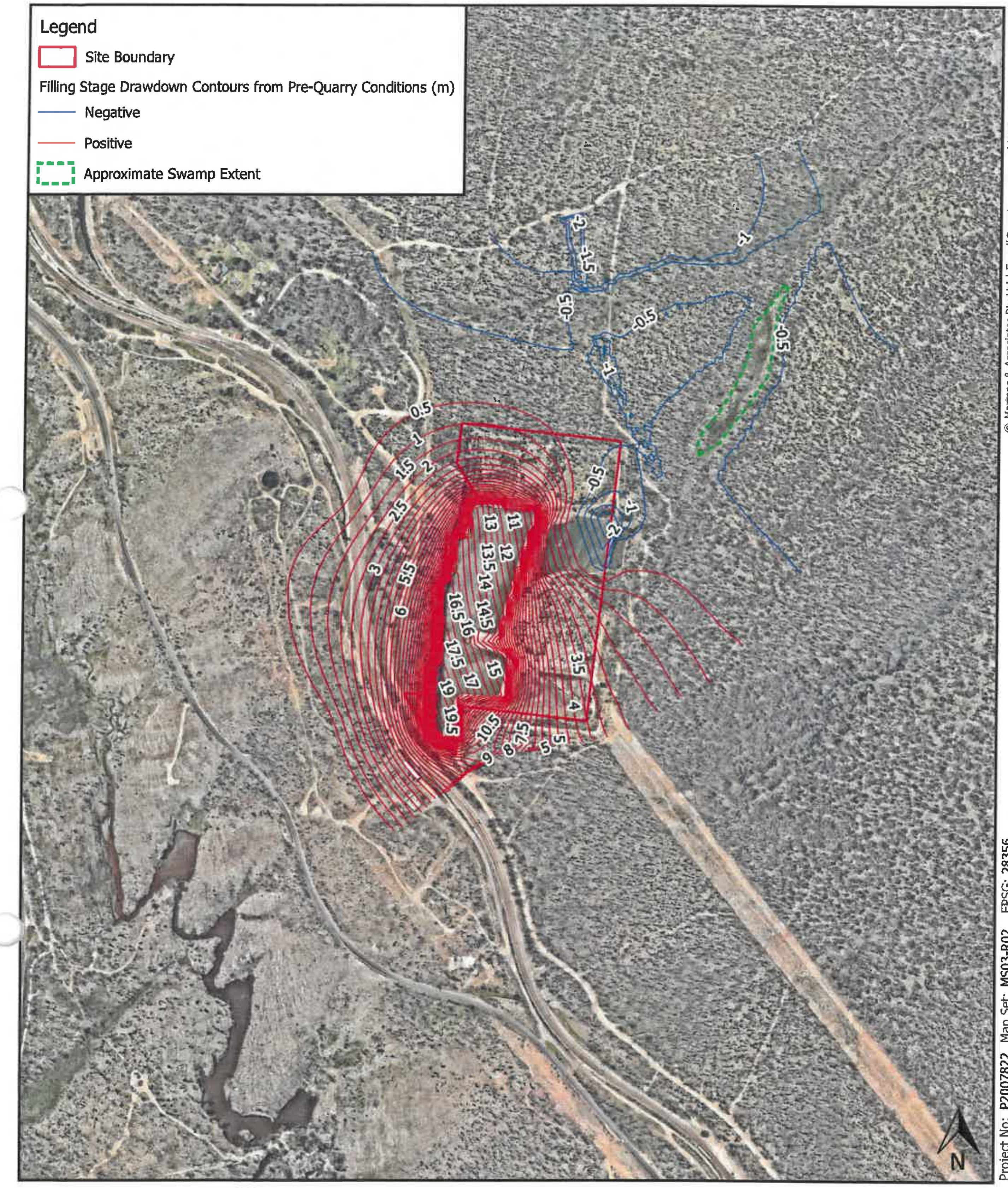
Map Title / Figure:

Filling Stage Groundwater Drawdown from Existing Conditions

Map 19	Map
Sandham Road, Dargan, NSW	Site
Bell Quarry Rehabilitation	Project
Hydrological Study	Sub-Project
Bell Quarry Rehabilitation Project Pty Ltd	Client
19/11/2021	Date

Project No: P2007822 Map Set: MS03-R EPSG: 28356



1:7500 @ A4

Viewport A

Notes:
- Aerial from Nearmap (2021).
- Drawdown is calculated as the later groundwater level minus the earlier, hence a negative drawdown value represents an increase in groundwater levels.

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Map Title / Figure:

Filling Stage Groundwater Drawdown from Pre-Quarry Conditions

Map 20	Map
Sandham Road, Dargan, NSW	Site
Bell Quarry Rehabilitation	Project
Hydrological Study	Sub-Project
Bell Quarry Rehabilitation Project Pty Ltd	Client
19/11/2021	Date

Project No: P2007822 Map Set: MS03-R02 EPSG: 28356

0 80 160 240 320 400 m

1:7500 @ A4

Viewport A

Notes:
- Aerial from Nearmap (2021).
- Contours are in mAHD.

Map Title / Figure:

Final Surface Groundwater Levels (Modelled)

Map 21	Map
Sandham Road, Dargan, NSW	Site
Bell Quarry Rehabilitation	Project
Hydrological Study	Sub-Project
Bell Quarry Rehabilitation Project Pty Ltd	Client
19/11/2021	Date

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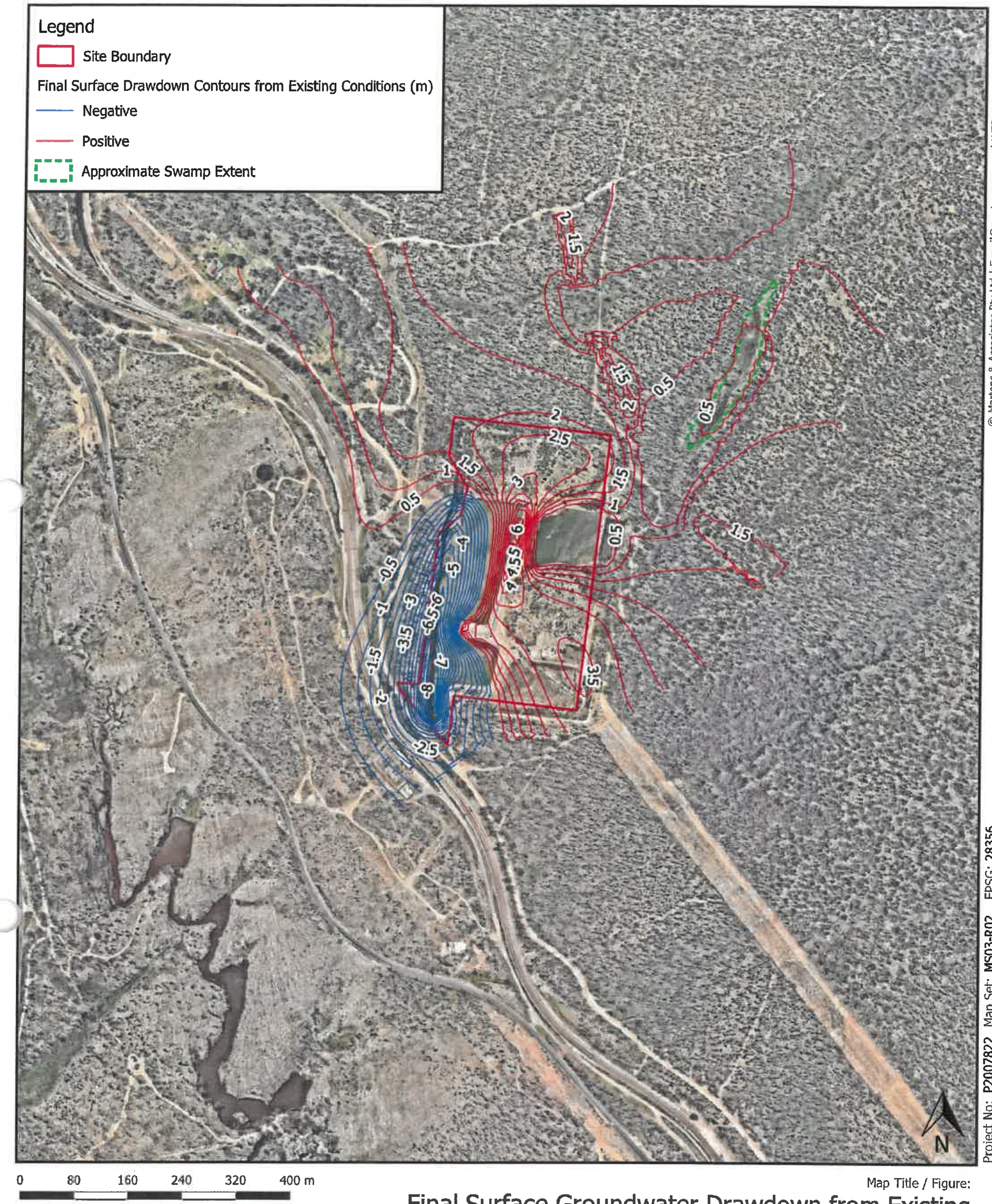
Project No: P2007822 Map Set: MS03-R EPSG: 28356



1:7500 @ A4

Viewport A

Notes:
- Aerial from Nearmap (2021).
- Drawdown is calculated as the later groundwater level minus the earlier, hence a negative drawdown value represents an increase in groundwater levels.

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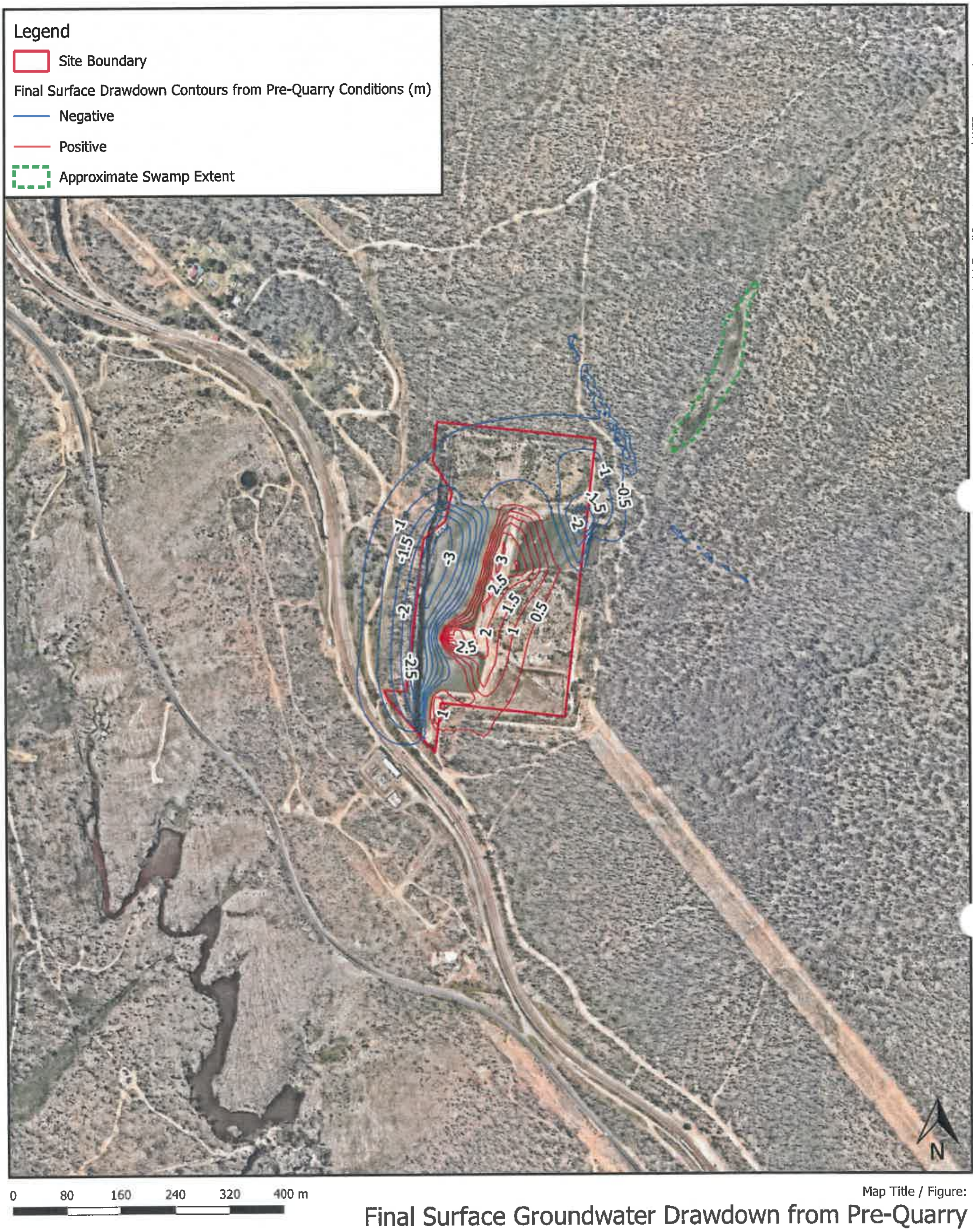
Map Title / Figure:

Final Surface Groundwater Drawdown from Existing Conditions

Map 22	Map
Sandham Road, Dargan, NSW	Site
Bell Quarry Rehabilitation	Project
Hydrological Study	Sub-Project
Bell Quarry Rehabilitation Project Pty Ltd	Client
19/11/2021	Date

Project No: **P2007822** Map Set: **MS03-R02** EPSG: **28356**



1:7500 @ A4

Viewport A

Notes:
- Aerial from Nearmap (2021).
- Drawdown is calculated as the later groundwater level minus the earlier, hence a negative drawdown value represents an increase in groundwater levels.

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Map Title / Figure:

Final Surface Groundwater Drawdown from Pre-Quarry Conditions

Map 23	Map
Sandham Road, Dargan, NSW	Site
Bell Quarry Rehabilitation	Project
Hydrological Study	Sub-Project
Bell Quarry Rehabilitation Project Pty Ltd	Client
19/11/2021	Date

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Project No: P2007822 Map Set: MS03-R EPSG: 28356

Appendix C –Borehole Logs

CLIENT	HWL Ebsworth	COMMENCED	22/02/2021	COMPLETED	22/02/2021	**REF BH201**
PROJECT	Bell Quarry - Rehabilitation	LOGGED	BM	CHECKED		Sheet · 1 OF 1
SITE	Bell Quarry, Dargan, NSW	GEOLOGY	Sandstone	VEGETATION	NA	PROJECT NO. P2007822
EQUIPMENT	4WD truck-mounted hydraulic drill rig	LONGITUDE		RL SURFACE	1067.17 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 44.00 m depth	LATITUDE		ASPECT		SLOPE

Drilling					**Sampling**		**Field Material Description**					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V		Not Encountered		1066.87				SP	FILL: Gravelly SAND; coarse grained; light brown and brown; angular gravel (5-50mm).			
				1.30 1065.87				SP	SAND; coarse grained; trace clay.			1.30: Down hole hammer.
									SANDSTONE; light brown and brown; variable strength and weathering.			
			5									
			10									
			15									
			20									
												24.00: Hammer stuck.
			25									
			30									
			35									
			40									
				44.00					Hole Terminated at 44.00 m (Target depth reached)			44.00: Note: hole drilled to 50m final measurement of 44m following collapse.
			45									

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - BOREHOLE

MARTENS 2.00 LIB.GLB Log MARTENS BOREHOLE P2007822BH201V01MW201.GPJ <<DrawingFile>> 28/10/2021 16:11 10.02.00.04 Datgel Lab and In Situ Tool - DGD | Lib: Martens 2.00 2016-11-13 Prj: Martens 2.00 2016-11-13

CLIENT	HWL Ebsworth	COMMENCED	19/04/2021	COMPLETED	19/04/2021	**REF BH301A**
PROJECT	Bell Quarry - Rehabilitation	LOGGED	BM	CHECKED		Sheet 1 OF 1
SITE	Bell Quarry, Dargan, NSW	GEOLOGY	Sandstone	VEGETATION	Grass	PROJECT NO. P2007822
EQUIPMENT	4WD truck-mounted hydraulic drill rig	LONGITUDE		RL SURFACE	1014.58 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 5.50 m depth	LATITUDE		ASPECT		SLOPE

Drilling					**Sampling**		**Field Material Description**					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V		▽ Inflow		1014.58				SP	SAND; coarse grained; light brown - brown; trace grey clay; very wet.	W		
			1.60	1012.98					SANDSTONE; fine to medium grained; pale white - grey and light brown; variable strength and weathering.			
			3.00	1011.56					Sandy clay seams.			
			5.50						Hole Terminated at 5.50 m (Target depth reached)			

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CLIENT	HWL Ebsworth	COMMENCED	19/04/2021	COMPLETED	19/04/2021	**REF BH301B**
PROJECT	Bell Quarry - Rehabilitation	LOGGED	BM	CHECKED		Sheet 1 OF 1
SITE	Bell Quarry, Dargan, NSW	GEOLOGY	Sandstone	VEGETATION	Grass	PROJECT NO. P2007822
EQUIPMENT	4WD truck-mounted hydraulic drill rig	LONGITUDE		RL SURFACE	1014.19 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 1.30 m depth	LATITUDE		ASPECT		SLOPE

Drilling					**Sampling**		**Field Material Description**					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V		▽ Inflow		1014.19				SP	SAND; coarse grained; light brown - brown.	W		
			1	*1.00* 1013.19					Trace grey clay.			
				1.30					Hole Terminated at 1.30 m (Target depth reached)			
			2									
			3									
			4									
			5									

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CLIENT	HWL Ebsworth	COMMENCED	19/04/2021	COMPLETED	19/04/2021	**REF BH302A**
PROJECT	Bell Quarry - Rehabilitation	LOGGED	BM	CHECKED		Sheet 1 OF 1
SITE	Bell Quarry, Dargan, NSW	GEOLOGY	Sandstone	VEGETATION	Grass	PROJECT NO. P2007822
EQUIPMENT	4WD truck-mounted hydraulic drill rig	LONGITUDE		RL SURFACE	m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 5.00 m depth	LATITUDE		ASPECT		SLOPE

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V								SP	SAND; coarse grained; light brown - brown; trace grey clay; very wet.			
				0.50					Extremely Weathered SANDSTONE/Sandy CLAY; light brown, grey.			
			1									
			2									
				2.50					SANDSTONE; fine to medium grained; white, grey, light brown; variable strength.			
			3									3.00: Borehole collapse noted at 3.00m during well installation.
			4									
			5	5.00					Hole Terminated at 5.00 m (Target depth reached)			

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CLIENT	HWL Ebsworth	COMMENCED	19/04/2021	COMPLETED	19/04/2021	**REF**	**BH302B**
PROJECT	Bell Quarry - Rehabilitation	LOGGED	BM	CHECKED		Sheet	1 OF 1
SITE	Bell Quarry, Dargan, NSW	GEOLOGY	Sandstone	VEGETATION	Grass	PROJECT NO.	P2007822
EQUIPMENT	4WD truck-mounted hydraulic drill rig	LONGITUDE		RL SURFACE	1008.16 m	DATUM	AHD
EXCAVATION DIMENSIONS	Ø100 mm x 0.70 m depth	LATITUDE		ASPECT		SLOPE	

Drilling					**Sampling**		**Field Material Description**					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
AD/V		▽ Inflow		1008.16 *0.70*			░	SP	SAND; coarse grained; light brown - brown; trace grey clay; very wet.	W		
									Hole Terminated at 0.70 m (Target depth reached)			
			1									
			2									
			3									
			4									
			5									

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CLIENT	HWL Ebsworth	COMMENCED	08/07/2021	COMPLETED	08/07/2021	**REF BH401**
PROJECT	Monitoring Well Installations	LOGGED	RJK	CHECKED		Sheet 1 OF 1
SITE	Bell Quarry, Bell, NSW	GEOLOGY	Sandstone	VEGETATION	Nil	PROJECT NO. P2007822
EQUIPMENT	4WD ute-mounted hydraulic dril rig	LONGITUDE		RL SURFACE	1022.02 m	DATUM AHD
EXCAVATION DIMENSIONS	12.00 m depth	LATITUDE		ASPECT	West	SLOPE 0-5%

Drilling					**Sampling**		**Field Material Description**					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
				1022.02				SP	SAND; pale yellow; medium to coarse grained; subangular; trace silt.	D		
				0.30 1021.72				SC	Clayey SAND; dark brown; medium grained.	M		
				0.70 1021.32				CL	CLAY; low plasticity; dark yellow; with sand.	M		
			2	*1.80* 1020.22					SANDSTONE.			
			4									
			6									
			8									
			10									
			12	*12.00*					Hole Terminated at 12.00 m (Target depth reached)			

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CLIENT	HWL Ebsworth	COMMENCED	30/08/2021	COMPLETED	30/08/2021	**REF BH501**
PROJECT	Soil Survey	LOGGED	BM	CHECKED	MD	Sheet 1 OF 1
SITE	Bell Quarry, Bell, NSW	GEOLOGY		VEGETATION	Grass	PROJECT NO. P2007822
EQUIPMENT		LONGITUDE		RL SURFACE	m	DATUM AHD
EXCAVATION DIMENSIONS	Ø75 mm x 1.10 m depth	LATITUDE		ASPECT		SLOPE

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
PT		Not Encountered	0.2	0.25				SM	Silty SAND: medium grained; light brown.			
			0.4	0.50				CL-CI	Sandy CLAY; low to medium plasticity; light brown-orange.			
			0.6 0.8 1.0	1.10				CI	CLAY / Extremely Weathered SANDSTONE; white-light brown.			
			1.2 1.4						Hole Terminated at 1.10 m			1.10: Push tube refusal.

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CLIENT	HWL Ebsworth	COMMENCED	30/08/2021	COMPLETED	30/08/2021	**REF BH502**
PROJECT	Soil Survey	LOGGED	BM	CHECKED	MD	Sheet 1 OF 1
SITE	Bell Quarry, Bell, NSW	GEOLOGY		VEGETATION	Grass	PROJECT NO. P2007822
EQUIPMENT		LONGITUDE		RL SURFACE	m	DATUM AHD
EXCAVATION DIMENSIONS	Ø75 mm x 1.20 m depth	LATITUDE		ASPECT		SLOPE

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
PT		Not Encountered	0.2	0.30				SM	Silty SAND: medium grained; light brown.			
			0.4	0.60				CL-CI	Sandy CLAY; low to medium plasticity; light brown-orange.			
			0.6 0.8 1.0	1.20				CI	CLAY / Extremely Weathered SANDSTONE; white-light brown.			
			1.2 1.4						Hole Terminated at 1.20 m			1.20: Refusal.

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CLIENT	HWL Ebsworth	COMMENCED	30/08/2021	COMPLETED	30/08/2021	**REF BH503**
PROJECT	Soil Survey	LOGGED	BM	CHECKED	MD	Sheet 1 OF 1
SITE	Bell Quarry, Bell, NSW	GEOLOGY		VEGETATION	Grass	PROJECT NO. P2007822
EQUIPMENT		LONGITUDE		RL SURFACE	m	DATUM AHD
EXCAVATION DIMENSIONS	Ø75 mm x 1.10 m depth	LATITUDE		ASPECT		SLOPE

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
PT		Not Encountered						SM	Silty SAND: medium grained; light brown.			
			0.2	0.20				CL-CI	Sandy CLAY; low to medium plasticity; light brown-orange.			
			0.4									
			0.6	0.60				CI	CLAY / Extremely Weathered SANDSTONE; white-light brown.			
			0.8									
			1.0									
				1.10					Hole Terminated at 1.10 m			1.10: Refusal.
			1.2									
			1.4									

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CLIENT	HWL Ebsworth	COMMENCED	30/08/2021	COMPLETED	30/08/2021	**REF BH504**
PROJECT	Soil Survey	LOGGED	BM	CHECKED	MD	Sheet 1 OF 1
SITE	Bell Quarry, Bell, NSW	GEOLOGY		VEGETATION	Grass	PROJECT NO. P2007822
EQUIPMENT		LONGITUDE		RL SURFACE	m	DATUM AHD
EXCAVATION DIMENSIONS	Ø75 mm x 0.80 m depth	LATITUDE		ASPECT		SLOPE

Drilling					**Sampling**		**Field Material Description**					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
PT		Not Encountered						SM	Silty SAND: medium grained; light brown.			
				0.15				CI	CLAY / Extremely Weathered SANDSTONE; white-light brown.			
			0.2									
			0.4									
			0.6									
			0.8	*0.80*					Hole Terminated at 0.80 m			0.80: Refusal.
			1.0									
			1.2									
			1.4									

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CLIENT	HWL Ebsworth	COMMENCED	30/08/2021	COMPLETED	30/08/2021	**REF BH505**
PROJECT	Soil Survey	LOGGED	BM	CHECKED	MD	Sheet 1 OF 1
SITE	Bell Quarry, Bell, NSW	GEOLOGY		VEGETATION	Grass	PROJECT NO. P2007822
EQUIPMENT		LONGITUDE		RL SURFACE	m	DATUM AHD
EXCAVATION DIMENSIONS	Ø75 mm x 0.45 m depth	LATITUDE		ASPECT		SLOPE

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
PT		Not Encountered	0.2	*0.25*			× · ·	SM	Silty SAND: medium grained; light brown.			
			0.4	*0.45*			— —	CI	CLAY / Extremely Weathered SANDSTONE; white-light brown.			
			0.6 0.8 1.0 1.2 1.4						Hole Terminated at 0.45 m			0.45: Refusal.

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CLIENT	HWL Ebsworth	COMMENCED	30/08/2021	COMPLETED	30/08/2021	**REF BH506**
PROJECT	Soil Survey	LOGGED	BM	CHECKED	MD	Sheet 1 OF 1
SITE	Bell Quarry, Bell, NSW	GEOLOGY		VEGETATION	Grass	PROJECT NO. P2007822
EQUIPMENT		LONGITUDE		RL SURFACE	m	DATUM AHD
EXCAVATION DIMENSIONS	⌀75 mm x 0.50 m depth	LATITUDE		ASPECT		SLOPE

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
PT		Not Encountered						SM	Silty SAND: medium grained; light brown.			
			0.2	*0.20*				CI	CLAY / Extremely Weathered SANDSTONE; white-light brown.			
			0.4									
				0.50					Hole Terminated at 0.50 m			0.50: Refusal.
			0.6									
			0.8									
			1.0									
			1.2									
			1.4									

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Engineering Log - BOREHOLE

CLIENT	HWL Ebsworth	COMMENCED	30/08/2021	COMPLETED	30/08/2021	**REF BH507**	
PROJECT	Soil Survey	LOGGED	BM	CHECKED	MD	Sheet	1 OF 1
SITE	Bell Quarry, Bell, NSW	GEOLOGY		VEGETATION	Grass	PROJECT NO. P2007822	
EQUIPMENT		LONGITUDE		RL SURFACE	m	DATUM	AHD
EXCAVATION DIMENSIONS	ø75 mm x 0.50 m depth	LATITUDE		ASPECT		SLOPE	

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
PT		Not Encountered	0.2	0.30				SP	Gravelly SAND; medium grained; light brown.			
			0.4	0.50					SANDSTONE; brown, light brown.			
			0.6 0.8 1.0 1.2 1.4						Hole Terminated at 0.50 m			0.50: Refusal.

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CLIENT	HWL Ebsworth	COMMENCED	30/08/2021	COMPLETED	30/08/2021	**REF BH508**
PROJECT	Soil Survey	LOGGED	BM	CHECKED	MD	Sheet 1 OF 1
SITE	Bell Quarry, Bell, NSW	GEOLOGY		VEGETATION	Grass	PROJECT NO. P2007822
EQUIPMENT		LONGITUDE		RL SURFACE	m	DATUM AHD
EXCAVATION DIMENSIONS	Ø75 mm x 0.70 m depth	LATITUDE		ASPECT		SLOPE

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
PT		Not Encountered	0.2					SP	Gravelly SAND; medium grained; light brown.			
			0.4	*0.30*				CL-CI	Sandy CLAY; low to medium plasticity; light brown-orange.			
			0.6	*0.50*					SANDSTONE; brown, light brown.			
			0.8 1.0 1.2 1.4	*0.70*					Hole Terminated at 0.70 m			

EXCAVATION LOG TO BE READ IN CONJUCTION WITH ACCOMPANYING REPORT NOTES AND ABBREVIATIONS

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Engineering Log - BOREHOLE

MARTENS 2.00 LIB.GLB Log MARTENS BOREHOLE P2007822BH401-BH414V01.GPJ <<DrawingFile>> 03/11/2021 13:24 10.02.00.04 Datgel Lab and In Situ Tool - DGD | Lib: Martens 2.00 2016-11-13 Prj: Martens 2.00 2016-11-13

CLIENT	HWL Ebsworth	COMMENCED	30/08/2021	COMPLETED	30/08/2021	**REF BH509**
PROJECT	Soil Survey	LOGGED	BM	CHECKED	MD	Sheet 1 OF 1
SITE	Bell Quarry, Bell, NSW	GEOLOGY		VEGETATION	Grass	PROJECT NO. P2007822
EQUIPMENT		LONGITUDE		RL SURFACE	m	DATUM AHD
EXCAVATION DIMENSIONS	Ø75 mm x 1.30 m depth	LATITUDE		ASPECT		SLOPE

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
PT		Not Encountered						SM	Silty SAND: medium grained; light brown.			
			0.2	0.20				CL-CI	Sandy CLAY; low to medium plasticity; light brown-orange.			
			0.4									
			0.6	0.60				CI	CLAY / Extremely Weathered SANDSTONE; white-light brown.			
			0.8									
			1.0									
			1.2	1.30								
			1.4						Hole Terminated at 1.30 m			

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CLIENT	HWL Ebsworth	COMMENCED	30/08/2021	COMPLETED	30/08/2021	**REF BH510**
PROJECT	Soil Survey	LOGGED	BM	CHECKED	MD	Sheet 1 OF 1
SITE	Bell Quarry, Bell, NSW	GEOLOGY		VEGETATION	Grass	PROJECT NO. P2007822
EQUIPMENT		LONGITUDE		RL SURFACE	m	DATUM AHD
EXCAVATION DIMENSIONS	Ø75 mm x 0.80 m depth	LATITUDE		ASPECT		SLOPE

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
PT		Not Encountered						SM	Silty SAND: medium grained; light brown.			
			0.2	0.20				CL-CI	Sandy CLAY; low to medium plasticity; light brown-orange.			
			0.4	0.50				CI	CLAY / Extremely Weathered SANDSTONE; white-light brown.			
			0.6									
			0.8	0.80					Hole Terminated at 0.80 m			
			1.0									
			1.2									
			1.4									

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Engineering Log - BOREHOLE

MARTENS 2.00 LIB.GLB Log MARTENS BOREHOLE P2007822BH401-BH414/01.GPJ <<DrawingFile>> 03/11/2021 13:24 10.02.00.04 Datgel Lab and In Situ Tool - DGD | Lib: Martens 2.00 2016-11-13 Prj: Martens 2.00 2016-11-13

CLIENT	HWL Ebsworth	COMMENCED	30/08/2021	COMPLETED	30/08/2021	**REF BH511**	
PROJECT	Soil Survey	LOGGED	BM	CHECKED	MD	Sheet 1 OF 1	
SITE	Bell Quarry, Bell, NSW	GEOLOGY		VEGETATION	Grass	PROJECT NO. P2007822	
EQUIPMENT		LONGITUDE		RL SURFACE	m	DATUM	AHD
EXCAVATION DIMENSIONS	Ø75 mm x 0.60 m depth	LATITUDE		ASPECT		SLOPE	

Drilling					**Sampling**		**Field Material Description**					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
PT		Not Encountered					▨	SM	Silty SAND: medium grained; light brown.			
			0.2	*0.20*			▨	CL-CI	Sandy CLAY; low to medium plasticity; light brown-orange.			
			0.4									
			0.6	*0.60*					Hole Terminated at 0.60 m			0.60: Refusal at 0.6m on sandstone.
			0.8									
			1.0									
			1.2									
			1.4									

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Engineering Log - BOREHOLE

CLIENT	HWL Ebsworth	COMMENCED	30/08/2021	COMPLETED	30/08/2021	**REF BH512**
PROJECT	Soil Survey	LOGGED	BM	CHECKED	MD	Sheet 1 OF 1
SITE	Bell Quarry, Bell, NSW	GEOLOGY		VEGETATION	Grass	PROJECT NO. P2007822
EQUIPMENT		LONGITUDE		RL SURFACE	m	DATUM AHD
EXCAVATION DIMENSIONS	Ø75 mm x 1.00 m depth	LATITUDE		ASPECT		SLOPE

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
PT		Not Encountered						SP	SAND; coarse grained; light brown-brown; trace clay; saturated.			
			0.2									
			0.4									
			0.6	*0.60*				CI	CLAY / Extremely Weathered SANDSTONE; white-light brown.			
			0.8									
			1.0	*1.00*					Hole Terminated at 1.00 m			1.00: Refusal.
			1.2									
			1.4									

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Engineering Log - BOREHOLE

CLIENT	HWL Ebsworth	COMMENCED	30/08/2021	COMPLETED	30/08/2021	**REF BH513**	
PROJECT	Soil Survey	LOGGED	BM	CHECKED	MD	Sheet	1 OF 1
SITE	Bell Quarry, Bell, NSW	GEOLOGY		VEGETATION	Grass	PROJECT NO. P2007822	
EQUIPMENT		LONGITUDE		RL SURFACE	m	DATUM	AHD
EXCAVATION DIMENSIONS	Ø75 mm x 0.50 m depth	LATITUDE		ASPECT		SLOPE	

Drilling					**Sampling**		**Field Material Description**					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
PT		Not Encountered	0.2 0.4	*0.50*			▨	SP	FILL: Gravelly SAND; brown; sandstone gravels and boulders.			
			0.6 0.8 1.0 1.2 1.4						Hole Terminated at 0.50 m			0.50: Refusal.

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Engineering Log - BOREHOLE

CLIENT	HWL Ebsworth	COMMENCED	30/08/2021	COMPLETED	30/08/2021	**REF BH514**	
PROJECT	Soil Survey	LOGGED	BM	CHECKED	MD	Sheet	1 OF 1
SITE	Bell Quarry, Bell, NSW	GEOLOGY		VEGETATION	Grass	PROJECT NO. P2007822	
EQUIPMENT		LONGITUDE		RL SURFACE	m	DATUM	AHD
EXCAVATION DIMENSIONS	Ø75 mm x 1.20 m depth	LATITUDE		ASPECT		SLOPE	

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
PT								SM	Silty SAND: medium grained; light brown.			
			0.2	*0.30*				SC	Sandy CLAY; medium plasticity; red-brown.			
			0.4									
			0.6									
		⊻ 30/08/21										
			0.8	*0.80*					SANDSTONE; extremely weathered; light brown, brown.			
			1.0									
			1.2	*1.20*					Hole Terminated at 1.20 m			1.20: Refusal.
			1.4									

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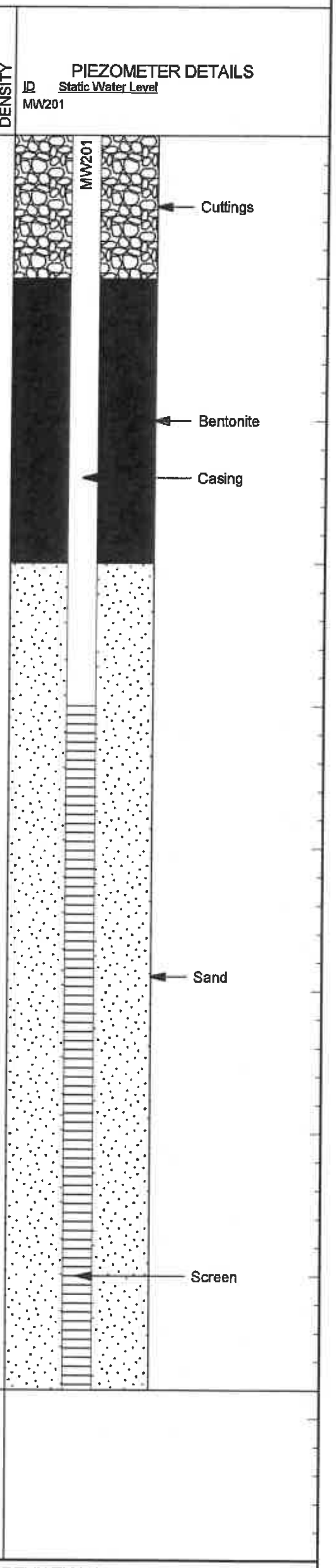
Engineering Log - BOREHOLE

Appendix D – Monitoring Well Logs

CLIENT	HWL Ebsworth	COMMENCED	22/02/2021	COMPLETED	22/02/2021	**REF MW201**
PROJECT	Bell Quarry - Rehabilitation	LOGGED	BM	CHECKED		Sheet 1 OF 1
SITE	Bell Quarry, Dargan, NSW	GEOLOGY	Sandstone	VEGETATION	NA	PROJECT NO. P2007822
EQUIPMENT	4WD truck-mounted hydraulic drill rig	LONGITUDE		RL SURFACE	1067.17 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 44.00 m depth	LATITUDE		ASPECT		SLOPE

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS
AD/V		Not Encountered		1066.87 *1.30* 1065.87				SP SP	FILL: Gravelly SAND; coarse grained; light brown and brown; angular gravel (5-50mm). SAND; coarse grained; trace clay. SANDSTONE; light brown and brown; variable strength and weathering.			
			44.00	*44.00*					Hole Terminated at 44.00 m (Target depth reached)			



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Engineering Log - TEST

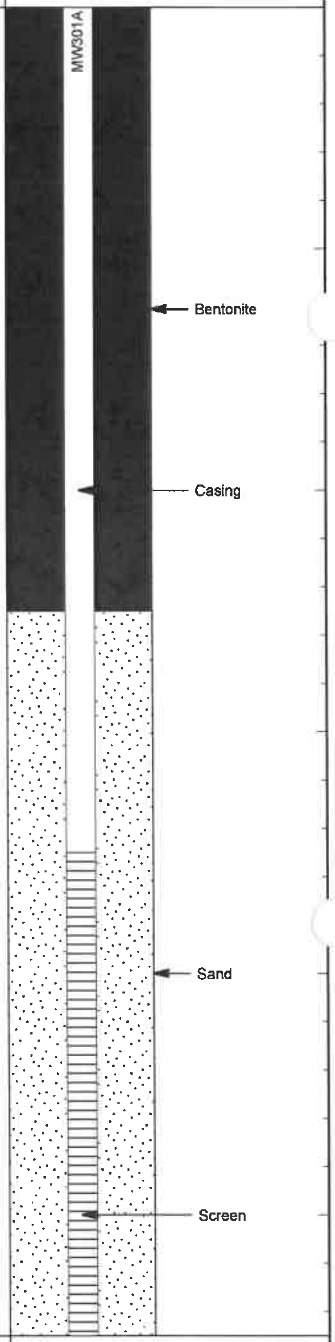
CLIENT	HWL Ebsworth	COMMENCED	19/04/2021	COMPLETED	19/04/2021	**REF MW301A**
PROJECT	Bell Quarry - Rehabilitation	LOGGED	BM	CHECKED		Sheet 1 OF 1
SITE	Bell Quarry, Dargan, NSW	GEOLOGY	Sandstone	VEGETATION	Grass	PROJECT NO. P2007822
EQUIPMENT	4WD truck-mounted hydraulic drill rig	LONGITUDE		RL SURFACE	1014.58 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 5.50 m depth	LATITUDE		ASPECT		SLOPE

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY
AD/V		Inflow	1	1014.58				SP	SAND; coarse grained; light brown - brown; trace grey clay; very wet.	W	
			2	1.60 1012.98					SANDSTONE; fine to medium grained; pale white - grey and light brown; strength highly weathered.		
			3 4 5	3.00 1011.58					Sandy clay seams.		
				5.50					Hole Terminated at 5.50 m (Target depth reached)		

PIEZOMETER DETAILS

ID Static Water Level

MW301A



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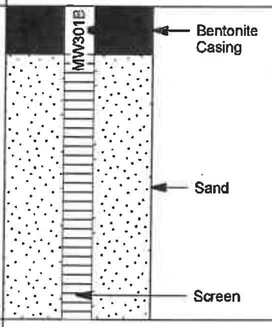
Engineering Log - TEST

CLIENT	HWL Ebsworth	COMMENCED	19/04/2021	COMPLETED	19/04/2021	**REF MW301B**	
PROJECT	Bell Quarry - Rehabilitation	LOGGED	BM	CHECKED		Sheet	1 OF 1
SITE	Bell Quarry, Dargan, NSW	GEOLOGY	Sandstone	VEGETATION	Grass	PROJECT NO. P2007822	
EQUIPMENT	4WD truck-mounted hydraulic drill rig	LONGITUDE		RL SURFACE	1014.19 m	DATUM	AHD
EXCAVATION DIMENSIONS	Ø100 mm x 1.30 m depth	LATITUDE		ASPECT		SLOPE	

Drilling					**Sampling**		**Field Material Description**					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS ID Static Water Level MW301B
AD/V		Inflow		1014.19				SP	SAND; coarse grained; light brown - brown.	W		
			1	1.00 1013.19					Trace grey clay.			
				1.30								
			2 3 4 5						Hole Terminated at 1.30 m (Target depth reached)			



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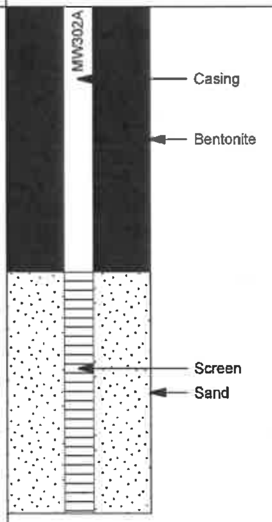
Engineering Log - TEST

CLIENT	HWL Ebsworth	COMMENCED	19/04/2021	COMPLETED	19/04/2021	**REF MW302A**
PROJECT	Bell Quarry - Rehabilitation	LOGGED	BM	CHECKED		Sheet 1 OF 1
SITE	Bell Quarry, Dargan, NSW	GEOLOGY	Sandstone	VEGETATION	Grass	PROJECT NO. P2007822
EQUIPMENT	4WD truck-mounted hydraulic drill rig	LONGITUDE		RL SURFACE	m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 5.00 m depth	LATITUDE		ASPECT		SLOPE

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS ID Static Water Level MW302A
AD/V								SP	SAND; coarse grained; light brown - brown; trace grey clay; very wet.			
				0.50					Extremely Weathered SANDSTONE/Sandy CLAY; light brown, grey.			
			1									
			2									
				2.50					SANDSTONE; fine to medium grained; white, grey, light brown; variable strength.			
			3									
			4									
			5	5.00					Hole Terminated at 5.00 m (Target depth reached)			

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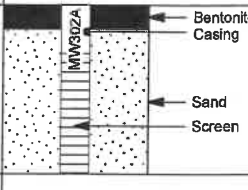
Engineering Log - TEST

MARTENS 2.00 LIB.GLB Log MARTENS BOREHOLE P2007822BH301, BH301B-BH302 MW301A,MW301B, MW302V01.GPJ <<DrawingFile>> 09/11/2021 11:42 10.02.00.04 Datgel Lab and In Situ Tool - DGD | Lib: Martens 2.00 2016-11-13 Prj: Martens 2.00 2016-11-13

CLIENT	HWL Ebsworth	COMMENCED	19/04/2021	COMPLETED	19/04/2021	**REF MW302B**
PROJECT	Bell Quarry - Rehabilitation	LOGGED	BM	CHECKED		Sheet 1 OF 1
SITE	Bell Quarry, Dargan, NSW	GEOLOGY	Sandstone	VEGETATION	Grass	PROJECT NO. P2007822
EQUIPMENT	4WD truck-mounted hydraulic drill rig	LONGITUDE		RL SURFACE	1008.16 m	DATUM AHD
EXCAVATION DIMENSIONS	Ø100 mm x 0.70 m depth	LATITUDE		ASPECT		SLOPE

Drilling					**Sampling**		**Field Material Description**					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS ID Static Water Level MW302A
AD/V		Inflow		1008.16 *0.70*				SP	SAND; coarse grained; light brown - brown; trace grey clay; very wet.	W		
			1 2 3 4 5						Hole Terminated at 0.70 m (Target depth reached)			

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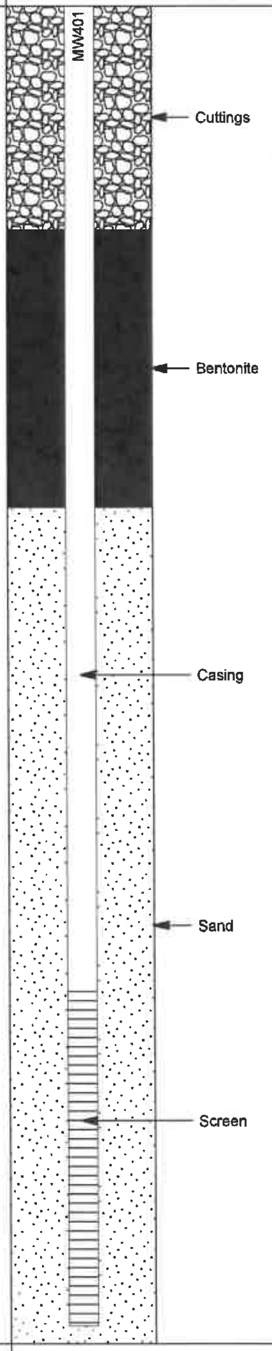
Engineering Log - TEST

CLIENT	HWL Ebsworth	COMMENCED	08/07/2021	COMPLETED	08/07/2021	**REF**	**BH401/MW01**
PROJECT	Monitoring Well Installations	LOGGED	RJK	CHECKED		Sheet	1 OF 1
SITE	Bell Quarry, Bell, NSW	GEOLOGY	Sandstone	VEGETATION	Nil	PROJECT NO.	P2007822
EQUIPMENT	4WD ute-mounted hydraulic dril rig	LONGITUDE		RL SURFACE	1022.02 m	DATUM	AHD
EXCAVATION DIMENSIONS	12.00 m depth	LATITUDE		ASPECT	West	SLOPE	0-5%

Drilling					**Sampling**		**Field Material Description**					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USCS / ASCS CLASSIFICATION	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	PIEZOMETER DETAILS
				1022.02				SP	SAND; pale yellow; medium to coarse grained; subangular; trace silt.	D		
				0.30 1021.72				SC	Clayey SAND; dark brown; medium grained.	M		
				0.70 1021.32				CL	CLAY; low plasticity; dark yellow; with sand.	M		
			2	1.80 1020.22					SANDSTONE.			
			4									
			6									
			8									
			10									
			12	12.00					Hole Terminated at 12.00 m (Target depth reached)			

ID Static Water Level
MW401



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Engineering Log - TEST

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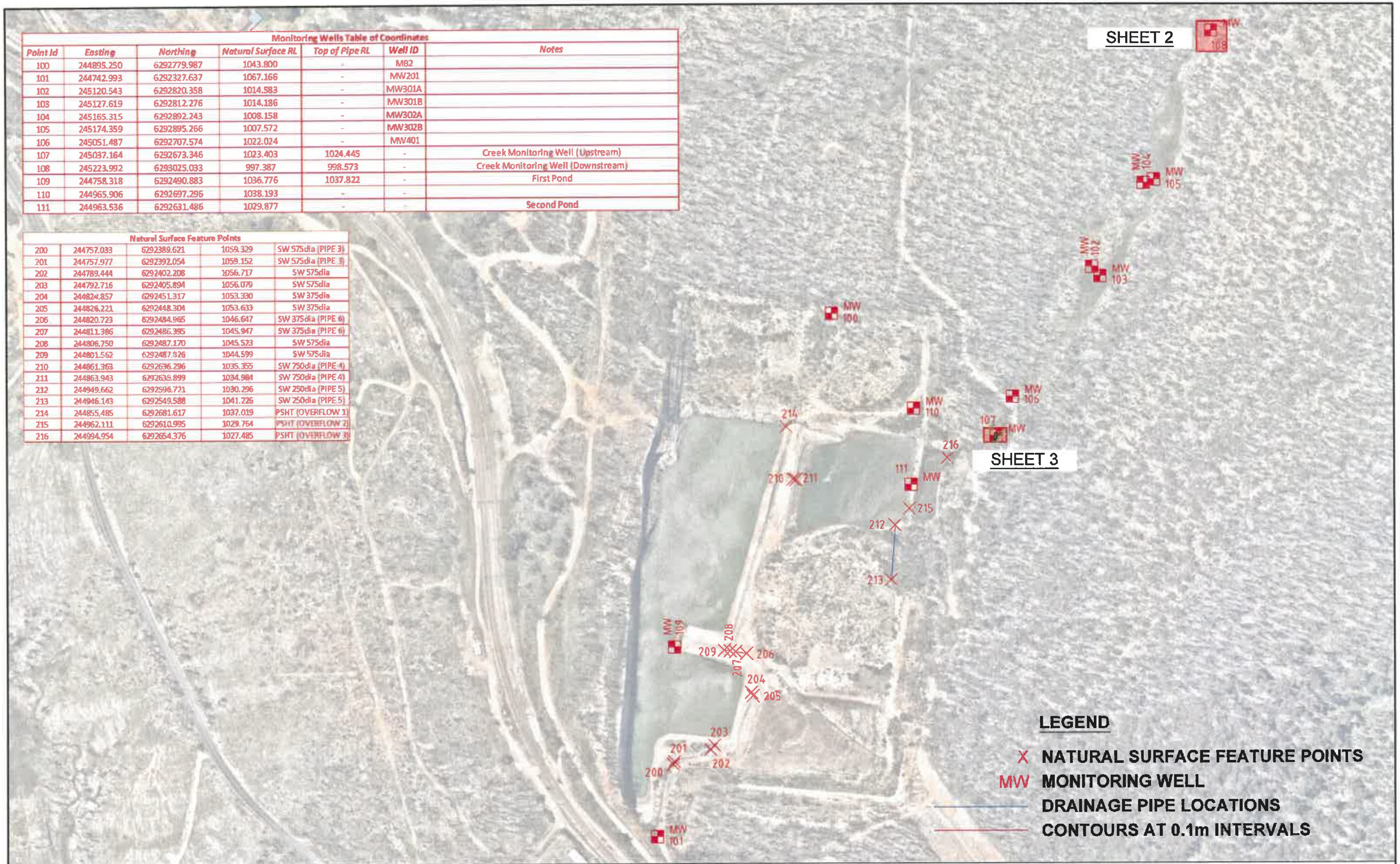
Appendix E – Survey Data



Monitoring Wells Table of Coordinates

Point Id	Easting	Northing	Natural Surface RL	Top of Pipe RL	Well ID	Notes
100	244895.250	6292779.987	1043.800	-	MB2	
101	244742.993	6292327.637	1067.166	-	MW201	
102	245120.543	6292820.358	1014.583	-	MW301A	
103	245127.619	6292812.276	1014.186	-	MW301B	
104	245165.315	6292892.243	1008.158	-	MW302A	
105	245174.359	6292895.266	1007.572	-	MW302B	
106	245051.487	6292707.574	1022.024	-	MW401	
107	245037.164	6292673.346	1023.403	1024.445	-	Creek Monitoring Well (Upstream)
108	245223.992	6293025.033	997.387	998.573	-	Creek Monitoring Well (Downstream)
109	244758.318	6292490.883	1036.776	1037.822	-	First Pond
110	244965.906	6292697.296	1038.193	-	-	
111	244963.536	6292631.486	1029.877	-	-	Second Pond

Natural Surface Feature Points

200	244757.033	6292389.621	1059.329	SW 575dia (PIPE 3)
201	244757.977	6292392.054	1059.152	SW 575dia (PIPE 3)
202	244789.444	6292402.208	1056.717	SW 575dia
203	244792.716	6292405.894	1056.079	SW 575dia
204	244824.857	6292451.317	1053.330	SW 375dia
205	244826.221	6292448.304	1053.633	SW 375dia
206	244820.723	6292484.965	1046.647	SW 375dia (PIPE 6)
207	244811.386	6292486.395	1045.947	SW 375dia (PIPE 6)
208	244806.750	6292487.170	1045.523	SW 575dia
209	244801.562	6292487.826	1044.599	SW 575dia
210	244861.363	6292636.296	1035.355	SW 750dia (PIPE 4)
211	244863.943	6292635.899	1034.984	SW 750dia (PIPE 4)
212	244949.662	6292596.721	1030.296	SW 250dia (PIPE 5)
213	244946.143	6292549.588	1041.226	SW 250dia (PIPE 5)
214	244855.485	6292681.617	1037.019	PSHT (OVERFLOW 1)
215	244962.111	6292610.995	1029.764	PSHT (OVERFLOW 2)
216	244994.954	6292654.376	1027.485	PSHT (OVERFLOW 3)

PREPARED BY:

geosurv.
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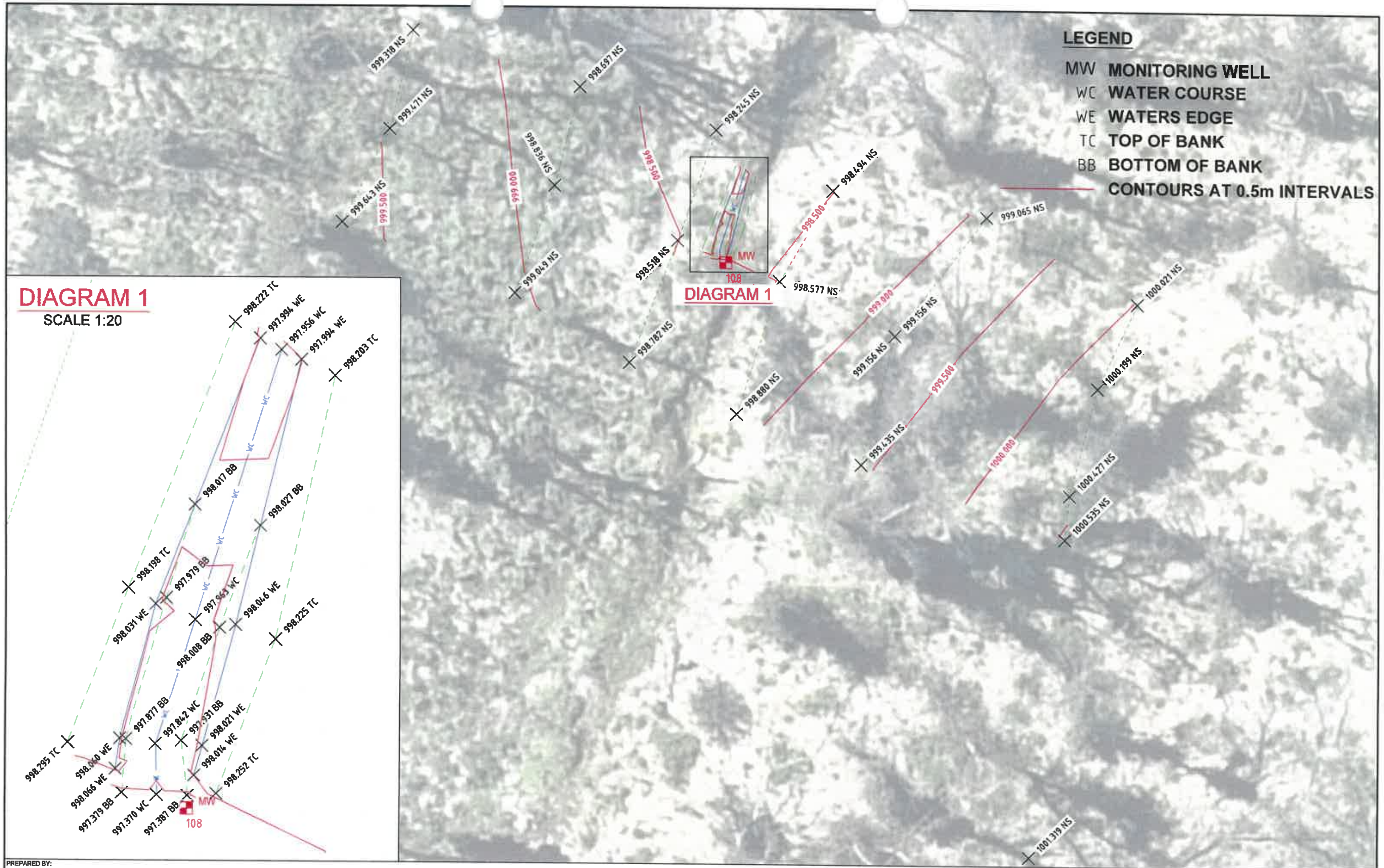
Grid Origin:	GDA94 Z56	Datum Origin:	AHD71 (PM57366 - 1072.319)
Date of survey:	18/09/2021	Survey checked:	21/09/2021
Surveyed by:	J. BASHA	Checked by:	M. NGUYEN

Note: This sketch plan is only a record of the sur [illegible] del shown heron.

Record of Survey - Bell Quarry, Clarence NSW 2790

SHEET 1 of 3
SCALE 1:3000

ASP212094-DT-01[C].dwg



PREPARED BY:

geosurv. with you from beginning to end

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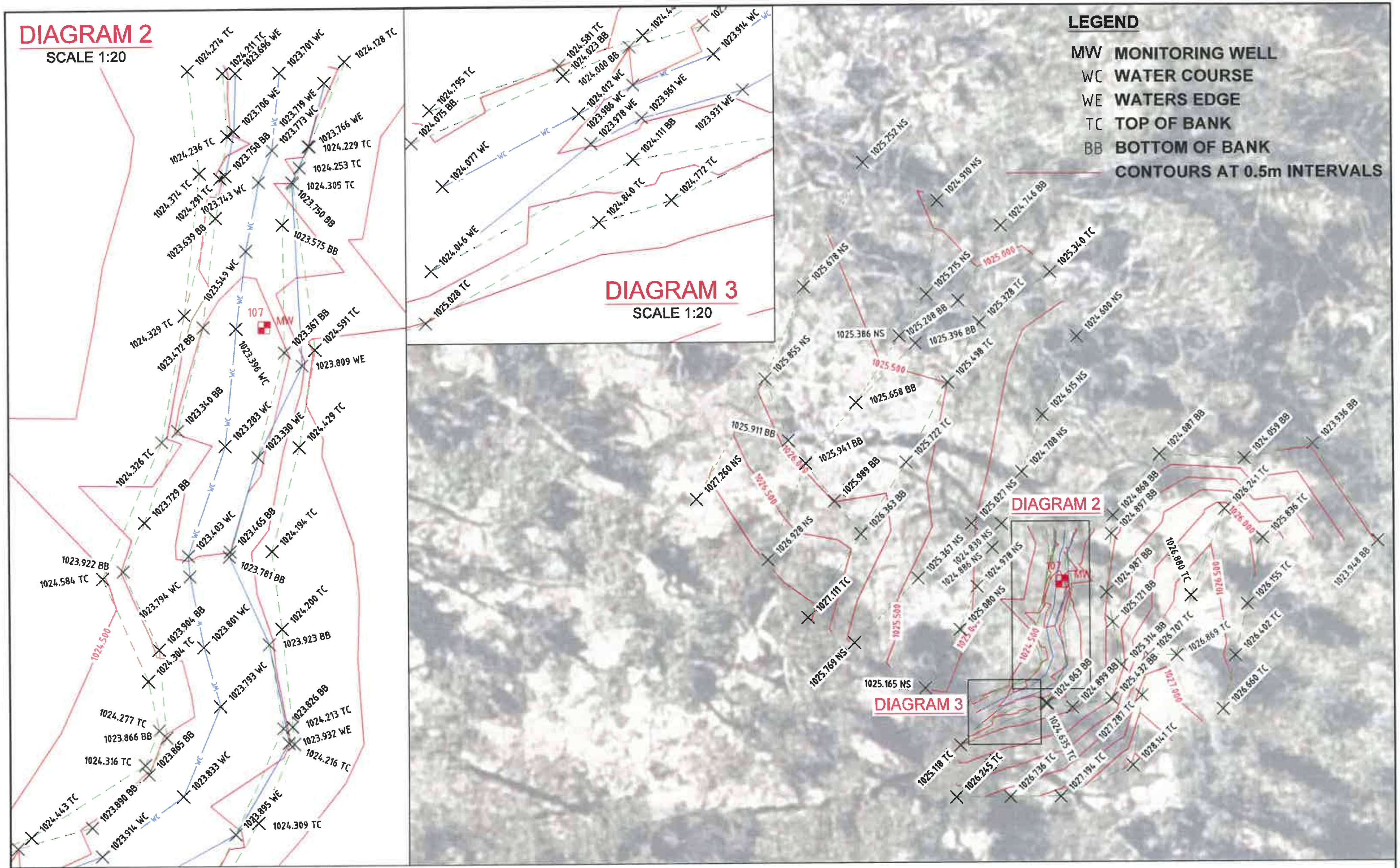
Grid Origin:	GDA94 Z56	Datum Origin:	AHD71 (PM57366 - 1072.319)
Date of survey:	18/09/2021	Survey checked:	21/09/2021
Surveyed by:	J. BASHA	Checked by:	M. NGUYEN

Note: This sketch plan is only a record of the survey model shown heron.

Record of Survey at Bell Quarry, Clarence NSW 2790

SHEET 2 of 3
SCALE 1:100

ASP212094-DT-01[C].dwg



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Grid Origin: GDA94 Z56
Date of survey: 18/09/2021
Surveyed by: J. BASHA

Datum Origin: AHD71 (PM57366 - 1072.319)
Survey checked: 21/09/2021
Checked by: M. NGUYEN

Note: This sketch plan is only a record of the sur del shown heron.

Record of Survey at Bell Quarry, Clarence NSW 2790

SHEET 3 of 3
SCALE 1:100

ASP212094-DT-01[C].dwg

Appendix F – Laboratory Reports

Envirolab Services Pty Ltd
ABN 37 112 535 645
12 Ashley St Chatswood NSW 2067
ph 02 9910 6200 fax 02 9910 6201
customerservice@envirolab.com.au
www.envirolab.com.au

CERTIFICATE OF ANALYSIS 269664

Client Details

Client	Martens & Associates Pty Ltd
Attention	R Kightley
Address	Suite 201, 20 George St, Hornsby, NSW, 2077

Sample Details

Your Reference	**P2007822 Bell Quarry**
Number of Samples	7 WATER
Date samples received	21/05/2021
Date completed instructions received	21/05/2021

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Please refer to the last page of this report for any comments relating to the results.

Report Details

Date results requested by	28/05/2021
Date of Issue	28/05/2021

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Accredited for compliance with ISO/IEC 17025 - Testing. **Tests not covered by NATA are denoted with ***

Results Approved By
Dragana Tomas, Senior Chemist
Hannah Nguyen, Senior Chemist
Priya Samarawickrama, Senior Chemist

Authorised By

Nancy Zhang, Laboratory Manager

Client Reference: P2007822 Bell Quarry

vTRH(C6-C10)/BTEXN in Water						
Our Reference		269664-1	269664-2	269664-3	269664-4	269664-5
Your Reference	UNITS	7822/MW302A	7822/MW302B	7822/MW301A	7822/MW301B	7822/MB02
Date Sampled		20/05/2021	20/05/2021	20/05/2021	20/05/2021	20/05/2021
Type of sample		WATER	WATER	WATER	WATER	WATER
Date extracted	-	24/05/2021	24/05/2021	24/05/2021	24/05/2021	24/05/2021
Date analysed	-	24/05/2021	24/05/2021	24/05/2021	24/05/2021	24/05/2021
TRH C_6 - C_9	µg/L	<10	<10	<10	<10	<10
TRH C_6 - C_{10}	µg/L	<10	<10	<10	<10	<10
TRH C_6 - C_{10} less BTEX (F1)	µg/L	<10	<10	<10	<10	<10
Benzene	µg/L	<1	<1	<1	<1	<1
Toluene	µg/L	<1	<1	<1	<1	<1
Ethylbenzene	µg/L	<1	<1	<1	<1	<1
m+p-xylene	µg/L	<2	<2	<2	<2	<2
o-xylene	µg/L	<1	<1	<1	<1	<1
Naphthalene	µg/L	<1	<1	<1	<1	<1
Surrogate Dibromofluoromethane	%	120	103	104	131	107
Surrogate toluene-d8	%	94	71	82	95	95
Surrogate 4-BFB	%	90	105	119	96	108

vTRH(C6-C10)/BTEXN in Water			
Our Reference		269664-6	269664-7
Your Reference	UNITS	7822/MB03	7822/MW201
Date Sampled		20/05/2021	20/05/2021
Type of sample		WATER	WATER
Date extracted	-	24/05/2021	24/05/2021
Date analysed	-	24/05/2021	24/05/2021
TRH C_6 - C_9	µg/L	<10	<10
TRH C_6 - C_{10}	µg/L	<10	<10
TRH C_6 - C_{10} less BTEX (F1)	µg/L	<10	<10
Benzene	µg/L	<1	<1
Toluene	µg/L	<1	<1
Ethylbenzene	µg/L	<1	<1
m+p-xylene	µg/L	<2	<2
o-xylene	µg/L	<1	<1
Naphthalene	µg/L	<1	<1
Surrogate Dibromofluoromethane	%	118	117
Surrogate toluene-d8	%	95	129
Surrogate 4-BFB	%	104	99

svTRH (C10-C40) in Water						
Our Reference		269664-1	269664-2	269664-3	269664-4	269664-5
Your Reference	UNITS	7822/MW302A	7822/MW302B	7822/MW301A	7822/MW301B	7822/MB02
Date Sampled		20/05/2021	20/05/2021	20/05/2021	20/05/2021	20/05/2021
Type of sample		WATER	WATER	WATER	WATER	WATER
Date extracted	-	24/05/2021	24/05/2021	24/05/2021	24/05/2021	24/05/2021
Date analysed	-	25/05/2021	25/05/2021	25/05/2021	25/05/2021	25/05/2021
TRH C_{10} - C_{14}	µg/L	<50	<50	<50	<50	<50
TRH C_{15} - C_{28}	µg/L	<100	<100	<100	<100	<100
TRH C_{29} - C_{36}	µg/L	<100	<100	<100	<100	<100
TRH >C_{10} - C_{16}	µg/L	<50	<50	<50	<50	<50
TRH >C_{10} - C_{16} less Naphthalene (F2)	µg/L	<50	<50	<50	<50	<50
TRH >C_{16} - C_{34}	µg/L	<100	<100	<100	<100	<100
TRH >C_{34} - C_{40}	µg/L	<100	<100	<100	<100	<100
Surrogate o-Terphenyl	%	84	79	80	65	78

svTRH (C10-C40) in Water			
Our Reference		269664-6	269664-7
Your Reference	UNITS	7822/MB03	7822/MW201
Date Sampled		20/05/2021	20/05/2021
Type of sample		WATER	WATER
Date extracted	-	24/05/2021	24/05/2021
Date analysed	-	25/05/2021	25/05/2021
TRH C_{10} - C_{14}	µg/L	<50	<50
TRH C_{15} - C_{28}	µg/L	<100	200
TRH C_{29} - C_{36}	µg/L	<100	<100
TRH >C_{10} - C_{16}	µg/L	<50	72
TRH >C_{10} - C_{16} less Naphthalene (F2)	µg/L	<50	72
TRH >C_{16} - C_{34}	µg/L	<100	140
TRH >C_{34} - C_{40}	µg/L	<100	<100
Surrogate o-Terphenyl	%	82	90

PAHs in Water						
Our Reference		269664-1	269664-2	269664-3	269664-4	269664-5
Your Reference	UNITS	7822/MW302A	7822/MW302B	7822/MW301A	7822/MW301B	7822/MB02
Date Sampled		20/05/2021	20/05/2021	20/05/2021	20/05/2021	20/05/2021
Type of sample		WATER	WATER	WATER	WATER	WATER
Date extracted	-	24/05/2021	24/05/2021	24/05/2021	24/05/2021	24/05/2021
Date analysed	-	24/05/2021	24/05/2021	24/05/2021	24/05/2021	24/05/2021
Naphthalene	µg/L	<1	<1	<1	<1	<1
Acenaphthylene	µg/L	<1	<1	<1	<1	<1
Acenaphthene	µg/L	<1	<1	<1	<1	<1
Fluorene	µg/L	<1	<1	<1	<1	<1
Phenanthrene	µg/L	<1	<1	<1	<1	<1
Anthracene	µg/L	<1	<1	<1	<1	<1
Fluoranthene	µg/L	<1	<1	<1	<1	<1
Pyrene	µg/L	<1	<1	<1	<1	<1
Benzo(a)anthracene	µg/L	<1	<1	<1	<1	<1
Chrysene	µg/L	<1	<1	<1	<1	<1
Benzo(b,j+k)fluoranthene	µg/L	<2	<2	<2	<2	<2
Benzo(a)pyrene	µg/L	<1	<1	<1	<1	<1
Indeno(1,2,3-c,d)pyrene	µg/L	<1	<1	<1	<1	<1
Dibenzo(a,h)anthracene	µg/L	<1	<1	<1	<1	<1
Benzo(g,h,i)perylene	µg/L	<1	<1	<1	<1	<1
Benzo(a)pyrene TEQ	µg/L	<5	<5	<5	<5	<5
Total +ve PAH's	µg/L	NIL (+)VE	NIL (+)VE	NIL (+)VE	NIL (+)VE	NIL (+)VE
Surrogate p-Terphenyl-d14	%	87	97	132	106	100

PAHs in Water			
Our Reference		269664-6	269664-7
Your Reference	UNITS	7822/MB03	7822/MW201
Date Sampled		20/05/2021	20/05/2021
Type of sample		WATER	WATER
Date extracted	-	24/05/2021	24/05/2021
Date analysed	-	24/05/2021	24/05/2021
Naphthalene	µg/L	<1	<1
Acenaphthylene	µg/L	<1	<1
Acenaphthene	µg/L	<1	<1
Fluorene	µg/L	<1	<1
Phenanthrene	µg/L	<1	<1
Anthracene	µg/L	<1	<1
Fluoranthene	µg/L	<1	<1
Pyrene	µg/L	<1	<1
Benzo(a)anthracene	µg/L	<1	<1
Chrysene	µg/L	<1	<1
Benzo(b,j+k)fluoranthene	µg/L	<2	<2
Benzo(a)pyrene	µg/L	<1	<1
Indeno(1,2,3-c,d)pyrene	µg/L	<1	<1
Dibenzo(a,h)anthracene	µg/L	<1	<1
Benzo(g,h,i)perylene	µg/L	<1	<1
Benzo(a)pyrene TEQ	µg/L	<5	<5
Total +ve PAH's	µg/L	NIL (+)VE	NIL (+)VE
Surrogate p-Terphenyl-d14	%	106	98

HM in water - dissolved						
Our Reference		269664-1	269664-2	269664-3	269664-4	269664-5
Your Reference	UNITS	7822/MW302A	7822/MW302B	7822/MW301A	7822/MW301B	7822/MB02
Date Sampled		20/05/2021	20/05/2021	20/05/2021	20/05/2021	20/05/2021
Type of sample		WATER	WATER	WATER	WATER	WATER
Date prepared	-	28/05/2021	28/05/2021	28/05/2021	28/05/2021	28/05/2021
Date analysed	-	28/05/2021	28/05/2021	28/05/2021	28/05/2021	28/05/2021
Arsenic-Dissolved	µg/L	<1	<1	<1	<1	<1
Cadmium-Dissolved	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium-Dissolved	µg/L	<1	<1	<1	<1	<1
Copper-Dissolved	µg/L	<1	2	17	<1	1
Lead-Dissolved	µg/L	<1	<1	<1	<1	<1
Mercury-Dissolved	µg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Nickel-Dissolved	µg/L	<1	<1	9	<1	<1
Zinc-Dissolved	µg/L	<1	<1	35	<1	7

HM in water - dissolved			
Our Reference		269664-6	269664-7
Your Reference	UNITS	7822/MB03	7822/MW201
Date Sampled		20/05/2021	20/05/2021
Type of sample		WATER	WATER
Date prepared	-	28/05/2021	28/05/2021
Date analysed	-	28/05/2021	28/05/2021
Arsenic-Dissolved	µg/L	<1	<1
Cadmium-Dissolved	µg/L	<0.1	<0.1
Chromium-Dissolved	µg/L	<1	<1
Copper-Dissolved	µg/L	2	190
Lead-Dissolved	µg/L	<1	<1
Mercury-Dissolved	µg/L	<0.05	<0.05
Nickel-Dissolved	µg/L	3	85
Zinc-Dissolved	µg/L	36	800

Client Reference: P2007822 Bell Quarry

Ion Balance						
Our Reference		269664-1	269664-2	269664-3	269664-4	269664-5
Your Reference	UNITS	7822/MW302A	7822/MW302B	7822/MW301A	7822/MW301B	7822/MB02
Date Sampled		20/05/2021	20/05/2021	20/05/2021	20/05/2021	20/05/2021
Type of sample		WATER	WATER	WATER	WATER	WATER
Date prepared	-	24/05/2021	24/05/2021	24/05/2021	24/05/2021	24/05/2021
Date analysed	-	24/05/2021	24/05/2021	24/05/2021	24/05/2021	24/05/2021
Calcium - Dissolved	mg/L	<0.5	2.6	<0.5	<0.5	<0.5
Potassium - Dissolved	mg/L	0.8	<0.5	1.2	1.2	1.2
Sodium - Dissolved	mg/L	16	5.7	3.2	2.9	4.4
Magnesium - Dissolved	mg/L	<0.5	<0.5	<0.5	<0.5	0.5
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	<5	<5	<5	<5	<5
Bicarbonate Alkalinity as $CaCO_3$	mg/L	32	6	<5	<5	<5
Carbonate Alkalinity as $CaCO_3$	mg/L	<5	<5	<5	<5	<5
Total Alkalinity as $CaCO_3$	mg/L	32	6	<5	<5	<5
Sulphate, SO4	mg/L	3	2	2	2	3
Chloride, Cl	mg/L	6	5	5	4	6
Ionic Balance	%	-12	11	-2.0	1.0	9.0

Ion Balance			
Our Reference		269664-6	269664-7
Your Reference	UNITS	7822/MB03	7822/MW201
Date Sampled		20/05/2021	20/05/2021
Type of sample		WATER	WATER
Date prepared	-	24/05/2021	24/05/2021
Date analysed	-	24/05/2021	24/05/2021
Calcium - Dissolved	mg/L	1.1	2.5
Potassium - Dissolved	mg/L	2.1	<0.5
Sodium - Dissolved	mg/L	2.8	5.6
Magnesium - Dissolved	mg/L	0.9	<0.5
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	<5	<5
Bicarbonate Alkalinity as $CaCO_3$	mg/L	7	11
Carbonate Alkalinity as $CaCO_3$	mg/L	<5	<5
Total Alkalinity as $CaCO_3$	mg/L	7	11
Sulphate, SO4	mg/L	3	2
Chloride, Cl	mg/L	4	4
Ionic Balance	%	0	-1.0

Miscellaneous Inorganics						
Our Reference		269664-1	269664-2	269664-3	269664-4	269664-5
Your Reference	UNITS	7822/MW302A	7822/MW302B	7822/MW301A	7822/MW301B	7822/MB02
Date Sampled		20/05/2021	20/05/2021	20/05/2021	20/05/2021	20/05/2021
Type of sample		WATER	WATER	WATER	WATER	WATER
Date prepared	-	24/05/2021	24/05/2021	24/05/2021	24/05/2021	24/05/2021
Date analysed	-	24/05/2021	24/05/2021	24/05/2021	24/05/2021	24/05/2021
Total Nitrogen in water	mg/L	0.7	0.1	<0.1	0.1	<0.1
NOx as N in water	mg/L	0.009	0.009	0.02	<0.005	0.01
Ammonia as N in water	mg/L	0.096	0.051	0.008	0.015	0.033
Phosphate as P in water	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005

Miscellaneous Inorganics			
Our Reference		269664-6	269664-7
Your Reference	UNITS	7822/MB03	7822/MW201
Date Sampled		20/05/2021	20/05/2021
Type of sample		WATER	WATER
Date prepared	-	24/05/2021	24/05/2021
Date analysed	-	24/05/2021	24/05/2021
Total Nitrogen in water	mg/L	1.8	0.7
NOx as N in water	mg/L	1.8	0.4
Ammonia as N in water	mg/L	0.029	0.009
Phosphate as P in water	mg/L	<0.005	<0.005

Metals in Waters - Acid extractable						
Our Reference		269664-1	269664-2	269664-3	269664-4	269664-5
Your Reference	UNITS	7822/MW302A	7822/MW302B	7822/MW301A	7822/MW301B	7822/MB02
Date Sampled		20/05/2021	20/05/2021	20/05/2021	20/05/2021	20/05/2021
Type of sample		WATER	WATER	WATER	WATER	WATER
Date prepared	-	24/05/2021	24/05/2021	24/05/2021	24/05/2021	24/05/2021
Date analysed	-	24/05/2021	24/05/2021	24/05/2021	24/05/2021	24/05/2021
Phosphorus - Total	mg/L	0.2	0.07	<0.05	<0.05	<0.05

Metals in Waters - Acid extractable			
Our Reference		269664-6	269664-7
Your Reference	UNITS	7822/MB03	7822/MW201
Date Sampled		20/05/2021	20/05/2021
Type of sample		WATER	WATER
Date prepared	-	24/05/2021	24/05/2021
Date analysed	-	24/05/2021	24/05/2021
Phosphorus - Total	mg/L	<0.05	<0.05

Client Reference: P2007822 Bell Quarry

Method ID	Methodology Summary
Inorg-006	Alkalinity - determined titrimetrically in accordance with APHA latest edition, 2320-B.
Inorg-040	The concentrations of the major ions (mg/L) are converted to milliequivalents and summed. The ionic balance should be within +/- 10% ie total anions = total cations +/-10%.
Inorg-055	Nitrate - determined colourimetrically. Waters samples are filtered on receipt prior to analysis. Soils are analysed following a water extraction.
Inorg-055/062/127	Total Nitrogen - Calculation sum of TKN and oxidised Nitrogen. Alternatively analysed by combustion and chemiluminescence.
Inorg-057	Ammonia - determined colourimetrically, based on APHA latest edition 4500-NH3 F. Waters samples are filtered on receipt prior to analysis. Soils are analysed following a KCl extraction.
Inorg-060	Phosphate determined colourimetrically based on EPA365.1 and APHA latest edition 4500 P E. Waters samples are filtered on receipt prior to analysis. Soils are analysed following a water extraction.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Waters samples are filtered on receipt prior to analysis. Alternatively determined by colourimetry/turbidity using Discrete Analyser.
Metals-020	Determination of various metals by ICP-AES.
Metals-021	Determination of Mercury by Cold Vapour AAS.
Metals-022	Determination of various metals by ICP-MS.
Org-020	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-FID. F2 = (>C10-C16)-Naphthalene as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater (HSLs Tables 1A (3, 4)). Note Naphthalene is determined from the VOC analysis.
Org-022/025	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS/GC-MSMS. Benzo(a)pyrene TEQ as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater - 2013.
Org-023	Water samples are analysed directly by purge and trap GC-MS.
Org-023	Soil samples are extracted with methanol and spiked into water prior to analysing by purge and trap GC-MS. Water samples are analysed directly by purge and trap GC-MS. F1 = (C6-C10)-BTEX as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater.

QUALITY CONTROL: vTRH(C6-C10)/BTEXN in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W2	[NT]
Date extracted	-			24/05/2021	1	24/05/2021	25/05/2021		24/05/2021	
Date analysed	-			24/05/2021	1	24/05/2021	25/05/2021		24/05/2021	
TRH C_6 - C_9	µg/L	10	Org-023	<10	1	<10	<10	0	105	
TRH C_6 - C_{10}	µg/L	10	Org-023	<10	1	<10	<10	0	105	
Benzene	µg/L	1	Org-023	<1	1	<1	<1	0	101	
Toluene	µg/L	1	Org-023	<1	1	<1	<1	0	95	
Ethylbenzene	µg/L	1	Org-023	<1	1	<1	<1	0	106	
m+p-xylene	µg/L	2	Org-023	<2	1	<2	<2	0	112	
o-xylene	µg/L	1	Org-023	<1	1	<1	<1	0	96	
Naphthalene	µg/L	1	Org-023	<1	1	<1	<1	0		
Surrogate Dibromofluoromethane	%		Org-023	89	1	120	102	16	101	
Surrogate toluene-d8	%		Org-023	72	1	94	97	3	89	
Surrogate 4-BFB	%		Org-023	112	1	90	108	18	89	

QUALITY CONTROL: svTRH (C10-C40) in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W3	[NT]
Date extracted	-			24/05/2021	1	24/05/2021	24/05/2021		24/05/2021	[NT]
Date analysed	-			25/05/2021	1	25/05/2021	25/05/2021		25/05/2021	[NT]
TRH C_{10} - C_{14}	µg/L	50	Org-020	<50	1	<50	<50	0	119	[NT]
TRH C_{15} - C_{28}	µg/L	100	Org-020	<100	1	<100	<100	0	92	[NT]
TRH C_{29} - C_{36}	µg/L	100	Org-020	<100	1	<100	<100	0	128	[NT]
TRH >C_{10} - C_{16}	µg/L	50	Org-020	<50	1	<50	<50	0	119	[NT]
TRH >C_{16} - C_{34}	µg/L	100	Org-020	<100	1	<100	<100	0	92	[NT]
TRH >C_{34} - C_{40}	µg/L	100	Org-020	<100	1	<100	<100	0	128	[NT]
Surrogate o-Terphenyl	%		Org-020	100	1	84	74	13	92	[NT]

Client Reference: P2007822 Bell Quarry

QUALITY CONTROL: PAHs in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W3	[NT]
Date extracted	-			24/05/2021	1	24/05/2021	24/05/2021		24/05/2021	
Date analysed	-			24/05/2021	1	24/05/2021	24/05/2021		24/05/2021	
Naphthalene	µg/L	1	Org-022/025	<1	1	<1	<1	0	80	
Acenaphthylene	µg/L	1	Org-022/025	<1	1	<1	<1	0		
Acenaphthene	µg/L	1	Org-022/025	<1	1	<1	<1	0	68	
Fluorene	µg/L	1	Org-022/025	<1	1	<1	<1	0	75	
Phenanthrene	µg/L	1	Org-022/025	<1	1	<1	<1	0	92	
Anthracene	µg/L	1	Org-022/025	<1	1	<1	<1	0		
Fluoranthene	µg/L	1	Org-022/025	<1	1	<1	<1	0	78	
Pyrene	µg/L	1	Org-022/025	<1	1	<1	<1	0	80	
Benzo(a)anthracene	µg/L	1	Org-022/025	<1	1	<1	<1	0		
Chrysene	µg/L	1	Org-022/025	<1	1	<1	<1	0	82	
Benzo(b,j+k)fluoranthene	µg/L	2	Org-022/025	<2	1	<2	<2	0		
Benzo(a)pyrene	µg/L	1	Org-022/025	<1	1	<1	<1	0	77	
Indeno(1,2,3-c,d)pyrene	µg/L	1	Org-022/025	<1	1	<1	<1	0		
Dibenzo(a,h)anthracene	µg/L	1	Org-022/025	<1	1	<1	<1	0		
Benzo(g,h,i)perylene	µg/L	1	Org-022/025	<1	1	<1	<1	0		
Surrogate p-Terphenyl-d14	%		Org-022/025	86	1	87	80	8	109	

Client Reference: P2007822 Bell Quarry

QUALITY CONTROL: HM in water - dissolved					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W10	269664-2
Date prepared	-			28/05/2021	1	28/05/2021	28/05/2021		28/05/2021	28/05/2021
Date analysed	-			28/05/2021	1	28/05/2021	28/05/2021		28/05/2021	28/05/2021
Arsenic-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	97	102
Cadmium-Dissolved	µg/L	0.1	Metals-022	<0.1	1	<0.1	<0.1	0	98	102
Chromium-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	93	95
Copper-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	91	94
Lead-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	93	94
Mercury-Dissolved	µg/L	0.05	Metals-021	<0.05	1	<0.05			119	114
Nickel-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	97	99
Zinc-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	97	103

QUALITY CONTROL: HM in water - dissolved					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-				5	28/05/2021	28/05/2021			
Date analysed	-				5	28/05/2021	28/05/2021			
Arsenic-Dissolved	µg/L	1	Metals-022		5	<1				
Cadmium-Dissolved	µg/L	0.1	Metals-022		5	<0.1				
Chromium-Dissolved	µg/L	1	Metals-022		5	<1				
Copper-Dissolved	µg/L	1	Metals-022		5	1				
Lead-Dissolved	µg/L	1	Metals-022		5	<1				
Mercury-Dissolved	µg/L	0.05	Metals-021		5	<0.05	<0.05	0		
Nickel-Dissolved	µg/L	1	Metals-022		5	<1				
Zinc-Dissolved	µg/L	1	Metals-022		5	7				

QUALITY CONTROL: Ion Balance					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W2	269664-2
Date prepared	-			24/05/2021	1	24/05/2021	24/05/2021		24/05/2021	24/05/2021
Date analysed	-			24/05/2021	1	24/05/2021	24/05/2021		24/05/2021	24/05/2021
Calcium - Dissolved	mg/L	0.5	Metals-020	<0.5	1	<0.5	<0.5	0	93	90
Potassium - Dissolved	mg/L	0.5	Metals-020	<0.5	1	0.8	0.8	0	87	83
Sodium - Dissolved	mg/L	0.5	Metals-020	<0.5	1	16	15	6	87	80
Magnesium - Dissolved	mg/L	0.5	Metals-020	<0.5	1	<0.5	<0.5	0	92	87
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	5	Inorg-006	<5	1	<5				
Bicarbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	1	32				
Carbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	1	<5				
Total Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	1	32			111	
Sulphate, SO4	mg/L	1	Inorg-081	<1	1	3			100	
Chloride, Cl	mg/L	1	Inorg-081	<1	1	6			90	
Ionic Balance	%		Inorg-040		1	-12				

QUALITY CONTROL: Ion Balance					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	269664-6
Date prepared	-				3	24/05/2021	24/05/2021			24/05/2021
Date analysed	-				3	24/05/2021	24/05/2021			24/05/2021
Calcium - Dissolved	mg/L	0.5	Metals-020		3	<0.5				
Potassium - Dissolved	mg/L	0.5	Metals-020		3	1.2				
Sodium - Dissolved	mg/L	0.5	Metals-020		3	3.2				
Magnesium - Dissolved	mg/L	0.5	Metals-020		3	<0.5				
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	5	Inorg-006		3	<5	<5	0		
Bicarbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006		3	<5	<5	0		
Carbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006		3	<5	<5	0		
Total Alkalinity as $CaCO_3$	mg/L	5	Inorg-006		3	<5	<5	0		
Sulphate, SO4	mg/L	1	Inorg-081		3	2	2	0		79
Chloride, Cl	mg/L	1	Inorg-081		3	5	5	0		83
Ionic Balance	%		Inorg-040		3	-2.0				

QUALITY CONTROL: Miscellaneous Inorganics					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W2	269664-2
Date prepared	-			24/05/2021	1	24/05/2021	24/05/2021		24/05/2021	24/05/2021
Date analysed	-			24/05/2021	1	24/05/2021	24/05/2021		24/05/2021	24/05/2021
Total Nitrogen in water	mg/L	0.1	Inorg-055/062/127	<0.1	1	0.7			104	
NOx as N in water	mg/L	0.005	Inorg-055	<0.005	1	0.009	0.006	40	111	116
Ammonia as N in water	mg/L	0.005	Inorg-057	<0.005	1	0.096	0.096	0	106	104
Phosphate as P in water	mg/L	0.005	Inorg-060	<0.005	1	<0.005	<0.005	0	97	102

QUALITY CONTROL: Miscellaneous Inorganics					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	269664-6
Date prepared	-				5	24/05/2021	24/05/2021			24/05/2021
Date analysed	-				5	24/05/2021	24/05/2021			24/05/2021
Total Nitrogen in water	mg/L	0.1	Inorg-055/062/127		5	<0.1	<0.1	0		90
NOx as N in water	mg/L	0.005	Inorg-055		5	0.01				
Ammonia as N in water	mg/L	0.005	Inorg-057		5	0.033				
Phosphate as P in water	mg/L	0.005	Inorg-060		5	<0.005				

Client Reference: P2007822 Bell Quarry

QUALITY CONTROL: Metals in Waters - Acid extractable					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W2	[NT]
Date prepared	-			24/05/2021					24/05/2021	
Date analysed	-			24/05/2021					24/05/2021	
Phosphorus - Total	mg/L	0.05	Metals-020	<0.05					102	

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

Report Comments

Dissolved Metals: no filtered, preserved sample was received, therefore the unpreserved sample was filtered through 0.45µm filter at the lab.
Note: there is a possibility some elements may be underestimated.

Total metals: no unfiltered, preserved sample was received, therefore analysis was conducted from the unpreserved sample bottle.
Note: there is a possibility some elements may be underestimated.

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CERTIFICATE OF ANALYSIS 279832

Client Details

Client	Martens & Associates Pty Ltd
Attention	R Kightley
Address	Suite 201, 20 George St, Hornsby, NSW, 2077

Sample Details

Your Reference	**P2007822 Bell Quarry**
Number of Samples	14 Water
Date samples received	06/10/2021
Date completed instructions received	07/10/2021

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Please refer to the last page of this report for any comments relating to the results.

Report Details

Date results requested by	14/10/2021
Date of Issue	14/10/2021

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Results Approved By

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Nancy Zhang, Laboratory Manager

vTRH(C6-C10)/BTEXN in Water

Our Reference		279832-1	279832-2	279832-3	279832-4	279832-5
Your Reference	UNITS	7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		05/10/2021	05/10/2021	05/10/2021	05/10/2021	05/10/2021
Type of sample		Water	Water	Water	Water	Water
Date extracted	-	08/10/2021	08/10/2021	08/10/2021	08/10/2021	08/10/2021
Date analysed	-	11/10/2021	11/10/2021	11/10/2021	11/10/2021	11/10/2021
TRH C_6 - C_9	µg/L	<10	<10	<10	<10	<10
TRH C_6 - C_{10}	µg/L	<10	<10	<10	<10	<10
TRH C_6 - C_{10} less BTEX (F1)	µg/L	<10	<10	<10	<10	<10
Benzene	µg/L	<1	<1	<1	<1	<1
Toluene	µg/L	<1	<1	<1	<1	<1
Ethylbenzene	µg/L	<1	<1	<1	<1	<1
m+p-xylene	µg/L	<2	<2	<2	<2	<2
o-xylene	µg/L	<1	<1	<1	<1	<1
Naphthalene	µg/L	<1	<1	<1	<1	<1
Surrogate Dibromofluoromethane	%	113	113	112	113	112
Surrogate toluene-d8	%	114	113	111	113	113
Surrogate 4-BFB	%	94	94	94	95	94

vTRH(C6-C10)/BTEXN in Water

Our Reference		279832-6	279832-7	279832-8	279832-9	279832-10
Your Reference	UNITS	7822/SW02	7822/MW401	7822/MW302A	7822/MW302B	7822/MW301A
Date Sampled		05/10/2021	05/10/2021	05/10/2021	05/10/2021	05/10/2021
Type of sample		Water	Water	Water	Water	Water
Date extracted	-	11/10/2021	08/10/2021	08/10/2021	08/10/2021	08/10/2021
Date analysed	-	12/10/2021	11/10/2021	11/10/2021	11/10/2021	11/10/2021
TRH C_6 - C_9	µg/L	<10	<10	<10	<10	<10
TRH C_6 - C_{10}	µg/L	<10	<10	<10	<10	<10
TRH C_6 - C_{10} less BTEX (F1)	µg/L	<10	<10	<10	<10	<10
Benzene	µg/L	<1	<1	<1	<1	<1
Toluene	µg/L	<1	<1	<1	<1	<1
Ethylbenzene	µg/L	<1	<1	<1	<1	<1
m+p-xylene	µg/L	<2	<2	<2	<2	<2
o-xylene	µg/L	<1	<1	<1	<1	<1
Naphthalene	µg/L	<1	<1	<1	<1	<1
Surrogate Dibromofluoromethane	%	108	114	112	113	114
Surrogate toluene-d8	%	95	113	114	113	114
Surrogate 4-BFB	%	87	95	92	93	94

vTRH(C6-C10)/BTEXN in Water					
Our Reference		279832-11	279832-12	279832-13	279832-14
Your Reference	UNITS	7822/MW301B	7822/MB02	7822/MB03	7822/MW201
Date Sampled		05/10/2021	05/10/2021	05/10/2021	05/10/2021
Type of sample		Water	Water	Water	Water
Date extracted	-	08/10/2021	08/10/2021	11/10/2021	08/10/2021
Date analysed	-	11/10/2021	11/10/2021	12/10/2021	11/10/2021
TRH C_6 - C_9	µg/L	<10	<10	<10	<10
TRH C_6 - C_{10}	µg/L	<10	<10	<10	<10
TRH C_6 - C_{10} less BTEX (F1)	µg/L	<10	<10	<10	<10
Benzene	µg/L	<1	<1	<1	<1
Toluene	µg/L	<1	<1	<1	<1
Ethylbenzene	µg/L	<1	<1	<1	<1
m+p-xylene	µg/L	<2	<2	<2	<2
o-xylene	µg/L	<1	<1	<1	<1
Naphthalene	µg/L	<1	<1	<1	<1
Surrogate Dibromofluoromethane	%	114	112	107	112
Surrogate toluene-d8	%	114	113	95	114
Surrogate 4-BFB	%	93	92	85	93

svTRH (C10-C40) in Water						
Our Reference		279832-1	279832-2	279832-3	279832-4	279832-5
Your Reference	UNITS	7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		05/10/2021	05/10/2021	05/10/2021	05/10/2021	05/10/2021
Type of sample		Water	Water	Water	Water	Water
Date extracted	-	11/10/2021	11/10/2021	11/10/2021	11/10/2021	11/10/2021
Date analysed	-	13/10/2021	13/10/2021	13/10/2021	13/10/2021	13/10/2021
TRH C_{10} - C_{14}	µg/L	<50	<50	<50	<50	<50
TRH C_{15} - C_{28}	µg/L	<100	<100	<100	<100	<100
TRH C_{29} - C_{36}	µg/L	<100	<100	<100	<100	<100
TRH >C_{10} - C_{16}	µg/L	<50	<50	<50	<50	<50
TRH >C_{10} - C_{16} less Naphthalene (F2)	µg/L	<50	<50	<50	<50	<50
TRH >C_{16} - C_{34}	µg/L	<100	<100	<100	<100	<100
TRH >C_{34} - C_{40}	µg/L	<100	<100	<100	<100	<100
Surrogate o-Terphenyl	%	76	82	92	90	77

svTRH (C10-C40) in Water						
Our Reference		279832-6	279832-7	279832-8	279832-9	279832-10
Your Reference	UNITS	7822/SW02	7822/MW401	7822/MW302A	7822/MW302B	7822/MW301A
Date Sampled		05/10/2021	05/10/2021	05/10/2021	05/10/2021	05/10/2021
Type of sample		Water	Water	Water	Water	Water
Date extracted	-	11/10/2021	11/10/2021	11/10/2021	11/10/2021	11/10/2021
Date analysed	-	13/10/2021	13/10/2021	13/10/2021	13/10/2021	13/10/2021
TRH C_{10} - C_{14}	µg/L	<50	<50	<50	<50	<50
TRH C_{15} - C_{28}	µg/L	<100	<100	<100	<100	<100
TRH C_{29} - C_{36}	µg/L	<100	<100	<100	<100	<100
TRH >C_{10} - C_{16}	µg/L	<50	<50	<50	<50	<50
TRH >C_{10} - C_{16} less Naphthalene (F2)	µg/L	<50	<50	<50	<50	<50
TRH >C_{16} - C_{34}	µg/L	<100	<100	<100	<100	<100
TRH >C_{34} - C_{40}	µg/L	<100	<100	<100	<100	<100
Surrogate o-Terphenyl	%	90	83	87	70	80

svTRH (C10-C40) in Water					
Our Reference		279832-11	279832-12	279832-13	279832-14
Your Reference	UNITS	7822/MW301B	7822/MB02	7822/MB03	7822/MW201
Date Sampled		05/10/2021	05/10/2021	05/10/2021	05/10/2021
Type of sample		Water	Water	Water	Water
Date extracted	-	11/10/2021	11/10/2021	11/10/2021	11/10/2021
Date analysed	-	13/10/2021	13/10/2021	13/10/2021	13/10/2021
TRH C_{10} - C_{14}	µg/L	<50	<50	<50	120
TRH C_{15} - C_{28}	µg/L	<100	<100	<100	490
TRH C_{29} - C_{36}	µg/L	<100	<100	<100	120
TRH >C_{10} - C_{16}	µg/L	<50	<50	<50	230
TRH >C_{10} - C_{16} less Naphthalene (F2)	µg/L	<50	<50	<50	230
TRH >C_{16} - C_{34}	µg/L	<100	<100	<100	460
TRH >C_{34} - C_{40}	µg/L	<100	<100	<100	<100
Surrogate o-Terphenyl	%	94	87	99	82

Client Reference: P2007822 Bell Quarry

PAHs in Water						
Our Reference		279832-1	279832-2	279832-3	279832-4	279832-5
Your Reference	UNITS	7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		05/10/2021	05/10/2021	05/10/2021	05/10/2021	05/10/2021
Type of sample		Water	Water	Water	Water	Water
Date extracted	-	11/10/2021	11/10/2021	11/10/2021	11/10/2021	11/10/2021
Date analysed	-	12/10/2021	12/10/2021	12/10/2021	12/10/2021	12/10/2021
Naphthalene	µg/L	<1	<1	<1	<1	<1
Acenaphthylene	µg/L	<1	<1	<1	<1	<1
Acenaphthene	µg/L	<1	<1	<1	<1	<1
Fluorene	µg/L	<1	<1	<1	<1	<1
Phenanthrene	µg/L	<1	<1	<1	<1	<1
Anthracene	µg/L	<1	<1	<1	<1	<1
Fluoranthene	µg/L	<1	<1	<1	<1	<1
Pyrene	µg/L	<1	<1	<1	<1	<1
Benzo(a)anthracene	µg/L	<1	<1	<1	<1	<1
Chrysene	µg/L	<1	<1	<1	<1	<1
Benzo(b,j+k)fluoranthene	µg/L	<2	<2	<2	<2	<2
Benzo(a)pyrene	µg/L	<1	<1	<1	<1	<1
Indeno(1,2,3-c,d)pyrene	µg/L	<1	<1	<1	<1	<1
Dibenzo(a,h)anthracene	µg/L	<1	<1	<1	<1	<1
Benzo(g,h,i)perylene	µg/L	<1	<1	<1	<1	<1
Benzo(a)pyrene TEQ	µg/L	<5	<5	<5	<5	<5
Total +ve PAH's	µg/L	NIL (+)VE	NIL (+)VE	NIL (+)VE	NIL (+)VE	NIL (+)VE
Surrogate p-Terphenyl-d14	%	84	86	85	86	83

PAHs in Water						
Our Reference		279832-6	279832-7	279832-8	279832-9	279832-10
Your Reference	UNITS	7822/SW02	7822/MW401	7822/MW302A	7822/MW302B	7822/MW301A
Date Sampled		05/10/2021	05/10/2021	05/10/2021	05/10/2021	05/10/2021
Type of sample		Water	Water	Water	Water	Water
Date extracted	-	11/10/2021	11/10/2021	11/10/2021	11/10/2021	11/10/2021
Date analysed	-	12/10/2021	12/10/2021	12/10/2021	12/10/2021	12/10/2021
Naphthalene	µg/L	<1	<1	<1	<1	<1
Acenaphthylene	µg/L	<1	<1	<1	<1	<1
Acenaphthene	µg/L	<1	<1	<1	<1	<1
Fluorene	µg/L	<1	<1	<1	<1	<1
Phenanthrene	µg/L	<1	<1	<1	<1	<1
Anthracene	µg/L	<1	<1	<1	<1	<1
Fluoranthene	µg/L	<1	<1	<1	<1	<1
Pyrene	µg/L	<1	<1	<1	<1	<1
Benzo(a)anthracene	µg/L	<1	<1	<1	<1	<1
Chrysene	µg/L	<1	<1	<1	<1	<1
Benzo(b,j+k)fluoranthene	µg/L	<2	<2	<2	<2	<2
Benzo(a)pyrene	µg/L	<1	<1	<1	<1	<1
Indeno(1,2,3-c,d)pyrene	µg/L	<1	<1	<1	<1	<1
Dibenzo(a,h)anthracene	µg/L	<1	<1	<1	<1	<1
Benzo(g,h,i)perylene	µg/L	<1	<1	<1	<1	<1
Benzo(a)pyrene TEQ	µg/L	<5	<5	<5	<5	<5
Total +ve PAH's	µg/L	NIL (+)VE	NIL (+)VE	NIL (+)VE	NIL (+)VE	NIL (+)VE
Surrogate p-Terphenyl-d14	%	85	82	81	71	86

PAHs in Water					
Our Reference		279832-11	279832-12	279832-13	279832-14
Your Reference	UNITS	7822/MW301B	7822/MB02	7822/MB03	7822/MW201
Date Sampled		05/10/2021	05/10/2021	05/10/2021	05/10/2021
Type of sample		Water	Water	Water	Water
Date extracted	-	11/10/2021	11/10/2021	11/10/2021	11/10/2021
Date analysed	-	12/10/2021	12/10/2021	12/10/2021	12/10/2021
Naphthalene	µg/L	<1	<1	<1	<1
Acenaphthylene	µg/L	<1	<1	<1	<1
Acenaphthene	µg/L	<1	<1	<1	<1
Fluorene	µg/L	<1	<1	<1	<1
Phenanthrene	µg/L	<1	<1	<1	<1
Anthracene	µg/L	<1	<1	<1	<1
Fluoranthene	µg/L	<1	<1	<1	<1
Pyrene	µg/L	<1	<1	<1	<1
Benzo(a)anthracene	µg/L	<1	<1	<1	<1
Chrysene	µg/L	<1	<1	<1	<1
Benzo(b,j+k)fluoranthene	µg/L	<2	<2	<2	<2
Benzo(a)pyrene	µg/L	<1	<1	<1	<1
Indeno(1,2,3-c,d)pyrene	µg/L	<1	<1	<1	<1
Dibenzo(a,h)anthracene	µg/L	<1	<1	<1	<1
Benzo(g,h,i)perylene	µg/L	<1	<1	<1	<1
Benzo(a)pyrene TEQ	µg/L	<5	<5	<5	<5
Total +ve PAH's	µg/L	NIL (+)VE	NIL (+)VE	NIL (+)VE	NIL (+)VE
Surrogate p-Terphenyl-d14	%	84	80	87	79

HM in water - dissolved						
Our Reference		279832-1	279832-2	279832-3	279832-4	279832-5
Your Reference	UNITS	7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		05/10/2021	05/10/2021	05/10/2021	05/10/2021	05/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	08/10/2021	08/10/2021	08/10/2021	08/10/2021	08/10/2021
Date analysed	-	08/10/2021	08/10/2021	08/10/2021	08/10/2021	08/10/2021
Arsenic-Dissolved	µg/L	<1	<1	<1	<1	<1
Cadmium-Dissolved	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium-Dissolved	µg/L	<1	<1	<1	<1	<1
Copper-Dissolved	µg/L	<1	<1	<1	<1	<1
Lead-Dissolved	µg/L	<1	<1	<1	<1	<1
Mercury-Dissolved	µg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Nickel-Dissolved	µg/L	<1	<1	<1	<1	<1
Zinc-Dissolved	µg/L	2	5	2	3	1

HM in water - dissolved						
Our Reference		279832-6	279832-7	279832-8	279832-9	279832-10
Your Reference	UNITS	7822/SW02	7822/MW401	7822/MW302A	7822/MW302B	7822/MW301A
Date Sampled		05/10/2021	05/10/2021	05/10/2021	05/10/2021	05/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	08/10/2021	08/10/2021	08/10/2021	08/10/2021	08/10/2021
Date analysed	-	08/10/2021	08/10/2021	08/10/2021	08/10/2021	08/10/2021
Arsenic-Dissolved	µg/L	<1	<1	<1	<1	<1
Cadmium-Dissolved	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium-Dissolved	µg/L	<1	<1	<1	<1	<1
Copper-Dissolved	µg/L	<1	4	1	15	1
Lead-Dissolved	µg/L	<1	<1	<1	<1	<1
Mercury-Dissolved	µg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Nickel-Dissolved	µg/L	<1	<1	<1	<1	<1
Zinc-Dissolved	µg/L	1	1	<1	1	2

Client Reference: P2007822 Bell Quarry

HM in water - dissolved					
Our Reference		279832-11	279832-12	279832-13	279832-14
Your Reference	UNITS	7822/MW301B	7822/MB02	7822/MB03	7822/MW201
Date Sampled		05/10/2021	05/10/2021	05/10/2021	05/10/2021
Type of sample		Water	Water	Water	Water
Date prepared	-	08/10/2021	08/10/2021	08/10/2021	08/10/2021
Date analysed	-	08/10/2021	08/10/2021	08/10/2021	08/10/2021
Arsenic-Dissolved	µg/L	<1	<1	<1	<1
Cadmium-Dissolved	µg/L	<0.1	<0.1	<0.1	<0.1
Chromium-Dissolved	µg/L	<1	<1	<1	<1
Copper-Dissolved	µg/L	<1	1	5	40
Lead-Dissolved	µg/L	<1	<1	<1	<1
Mercury-Dissolved	µg/L	<0.05	<0.05	<0.05	<0.05
Nickel-Dissolved	µg/L	<1	<1	5	5
Zinc-Dissolved	µg/L	2	7	46	65

Client Reference: P2007822 Bell Quarry

HM in water - total						
Our Reference	UNITS	279832-1	279832-2	279832-3	279832-4	279832-5
Your Reference		7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		05/10/2021	05/10/2021	05/10/2021	05/10/2021	05/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	08/10/2021	08/10/2021	08/10/2021	08/10/2021	08/10/2021
Date analysed	-	08/10/2021	08/10/2021	08/10/2021	08/10/2021	08/10/2021
Arsenic-Total	µg/L	<1	<1	<1	<1	<1
Cadmium-Total	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium-Total	µg/L	<1	<1	<1	<1	<1
Copper-Total	µg/L	<1	<1	<1	<1	<1
Lead-Total	µg/L	<1	<1	<1	<1	<1
Mercury-Total	µg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Nickel-Total	µg/L	<1	<1	<1	<1	<1
Zinc-Total	µg/L	3	3	4	2	2

HM in water - total						
Our Reference	UNITS	279832-6	279832-7	279832-8	279832-9	279832-10
Your Reference		7822/SW02	7822/MW401	7822/MW302A	7822/MW302B	7822/MW301A
Date Sampled		05/10/2021	05/10/2021	05/10/2021	05/10/2021	05/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	08/10/2021	08/10/2021	08/10/2021	08/10/2021	08/10/2021
Date analysed	-	08/10/2021	08/10/2021	08/10/2021	08/10/2021	08/10/2021
Arsenic-Total	µg/L	<1	<1	24	5	<1
Cadmium-Total	µg/L	<0.1	<0.1	0.7	<0.1	<0.1
Chromium-Total	µg/L	<1	<1	23	48	1
Copper-Total	µg/L	<1	6	83	650	3
Lead-Total	µg/L	<1	<1	210	50	<1
Mercury-Total	µg/L	<0.05	<0.05	0.08	0.07	<0.05
Nickel-Total	µg/L	<1	<1	11	10	<1
Zinc-Total	µg/L	2	4	200	35	4

Client Reference: P2007822 Bell Quarry

HM in water - total					
Our Reference		279832-11	279832-12	279832-13	279832-14
Your Reference	UNITS	7822/MW301B	7822/MB02	7822/MB03	7822/MW201
Date Sampled		05/10/2021	05/10/2021	05/10/2021	05/10/2021
Type of sample		Water	Water	Water	Water
Date prepared	-	08/10/2021	08/10/2021	08/10/2021	08/10/2021
Date analysed	-	08/10/2021	08/10/2021	08/10/2021	08/10/2021
Arsenic-Total	µg/L	<1	<1	<1	<1
Cadmium-Total	µg/L	<0.1	<0.1	<0.1	<0.1
Chromium-Total	µg/L	5	1	<1	<1
Copper-Total	µg/L	9	4	6	43
Lead-Total	µg/L	3	<1	1	<1
Mercury-Total	µg/L	<0.05	0.1	<0.05	<0.05
Nickel-Total	µg/L	<1	2	4	7
Zinc-Total	µg/L	1	23	52	59

Ion Balance						
Our Reference		279832-1	279832-2	279832-3	279832-4	279832-5
Your Reference	UNITS	7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		05/10/2021	05/10/2021	05/10/2021	05/10/2021	05/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	07/10/2021	07/10/2021	07/10/2021	07/10/2021	07/10/2021
Date analysed	-	07/10/2021	07/10/2021	07/10/2021	07/10/2021	07/10/2021
Calcium - Dissolved	mg/L	0.9	0.8	0.9	<0.5	<0.5
Potassium - Dissolved	mg/L	0.9	1	0.9	<0.5	<0.5
Sodium - Dissolved	mg/L	4	4	4	4	5.0
Magnesium - Dissolved	mg/L	0.6	0.5	0.5	<0.5	0.7
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	<5	<5	<5	<5	<5
Bicarbonate Alkalinity as $CaCO_3$	mg/L	5	5	6	<5	<5
Carbonate Alkalinity as $CaCO_3$	mg/L	<5	<5	<5	<5	<5
Total Alkalinity as $CaCO_3$	mg/L	5	5	6	<5	<5
Sulphate, SO4	mg/L	2	1	1	1	3
Chloride, Cl	mg/L	5	5	5	5	7
Ionic Balance	%	-1.0	1.0	1.0	-1.0	4.0

Ion Balance						
Our Reference		279832-6	279832-7	279832-8	279832-9	279832-10
Your Reference	UNITS	7822/SW02	7822/MW401	7822/MW302A	7822/MW302B	7822/MW301A
Date Sampled		05/10/2021	05/10/2021	05/10/2021	05/10/2021	05/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	07/10/2021	07/10/2021	07/10/2021	07/10/2021	07/10/2021
Date analysed	-	07/10/2021	07/10/2021	07/10/2021	07/10/2021	07/10/2021
Calcium - Dissolved	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Potassium - Dissolved	mg/L	<0.5	0.8	0.8	<0.5	0.8
Sodium - Dissolved	mg/L	5	6.1	5	6.2	3
Magnesium - Dissolved	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	<5	<5	<5	<5	<5
Bicarbonate Alkalinity as $CaCO_3$	mg/L	<5	<5	<5	8	<5
Carbonate Alkalinity as $CaCO_3$	mg/L	<5	<5	<5	<5	<5
Total Alkalinity as $CaCO_3$	mg/L	<5	<5	<5	8	<5
Sulphate, SO4	mg/L	<1	5	2	2	3
Chloride, Cl	mg/L	7	6	6	5	4
Ionic Balance	%	3.0	3.0	7.0	-14	-2.0

Ion Balance					
Our Reference		279832-11	279832-12	279832-13	279832-14
Your Reference	UNITS	7822/MW301B	7822/MB02	7822/MB03	7822/MW201
Date Sampled		05/10/2021	05/10/2021	05/10/2021	05/10/2021
Type of sample		Water	Water	Water	Water
Date prepared	-	07/10/2021	07/10/2021	07/10/2021	07/10/2021
Date analysed	-	07/10/2021	07/10/2021	07/10/2021	07/10/2021
Calcium - Dissolved	mg/L	<0.5	0.7	1	0.6
Potassium - Dissolved	mg/L	0.9	1	2	<0.5
Sodium - Dissolved	mg/L	3	5.0	4	6.1
Magnesium - Dissolved	mg/L	<0.5	<0.5	0.8	<0.5
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	<5	<5	<5	<5
Bicarbonate Alkalinity as $CaCO_3$	mg/L	<5	<5	8	9
Carbonate Alkalinity as $CaCO_3$	mg/L	<5	<5	<5	<5
Total Alkalinity as $CaCO_3$	mg/L	<5	<5	8	9
Sulphate, SO4	mg/L	2	2	2	2
Chloride, Cl	mg/L	4	6	5	5
Ionic Balance	%	3.0	14	-3.0	-11

Miscellaneous Inorganics						
Our Reference		279832-1	279832-2	279832-3	279832-4	279832-5
Your Reference	UNITS	7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		05/10/2021	05/10/2021	05/10/2021	05/10/2021	05/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	07/10/2021	07/10/2021	07/10/2021	07/10/2021	07/10/2021
Date analysed	-	07/10/2021	07/10/2021	07/10/2021	07/10/2021	07/10/2021
Total Nitrogen in water	mg/L	0.3	0.3	0.4	<0.1	<0.1
NOx as N in water	mg/L	<0.005	<0.005	<0.005	<0.005	0.03
Ammonia as N in water	mg/L	0.007	0.007	0.008	0.007	<0.005
Phosphate as P in water	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005

Miscellaneous Inorganics						
Our Reference		279832-6	279832-7	279832-8	279832-9	279832-10
Your Reference	UNITS	7822/SW02	7822/MW401	7822/MW302A	7822/MW302B	7822/MW301A
Date Sampled		05/10/2021	05/10/2021	05/10/2021	05/10/2021	05/10/202[illegible]
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	07/10/2021	07/10/2021	07/10/2021	07/10/2021	07/10/2021
Date analysed	-	07/10/2021	07/10/2021	07/10/2021	07/10/2021	07/10/2021
Total Nitrogen in water	mg/L	<0.1	<0.1	<0.1	0.2	<0.1
NOx as N in water	mg/L	<0.005	0.02	<0.005	0.01	0.02
Ammonia as N in water	mg/L	<0.005	<0.005	0.011	0.022	0.005
Phosphate as P in water	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005

Miscellaneous Inorganics					
Our Reference		279832-11	279832-12	279832-13	279832-14
Your Reference	UNITS	7822/MW301B	7822/MB02	7822/MB03	7822/MW201
Date Sampled		05/10/2021	05/10/2021	05/10/2021	05/10/2021
Type of sample		Water	Water	Water	Water
Date prepared	-	07/10/2021	07/10/2021	07/10/2021	07/10/2021
Date analysed	-	07/10/2021	07/10/2021	07/10/2021	07/10/2021
Total Nitrogen in water	mg/L	<0.1	<0.1	1.2	1
NOx as N in water	mg/L	<0.005	0.009	1.2	0.53
Ammonia as N in water	mg/L	0.008	0.025	0.029	0.013
Phosphate as P in water	mg/L	<0.005	<0.005	<0.005	<0.005

Client Reference: P2007822 Bell Quarry

Metals in Waters - Acid extractable						
Our Reference		279832-1	279832-2	279832-3	279832-4	279832-5
Your Reference	UNITS	7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		05/10/2021	05/10/2021	05/10/2021	05/10/2021	05/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	08/10/2021	08/10/2021	08/10/2021	08/10/2021	08/10/2021
Date analysed	-	08/10/2021	08/10/2021	08/10/2021	08/10/2021	08/10/2021
Phosphorus - Total	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05

Metals in Waters - Acid extractable						
Our Reference		279832-6	279832-7	279832-8	279832-9	279832-10
Your Reference	UNITS	7822/SW02	7822/MW401	7822/MW302A	7822/MW302B	7822/MW301A
Date Sampled		05/10/2021	05/10/2021	05/10/2021	05/10/2021	05/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	08/10/2021	08/10/2021	08/10/2021	08/10/2021	08/10/2021
Date analysed	-	08/10/2021	08/10/2021	08/10/2021	08/10/2021	08/10/2021
Phosphorus - Total	mg/L	<0.05	<0.05	1.1	0.2	<0.05

Metals in Waters - Acid extractable					
Our Reference		279832-11	279832-12	279832-13	279832-14
Your Reference	UNITS	7822/MW301B	7822/MB02	7822/MB03	7822/MW201
Date Sampled		05/10/2021	05/10/2021	05/10/2021	05/10/2021
Type of sample		Water	Water	Water	Water
Date prepared	-	08/10/2021	08/10/2021	08/10/2021	08/10/2021
Date analysed	-	08/10/2021	08/10/2021	08/10/2021	08/10/2021
Phosphorus - Total	mg/L	<0.05	<0.05	<0.05	<0.05

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Method ID	Methodology Summary
Inorg-006	Alkalinity - determined titrimetrically in accordance with APHA latest edition, 2320-B.
Inorg-040	The concentrations of the major ions (mg/L) are converted to milliequivalents and summed. The ionic balance should be within +/- 10% ie total anions = total cations +/-10%.
Inorg-055	Nitrate - determined colourimetrically. Waters samples are filtered on receipt prior to analysis. Soils are analysed following a water extraction.
Inorg-055/062/127	Total Nitrogen - Calculation sum of TKN and oxidised Nitrogen. Alternatively analysed by combustion and chemiluminescence.
Inorg-057	Ammonia - determined colourimetrically, based on APHA latest edition 4500-NH3 F. Waters samples are filtered on receipt prior to analysis. Soils are analysed following a KCl extraction.
Inorg-060	Phosphate determined colourimetrically based on EPA365.1 and APHA latest edition 4500 P E. Waters samples are filtered on receipt prior to analysis. Soils are analysed following a water extraction.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Waters samples are filtered on receipt prior to analysis. Alternatively determined by colourimetry/turbidity using Discrete Analyser.
Metals-020	Determination of various metals by ICP-AES.
Metals-021	Determination of Mercury by Cold Vapour AAS.
Metals-022	Determination of various metals by ICP-MS.
Org-020	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-FID. F2 = (>C10-C16)-Naphthalene as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater (HSLs Tables 1A (3, 4)). Note Naphthalene is determined from the VOC analysis.
Org-022/025	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS/GC-MSMS. Benzo(a)pyrene TEQ as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater - 2013.
Org-023	Water samples are analysed directly by purge and trap GC-MS.
Org-023	Soil samples are extracted with methanol and spiked into water prior to analysing by purge and trap GC-MS. Water samples are analysed directly by purge and trap GC-MS. F1 = (C6-C10)-BTEX as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater.

QUALITY CONTROL: vTRH(C6-C10)/BTEXN in Water						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W4	[NT]
Date extracted	-			08/10/2021	3	08/10/2021	11/10/2021		08/10/2021	[NT]
Date analysed	-			11/10/2021	3	11/10/2021	12/10/2021		11/10/2021	[NT]
TRH C_6 - C_9	µg/L	10	Org-023	<10	3	<10	<10	0	110	[NT]
TRH C_6 - C_{10}	µg/L	10	Org-023	<10	3	<10	<10	0	110	[NT]
Benzene	µg/L	1	Org-023	<1	3	<1	<1	0	118	[NT]
Toluene	µg/L	1	Org-023	<1	3	<1	<1	0	114	[NT]
Ethylbenzene	µg/L	1	Org-023	<1	3	<1	<1	0	105	[NT]
m+p-xylene	µg/L	2	Org-023	<2	3	<2	<2	0	106	[NT]
o-xylene	µg/L	1	Org-023	<1	3	<1	<1	0	106	[NT]
Naphthalene	µg/L	1	Org-023	<1	3	<1	<1	0	[NT]	[NT]
Surrogate Dibromofluoromethane	%		Org-023	110	3	112	109	3	99	[NT]
Surrogate toluene-d8	%		Org-023	108	3	111	96	14	102	[NT]
Surrogate 4-BFB	%		Org-023	94	3	94	88	7	108	[NT]

QUALITY CONTROL: vTRH(C6-C10)/BTEXN in Water						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date extracted	-			[NT]	11	08/10/2021	11/10/2021		[NT]	[NT]
Date analysed	-			[NT]	11	11/10/2021	12/10/2021		[NT]	[NT]
TRH C_6 - C_9	µg/L	10	Org-023	[NT]	11	<10	<10	0	[NT]	[NT]
TRH C_6 - C_{10}	µg/L	10	Org-023	[NT]	11	<10	<10	0	[NT]	[NT]
Benzene	µg/L	1	Org-023	[NT]	11	<1	<1	0	[NT]	[NT]
Toluene	µg/L	1	Org-023	[NT]	11	<1	<1	0	[NT]	[NT]
Ethylbenzene	µg/L	1	Org-023	[NT]	11	<1	<1	0	[NT]	[NT]
m+p-xylene	µg/L	2	Org-023	[NT]	11	<2	<2	0	[NT]	[NT]
o-xylene	µg/L	1	Org-023	[NT]	11	<1	<1	0	[NT]	[NT]
Naphthalene	µg/L	1	Org-023	[NT]	11	<1	<1	0	[NT]	[NT]
Surrogate Dibromofluoromethane	%		Org-023	[NT]	11	114	108	5	[NT]	[NT]
Surrogate toluene-d8	%		Org-023	[NT]	11	114	96	17	[NT]	[NT]
Surrogate 4-BFB	%		Org-023	[NT]	11	93	87	7	[NT]	[NT]

QUALITY CONTROL: svTRH (C10-C40) in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	279832-3
Date extracted	-			11/10/2021	2	11/10/2021	11/10/2021		11/10/2021	11/10/2021
Date analysed	-			13/10/2021	2	13/10/2021	13/10/2021		13/10/2021	13/10/2021
TRH C_{10} - C_{14}	µg/L	50	Org-020	<50	2	<50	<50	0	101	87
TRH C_{15} - C_{28}	µg/L	100	Org-020	<100	2	<100	<100	0	106	85
TRH C_{29} - C_{36}	µg/L	100	Org-020	<100	2	<100	<100	0	115	70
TRH $>C_{10}$ - C_{16}	µg/L	50	Org-020	<50	2	<50	<50	0	101	87
TRH $>C_{16}$ - C_{34}	µg/L	100	Org-020	<100	2	<100	<100	0	106	85
TRH $>C_{34}$ - C_{40}	µg/L	100	Org-020	<100	2	<100	<100	0	115	70
Surrogate o-Terphenyl	%		Org-020	89	2	82	87	6	80	90

QUALITY CONTROL: svTRH (C10-C40) in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W2	[NT]
Date extracted	-				12	11/10/2021	11/10/2021		11/10/2021	
Date analysed	-				12	13/10/2021	13/10/2021		13/10/2021	
TRH C_{10} - C_{14}	µg/L	50	Org-020		12	<50	<50	0	99	
TRH C_{15} - C_{28}	µg/L	100	Org-020		12	<100	<100	0	94	
TRH C_{29} - C_{36}	µg/L	100	Org-020		12	<100	<100	0	86	
TRH $>C_{10}$ - C_{16}	µg/L	50	Org-020		12	<50	<50	0	99	
TRH $>C_{16}$ - C_{34}	µg/L	100	Org-020		12	<100	<100	0	94	
TRH $>C_{34}$ - C_{40}	µg/L	100	Org-020		12	<100	<100	0	86	
Surrogate o-Terphenyl	%		Org-020		12	87	91	4	84	

QUALITY CONTROL: PAHs in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	279832-13
Date extracted	-			11/10/2021	2	11/10/2021	11/10/2021		11/10/2021	11/10/2021
Date analysed	-			12/10/2021	2	12/10/2021	12/10/2021		12/10/2021	12/10/2021
Naphthalene	µg/L	1	Org-022/025	<1	2	<1	<1	0	81	91
Acenaphthylene	µg/L	1	Org-022/025	<1	2	<1	<1	0		
Acenaphthene	µg/L	1	Org-022/025	<1	2	<1	<1	0	72	78
Fluorene	µg/L	1	Org-022/025	<1	2	<1	<1	0	86	93
Phenanthrene	µg/L	1	Org-022/025	<1	2	<1	<1	0	116	130
Anthracene	µg/L	1	Org-022/025	<1	2	<1	<1	0		
Fluoranthene	µg/L	1	Org-022/025	<1	2	<1	<1	0	72	83
Pyrene	µg/L	1	Org-022/025	<1	2	<1	<1	0	77	86
Benzo(a)anthracene	µg/L	1	Org-022/025	<1	2	<1	<1	0		
Chrysene	µg/L	1	Org-022/025	<1	2	<1	<1	0	72	74
Benzo(b,j+k)fluoranthene	µg/L	2	Org-022/025	<2	2	<2	<2	0		
Benzo(a)pyrene	µg/L	1	Org-022/025	<1	2	<1	<1	0	108	103
Indeno(1,2,3-c,d)pyrene	µg/L	1	Org-022/025	<1	2	<1	<1	0		
Dibenzo(a,h)anthracene	µg/L	1	Org-022/025	<1	2	<1	<1	0		
Benzo(g,h,i)perylene	µg/L	1	Org-022/025	<1	2	<1	<1	0		
Surrogate p-Terphenyl-d14	%		Org-022/025	83	2	86	77	11	86	81

QUALITY CONTROL: PAHs in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date extracted	-				12	11/10/2021	11/10/2021			
Date analysed	-				12	12/10/2021	12/10/2021			
Naphthalene	µg/L	1	Org-022/025		12	<1	<1	0		
Acenaphthylene	µg/L	1	Org-022/025		12	<1	<1	0		
Acenaphthene	µg/L	1	Org-022/025		12	<1	<1	0		
Fluorene	µg/L	1	Org-022/025		12	<1	<1	0		
Phenanthrene	µg/L	1	Org-022/025		12	<1	<1	0		
Anthracene	µg/L	1	Org-022/025		12	<1	<1	0		
Fluoranthene	µg/L	1	Org-022/025		12	<1	<1	0		
Pyrene	µg/L	1	Org-022/025		12	<1	<1	0		
Benzo(a)anthracene	µg/L	1	Org-022/025		12	<1	<1	0		
Chrysene	µg/L	1	Org-022/025		12	<1	<1	0		
Benzo(b,j+k)fluoranthene	µg/L	2	Org-022/025		12	<2	<2	0		
Benzo(a)pyrene	µg/L	1	Org-022/025		12	<1	<1	0		
Indeno(1,2,3-c,d)pyrene	µg/L	1	Org-022/025		12	<1	<1	0		
Dibenzo(a,h)anthracene	µg/L	1	Org-022/025		12	<1	<1	0		
Benzo(g,h,i)perylene	µg/L	1	Org-022/025		12	<1	<1	0		
Surrogate p-Terphenyl-d14	%		Org-022/025		12	80	83	4		

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QUALITY CONTROL: HM in water - dissolved					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W2	279832-2
Date prepared	-			08/10/2021	1	08/10/2021	08/10/2021		08/10/2021	08/10/2021
Date analysed	-			08/10/2021	1	08/10/2021	08/10/2021		08/10/2021	08/10/2021
Arsenic-Dissolved	µg/L	1	Metals-022	<1	1	<1			91	
Cadmium-Dissolved	µg/L	0.1	Metals-022	<0.1	1	<0.1			90	
Chromium-Dissolved	µg/L	1	Metals-022	<1	1	<1			88	
Copper-Dissolved	µg/L	1	Metals-022	<1	1	<1			89	
Lead-Dissolved	µg/L	1	Metals-022	<1	1	<1			92	
Mercury-Dissolved	µg/L	0.05	Metals-021	<0.05	1	<0.05	<0.05	0	100	107
Nickel-Dissolved	µg/L	1	Metals-022	<1	1	<1			90	
Zinc-Dissolved	µg/L	1	Metals-022	<1	1	2			90	

QUALITY CONTROL: HM in water - dissolved					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	279832-5
Date prepared	-				3	08/10/2021	08/10/2021			08/10/2021
Date analysed	-				3	08/10/2021	08/10/2021			08/10/
Arsenic-Dissolved	µg/L	1	Metals-022		3	<1	<1	0		90
Cadmium-Dissolved	µg/L	0.1	Metals-022		3	<0.1	<0.1	0		91
Chromium-Dissolved	µg/L	1	Metals-022		3	<1	<1	0		85
Copper-Dissolved	µg/L	1	Metals-022		3	<1	<1	0		88
Lead-Dissolved	µg/L	1	Metals-022		3	<1	<1	0		88
Mercury-Dissolved	µg/L	0.05	Metals-021		3	<0.05				
Nickel-Dissolved	µg/L	1	Metals-022		3	<1	<1	0		90
Zinc-Dissolved	µg/L	1	Metals-022		3	2	2	0		93

QUALITY CONTROL: HM in water - dissolved					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-				11	08/10/2021	08/10/2021			
Date analysed	-				11	08/10/2021	08/10/2021			
Arsenic-Dissolved	µg/L	1	Metals-022		11	<1				
Cadmium-Dissolved	µg/L	0.1	Metals-022		11	<0.1				
Chromium-Dissolved	µg/L	1	Metals-022		11	<1				
Copper-Dissolved	µg/L	1	Metals-022		11	<1				
Lead-Dissolved	µg/L	1	Metals-022		11	<1				
Mercury-Dissolved	µg/L	0.05	Metals-021		11	<0.05	<0.05	0		
Nickel-Dissolved	µg/L	1	Metals-022		11	<1				
Zinc-Dissolved	µg/L	1	Metals-022		11	2				

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QUALITY CONTROL: HM in water - total					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	279832-2
Date prepared	-			08/10/2021	1	08/10/2021	08/10/2021		08/10/2021	08/10/2021
Date analysed	-			08/10/2021	1	08/10/2021	08/10/2021		08/10/2021	08/10/2021
Arsenic-Total	µg/L	1	Metals-022	<1	1	<1	<1	0	97	102
Cadmium-Total	µg/L	0.1	Metals-022	<0.1	1	<0.1	<0.1	0	97	101
Chromium-Total	µg/L	1	Metals-022	<1	1	<1	<1	0	97	97
Copper-Total	µg/L	1	Metals-022	<1	1	<1	<1	0	97	98
Lead-Total	µg/L	1	Metals-022	<1	1	<1	<1	0	98	99
Mercury-Total	µg/L	0.05	Metals-021	<0.05	1	<0.05	<0.05	0	106	116
Nickel-Total	µg/L	1	Metals-022	<1	1	<1	<1	0	95	101
Zinc-Total	µg/L	1	Metals-022	<1	1	3	3	0	98	104

QUALITY CONTROL: HM in water - total					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-			[NT]	11	08/10/2021	08/10/2021		[NT]	[NT]
Date analysed	-			[NT]	11	08/10/2021	08/10/2021		[NT]	[NT]
Arsenic-Total	µg/L	1	Metals-022	[NT]	11	<1	[NT]		[NT]	[NT]
Cadmium-Total	µg/L	0.1	Metals-022	[NT]	11	<0.1	[NT]		[NT]	[NT]
Chromium-Total	µg/L	1	Metals-022	[NT]	11	5	[NT]		[NT]	[NT]
Copper-Total	µg/L	1	Metals-022	[NT]	11	9	[NT]		[NT]	[NT]
Lead-Total	µg/L	1	Metals-022	[NT]	11	3	[NT]		[NT]	[NT]
Mercury-Total	µg/L	0.05	Metals-021	[NT]	11	<0.05	<0.05	0	[NT]	[NT]
Nickel-Total	µg/L	1	Metals-022	[NT]	11	<1	[NT]		[NT]	[NT]
Zinc-Total	µg/L	1	Metals-022	[NT]	11	1	[NT]		[NT]	[NT]

QUALITY CONTROL: Ion Balance					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	279832-4
Date prepared	-			07/10/2021	3	07/10/2021	07/10/2021		07/10/2021	07/10/2021
Date analysed	-			07/10/2021	3	07/10/2021	07/10/2021		07/10/2021	07/10/2021
Calcium - Dissolved	mg/L	0.5	Metals-020	<0.5	3	0.9	0.9	0	106	88
Potassium - Dissolved	mg/L	0.5	Metals-020	<0.5	3	0.9	0.9	0	103	89
Sodium - Dissolved	mg/L	0.5	Metals-020	<0.5	3	4	4	0	113	92
Magnesium - Dissolved	mg/L	0.5	Metals-020	<0.5	3	0.5	0.5	0	111	91
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	5	Inorg-006	<5	3	<5				
Bicarbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	3	6				
Carbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	3	<5				
Total Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	3	6			107	
Sulphate, SO4	mg/L	1	Inorg-081	<1	3	1			102	99
Chloride, Cl	mg/L	1	Inorg-081	<1	3	5			102	100
Ionic Balance	%		Inorg-040		3	1.0				

QUALITY CONTROL: Ion Balance					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-				12	07/10/2021	07/10/2021			
Date analysed	-				12	07/10/2021	07/10/2021			
Calcium - Dissolved	mg/L	0.5	Metals-020		12	0.7	0.6	15		
Potassium - Dissolved	mg/L	0.5	Metals-020		12	1	1	0		
Sodium - Dissolved	mg/L	0.5	Metals-020		12	5.0	5.0	0		
Magnesium - Dissolved	mg/L	0.5	Metals-020		12	<0.5	<0.5	0		
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	5	Inorg-006		12	<5				
Bicarbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006		12	<5				
Carbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006		12	<5				
Total Alkalinity as $CaCO_3$	mg/L	5	Inorg-006		12	<5				
Sulphate, SO4	mg/L	1	Inorg-081		12	2				
Chloride, Cl	mg/L	1	Inorg-081		12	6				
Ionic Balance	%		Inorg-040		12	14				

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QUALITY CONTROL: Miscellaneous Inorganics					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	279832-2
Date prepared	-			07/10/2021	1	07/10/2021	07/10/2021		07/10/2021	07/10/2021
Date analysed	-			07/10/2021	1	07/10/2021	07/10/2021		07/10/2021	07/10/2021
Total Nitrogen in water	mg/L	0.1	Inorg-055/062/127	<0.1	1	0.3	0.3	0	103	101
NOx as N in water	mg/L	0.005	Inorg-055	<0.005	1	<0.005	<0.005	0	105	110
Ammonia as N in water	mg/L	0.005	Inorg-057	<0.005	1	0.007	0.005	33	111	103
Phosphate as P in water	mg/L	0.005	Inorg-060	<0.005	1	<0.005	<0.005	0	110	111

QUALITY CONTROL: Miscellaneous Inorganics					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-				11	07/10/2021	07/10/2021			
Date analysed	-				11	07/10/2021	07/10/2021			
Total Nitrogen in water	mg/L	0.1	Inorg-055/062/127		11	<0.1	<0.1	0		
NOx as N in water	mg/L	0.005	Inorg-055		11	<0.005	<0.005	0		
Ammonia as N in water	mg/L	0.005	Inorg-057		11	0.008	0.008	0		
Phosphate as P in water	mg/L	0.005	Inorg-060		11	<0.005	<0.005	0		

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QUALITY CONTROL: Metals in Waters - Acid extractable					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	279832-3
Date prepared	-			08/10/2021	1	08/10/2021	08/10/2021		08/10/2021	08/10/2021
Date analysed	-			08/10/2021	1	08/10/2021	08/10/2021		08/10/2021	08/10/2021
Phosphorus - Total	mg/L	0.05	Metals-020	<0.05	1	<0.05	<0.05	0	116	124

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

Report Comments

Dissolved Metals: no filtered, preserved sample was received, therefore the unpreserved sample was filtered through 0.45µm filter at the lab.
Note: there is a possibility some elements may be underestimated.

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CERTIFICATE OF ANALYSIS 280362

Client Details

Client	Martens & Associates Pty Ltd
Attention	Ben McGiffin
Address	Suite 201, 20 George St, Hornsby, NSW, 2077

Sample Details

Your Reference	**P2007822 Bell Quarry**
Number of Samples	14 Water
Date samples received	14/10/2021
Date completed instructions received	14/10/2021

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Please refer to the last page of this report for any comments relating to the results.

Report Details

Date results requested by	21/10/2021
Date of Issue	21/10/2021

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Accredited for compliance with ISO/IEC 17025 - Testing. **Tests not covered by NATA are denoted with ***

Results Approved By
Dragana Tomas, Senior Chemist
Giovanni Agosti, Group Technical Manager
Greta Petzold, Senior Report Coordinator
Hannah Nguyen, Metals Supervisor
Priya Samarawickrama, Senior Chemist

Authorised By

Nancy Zhang, Laboratory Manager

vTRH(C6-C10)/BTEXN in Water

Our Reference		280362-1	280362-2	280362-3	280362-4	280362-5
Your Reference	UNITS	7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		13/10/2021	13/10/2021	13/10/2021	13/10/2021	13/10/2021
Type of sample		Water	Water	Water	Water	Water
Date extracted	-	15/10/2021	15/10/2021	15/10/2021	15/10/2021	15/10/2021
Date analysed	-	18/10/2021	18/10/2021	18/10/2021	18/10/2021	18/10/2021
TRH C_6 - C_9	µg/L	<10	<10	<10	<10	<10
TRH C_6 - C_{10}	µg/L	<10	<10	<10	<10	<10
TRH C_6 - C_{10} less BTEX (F1)	µg/L	<10	<10	<10	<10	<10
Benzene	µg/L	<1	<1	<1	<1	<1
Toluene	µg/L	<1	<1	<1	<1	<1
Ethylbenzene	µg/L	<1	<1	<1	<1	<1
m+p-xylene	µg/L	<2	<2	<2	<2	<2
o-xylene	µg/L	<1	<1	<1	<1	<1
Naphthalene	µg/L	<1	<1	<1	<1	<1
Surrogate Dibromofluoromethane	%	98	99	97	99	98
Surrogate toluene-d8	%	99	99	98	99	99
Surrogate 4-BFB	%	103	104	103	98	101

vTRH(C6-C10)/BTEXN in Water

Our Reference		280362-6	280362-7	280362-8	280362-9	280362-10
Your Reference	UNITS	7822/SW02	7822/MW401	7822/MW302A	7822/MW302B	7822/MW301A
Date Sampled		13/10/2021	13/10/2021	13/10/2021	13/10/2021	13/10/2021
Type of sample		Water	Water	Water	Water	Water
Date extracted	-	15/10/2021	15/10/2021	15/10/2021	15/10/2021	15/10/2021
Date analysed	-	18/10/2021	18/10/2021	18/10/2021	18/10/2021	18/10/2021
TRH C_6 - C_9	µg/L	<10	<10	<10	<10	<10
TRH C_6 - C_{10}	µg/L	<10	<10	<10	<10	<10
TRH C_6 - C_{10} less BTEX (F1)	µg/L	<10	<10	<10	<10	<10
Benzene	µg/L	<1	<1	<1	<1	<1
Toluene	µg/L	<1	<1	<1	<1	<1
Ethylbenzene	µg/L	<1	<1	<1	<1	<1
m+p-xylene	µg/L	<2	<2	<2	<2	<2
o-xylene	µg/L	<1	<1	<1	<1	<1
Naphthalene	µg/L	<1	<1	<1	<1	<1
Surrogate Dibromofluoromethane	%	100	98	99	99	100
Surrogate toluene-d8	%	98	97	99	99	99
Surrogate 4-BFB	%	103	104	102	103	104

Client Reference: P2007822 Bell Quarry

vTRH(C6-C10)/BTEXN in Water					
Our Reference		280362-11	280362-12	280362-13	280362-14
Your Reference	UNITS	7822/MW301B	7822/MB02	7822/MB03	7822/MW201
Date Sampled		13/10/2021	13/10/2021	13/10/2021	13/10/2021
Type of sample		Water	Water	Water	Water
Date extracted	-	15/10/2021	15/10/2021	15/10/2021	15/10/2021
Date analysed	-	18/10/2021	18/10/2021	18/10/2021	18/10/2021
TRH C_6 - C_9	µg/L	<10	<10	<10	<10
TRH C_6 - C_{10}	µg/L	<10	<10	<10	<10
TRH C_6 - C_{10} less BTEX (F1)	µg/L	<10	<10	<10	<10
Benzene	µg/L	<1	<1	<1	<1
Toluene	µg/L	<1	<1	<1	<1
Ethylbenzene	µg/L	<1	<1	<1	<1
m+p-xylene	µg/L	<2	<2	<2	<2
o-xylene	µg/L	<1	<1	<1	<1
Naphthalene	µg/L	<1	<1	<1	<1
Surrogate Dibromofluoromethane	%	99	99	98	100
Surrogate toluene-d8	%	98	99	98	98
Surrogate 4-BFB	%	103	102	105	104

svTRH (C10-C40) in Water						
Our Reference		280362-1	280362-2	280362-3	280362-4	280362-5
Your Reference	UNITS	7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		13/10/2021	13/10/2021	13/10/2021	13/10/2021	13/10/2021
Type of sample		Water	Water	Water	Water	Water
Date extracted	-	18/10/2021	18/10/2021	18/10/2021	18/10/2021	18/10/2021
Date analysed	-	19/10/2021	19/10/2021	19/10/2021	19/10/2021	19/10/2021
TRH C_{10} - C_{14}	µg/L	<50	<50	<50	<50	<50
TRH C_{15} - C_{28}	µg/L	<100	<100	130	<100	<100
TRH C_{29} - C_{36}	µg/L	<100	<100	<100	<100	<100
TRH >C_{10} - C_{16}	µg/L	<50	<50	79	<50	<50
TRH >C_{10} - C_{16} less Naphthalene (F2)	µg/L	<50	<50	79	<50	<50
TRH >C_{16} - C_{34}	µg/L	<100	<100	<100	<100	<100
TRH >C_{34} - C_{40}	µg/L	<100	<100	<100	<100	<100
Surrogate o-Terphenyl	%	83	81	87	89	94

svTRH (C10-C40) in Water						
Our Reference		280362-6	280362-7	280362-8	280362-9	280362-10
Your Reference	UNITS	7822/SW02	7822/MW401	7822/MW302A	7822/MW302B	7822/MW301A
Date Sampled		13/10/2021	13/10/2021	13/10/2021	13/10/2021	13/10/2021
Type of sample		Water	Water	Water	Water	Water
Date extracted	-	18/10/2021	18/10/2021	18/10/2021	18/10/2021	18/10/2021
Date analysed	-	19/10/2021	19/10/2021	19/10/2021	19/10/2021	19/10/2021
TRH C_{10} - C_{14}	µg/L	70	<50	<50	<50	<50
TRH C_{15} - C_{28}	µg/L	<100	<100	<100	<100	<100
TRH C_{29} - C_{36}	µg/L	<100	<100	<100	<100	<100
TRH >C_{10} - C_{16}	µg/L	70	<50	<50	<50	<50
TRH >C_{10} - C_{16} less Naphthalene (F2)	µg/L	70	<50	<50	<50	<50
TRH >C_{16} - C_{34}	µg/L	<100	<100	<100	<100	<100
TRH >C_{34} - C_{40}	µg/L	<100	<100	<100	<100	<100
Surrogate o-Terphenyl	%	87	79	86	78	85

Client Reference: P2007822 Bell Quarry

svTRH (C10-C40) in Water					
Our Reference		280362-11	280362-12	280362-13	280362-14
Your Reference	UNITS	7822/MW301B	7822/MB02	7822/MB03	7822/MW201
Date Sampled		13/10/2021	13/10/2021	13/10/2021	13/10/2021
Type of sample		Water	Water	Water	Water
Date extracted	-	18/10/2021	18/10/2021	18/10/2021	18/10/2021
Date analysed	-	19/10/2021	19/10/2021	19/10/2021	19/10/2021
TRH C_{10} - C_{14}	µg/L	<50	<50	<50	<50
TRH C_{15} - C_{28}	µg/L	<100	<100	<100	260
TRH C_{29} - C_{36}	µg/L	<100	<100	<100	<100
TRH >C_{10} - C_{16}	µg/L	<50	<50	<50	88
TRH >C_{10} - C_{16} less Naphthalene (F2)	µg/L	<50	<50	<50	88
TRH >C_{16} - C_{34}	µg/L	<100	<100	<100	240
TRH >C_{34} - C_{40}	µg/L	<100	<100	<100	<100
Surrogate o-Terphenyl	%	77	90	82	67

PAHs in Water						
Our Reference		280362-1	280362-2	280362-3	280362-4	280362-5
Your Reference	UNITS	7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		13/10/2021	13/10/2021	13/10/2021	13/10/2021	13/10/2021
Type of sample		Water	Water	Water	Water	Water
Date extracted	-	18/10/2021	18/10/2021	18/10/2021	18/10/2021	18/10/2021
Date analysed	-	19/10/2021	19/10/2021	19/10/2021	19/10/2021	19/10/2021
Naphthalene	µg/L	<1	<1	<1	<1	<1
Acenaphthylene	µg/L	<1	<1	<1	<1	<1
Acenaphthene	µg/L	<1	<1	<1	<1	<1
Fluorene	µg/L	<1	<1	<1	<1	<1
Phenanthrene	µg/L	<1	<1	<1	<1	<1
Anthracene	µg/L	<1	<1	<1	<1	<1
Fluoranthene	µg/L	<1	<1	<1	<1	<1
Pyrene	µg/L	<1	<1	<1	<1	<1
Benzo(a)anthracene	µg/L	<1	<1	<1	<1	<1
Chrysene	µg/L	<1	<1	<1	<1	<1
Benzo(b,j+k)fluoranthene	µg/L	<2	<2	<2	<2	<2
Benzo(a)pyrene	µg/L	<1	<1	<1	<1	<1
Indeno(1,2,3-c,d)pyrene	µg/L	<1	<1	<1	<1	<1
Dibenzo(a,h)anthracene	µg/L	<1	<1	<1	<1	<1
Benzo(g,h,i)perylene	µg/L	<1	<1	<1	<1	<1
Benzo(a)pyrene TEQ	µg/L	<5	<5	<5	<5	<5
Total +ve PAH's	µg/L	NIL (+)VE	NIL (+)VE	NIL (+)VE	NIL (+)VE	NIL (+)VE
Surrogate p-Terphenyl-d14	%	92	94	93	88	103

Client Reference: P2007822 Bell Quarry

PAHs in Water						
Our Reference		280362-6	280362-7	280362-8	280362-9	280362-10
Your Reference	UNITS	7822/SW02	7822/MW401	7822/MW302A	7822/MW302B	7822/MW301A
Date Sampled		13/10/2021	13/10/2021	13/10/2021	13/10/2021	13/10/2021
Type of sample		Water	Water	Water	Water	Water
Date extracted	-	18/10/2021	18/10/2021	18/10/2021	18/10/2021	18/10/2021
Date analysed	-	19/10/2021	19/10/2021	19/10/2021	19/10/2021	19/10/2021
Naphthalene	µg/L	<1	<1	<1	<1	<1
Acenaphthylene	µg/L	<1	<1	<1	<1	<1
Acenaphthene	µg/L	<1	<1	<1	<1	<1
Fluorene	µg/L	<1	<1	<1	<1	<1
Phenanthrene	µg/L	<1	<1	<1	<1	<1
Anthracene	µg/L	<1	<1	<1	<1	<1
Fluoranthene	µg/L	<1	<1	<1	<1	<1
Pyrene	µg/L	<1	<1	<1	<1	<1
Benzo(a)anthracene	µg/L	<1	<1	<1	<1	<1
Chrysene	µg/L	<1	<1	<1	<1	<1
Benzo(b,j+k)fluoranthene	µg/L	<2	<2	<2	<2	<2
Benzo(a)pyrene	µg/L	<1	<1	<1	<1	<1
Indeno(1,2,3-c,d)pyrene	µg/L	<1	<1	<1	<1	<1
Dibenzo(a,h)anthracene	µg/L	<1	<1	<1	<1	<1
Benzo(g,h,i)perylene	µg/L	<1	<1	<1	<1	<1
Benzo(a)pyrene TEQ	µg/L	<5	<5	<5	<5	<5
Total +ve PAH's	µg/L	NIL (+)VE	NIL (+)VE	NIL (+)VE	NIL (+)VE	NIL (+)VE
Surrogate p-Terphenyl-d14	%	100	91	101	92	100

Client Reference: P2007822 Bell Quarry

PAHs in Water					
Our Reference		280362-11	280362-12	280362-13	280362-14
Your Reference	UNITS	7822/MW301B	7822/MB02	7822/MB03	7822/MW201
Date Sampled		13/10/2021	13/10/2021	13/10/2021	13/10/2021
Type of sample		Water	Water	Water	Water
Date extracted	-	18/10/2021	18/10/2021	18/10/2021	18/10/2021
Date analysed	-	19/10/2021	19/10/2021	19/10/2021	19/10/2021
Naphthalene	µg/L	<1	<1	<1	<1
Acenaphthylene	µg/L	<1	<1	<1	<1
Acenaphthene	µg/L	<1	<1	<1	<1
Fluorene	µg/L	<1	<1	<1	<1
Phenanthrene	µg/L	<1	<1	<1	<1
Anthracene	µg/L	<1	<1	<1	<1
Fluoranthene	µg/L	<1	<1	<1	<1
Pyrene	µg/L	<1	<1	<1	<1
Benzo(a)anthracene	µg/L	<1	<1	<1	<1
Chrysene	µg/L	<1	<1	<1	<1
Benzo(b,j+k)fluoranthene	µg/L	<2	<2	<2	<2
Benzo(a)pyrene	µg/L	<1	<1	<1	<1
Indeno(1,2,3-c,d)pyrene	µg/L	<1	<1	<1	<1
Dibenzo(a,h)anthracene	µg/L	<1	<1	<1	<1
Benzo(g,h,i)perylene	µg/L	<1	<1	<1	<1
Benzo(a)pyrene TEQ	µg/L	<5	<5	<5	<5
Total +ve PAH's	µg/L	NIL (+)VE	NIL (+)VE	NIL (+)VE	NIL (+)VE
Surrogate p-Terphenyl-d14	%	91	98	92	87

HM in water - dissolved						
Our Reference		280362-1	280362-2	280362-3	280362-4	280362-5
Your Reference	UNITS	7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		13/10/2021	13/10/2021	13/10/2021	13/10/2021	13/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	15/10/2021	15/10/2021	15/10/2021	15/10/2021	15/10/2021
Date analysed	-	18/10/2021	18/10/2021	18/10/2021	18/10/2021	18/10/2021
Arsenic-Dissolved	µg/L	<1	<1	<1	<1	<1
Cadmium-Dissolved	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium-Dissolved	µg/L	<1	<1	<1	<1	<1
Copper-Dissolved	µg/L	<1	<1	<1	<1	<1
Lead-Dissolved	µg/L	<1	<1	<1	<1	<1
Mercury-Dissolved	µg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Nickel-Dissolved	µg/L	<1	<1	<1	<1	<1
Zinc-Dissolved	µg/L	<1	1	2	<1	<1

HM in water - dissolved						
Our Reference		280362-6	280362-7	280362-8	280362-9	280362-10
Your Reference	UNITS	7822/SW02	7822/MW401	7822/MW302A	7822/MW302B	7822/MW301A
Date Sampled		13/10/2021	13/10/2021	13/10/2021	13/10/2021	13/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	15/10/2021	15/10/2021	15/10/2021	15/10/2021	15/10/2021
Date analysed	-	18/10/2021	18/10/2021	18/10/2021	18/10/2021	18/10/2021
Arsenic-Dissolved	µg/L	<1	<1	<1	<1	<1
Cadmium-Dissolved	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium-Dissolved	µg/L	<1	<1	<1	<1	1
Copper-Dissolved	µg/L	<1	6	<1	27	1
Lead-Dissolved	µg/L	<1	<1	<1	<1	<1
Mercury-Dissolved	µg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Nickel-Dissolved	µg/L	<1	<1	<1	<1	<1
Zinc-Dissolved	µg/L	2	9	1	4	3

HM in water - dissolved					
Our Reference		280362-11	280362-12	280362-13	280362-14
Your Reference	UNITS	7822/MW301B	7822/MB02	7822/MB03	7822/MW201
Date Sampled		13/10/2021	13/10/2021	13/10/2021	13/10/2021
Type of sample		Water	Water	Water	Water
Date prepared	-	15/10/2021	15/10/2021	15/10/2021	15/10/2021
Date analysed	-	18/10/2021	18/10/2021	18/10/2021	18/10/2021
Arsenic-Dissolved	µg/L	<1	<1	<1	<1
Cadmium-Dissolved	µg/L	<0.1	<0.1	<0.1	<0.1
Chromium-Dissolved	µg/L	<1	<1	<1	<1
Copper-Dissolved	µg/L	<1	2	5	27
Lead-Dissolved	µg/L	<1	<1	<1	<1
Mercury-Dissolved	µg/L	0.05	0.09	<0.05	<0.05
Nickel-Dissolved	µg/L	<1	<1	2	3
Zinc-Dissolved	µg/L	3	15	29	62

HM in water - total						
Our Reference	UNITS	280362-1	280362-2	280362-3	280362-4	280362-5
Your Reference		7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		13/10/2021	13/10/2021	13/10/2021	13/10/2021	13/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	15/10/2021	15/10/2021	15/10/2021	15/10/2021	15/10/2021
Date analysed	-	15/10/2021	15/10/2021	15/10/2021	15/10/2021	15/10/2021
Arsenic-Total	µg/L	1	<1	<1	<1	<1
Cadmium-Total	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium-Total	µg/L	<1	<1	<1	<1	<1
Copper-Total	µg/L	<1	<1	<1	<1	<1
Lead-Total	µg/L	<1	<1	<1	<1	<1
Mercury-Total	µg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Nickel-Total	µg/L	<1	<1	<1	<1	<1
Zinc-Total	µg/L	<1	<1	3	<1	<1

HM in water - total						
Our Reference	UNITS	280362-6	280362-7	280362-8	280362-9	280362-10
Your Reference		7822/SW02	7822/MW401	7822/MW302A	7822/MW302B	7822/MW301A
Date Sampled		13/10/2021	13/10/2021	13/10/2021	13/10/2021	13/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	15/10/2021	15/10/2021	15/10/2021	15/10/2021	15/10/2021
Date analysed	-	15/10/2021	15/10/2021	15/10/2021	15/10/2021	15/10/2021
Arsenic-Total	µg/L	<1	<1	14	<1	<1
Cadmium-Total	µg/L	<0.1	<0.1	0.3	<0.1	<0.1
Chromium-Total	µg/L	<1	1	16	5	3
Copper-Total	µg/L	1	9	48	51	3
Lead-Total	µg/L	<1	<1	97	4	<1
Mercury-Total	µg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Nickel-Total	µg/L	<1	1	8	1	<1
Zinc-Total	µg/L	2	7	100	4	2

HM in water - total					
Our Reference		280362-11	280362-12	280362-13	280362-14
Your Reference	UNITS	7822/MW301B	7822/MB02	7822/MB03	7822/MW201
Date Sampled		13/10/2021	13/10/2021	13/10/2021	13/10/2021
Type of sample		Water	Water	Water	Water
Date prepared	-	15/10/2021	15/10/2021	15/10/2021	15/10/2021
Date analysed	-	15/10/2021	15/10/2021	15/10/2021	15/10/2021
Arsenic-Total	µg/L	1	<1	<1	<1
Cadmium-Total	µg/L	<0.1	<0.1	<0.1	<0.1
Chromium-Total	µg/L	19	1	5	7
Copper-Total	µg/L	23	10	6	67
Lead-Total	µg/L	13	<1	<1	1
Mercury-Total	µg/L	<0.05	<0.05	<0.05	<0.05
Nickel-Total	µg/L	2	1	5	14
Zinc-Total	µg/L	5	19	22	87

Ion Balance						
Our Reference	UNITS	280362-1	280362-2	280362-3	280362-4	280362-5
Your Reference		7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		13/10/2021	13/10/2021	13/10/2021	13/10/2021	13/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	14/10/2021	14/10/2021	14/10/2021	14/10/2021	14/10/2021
Date analysed	-	14/10/2021	14/10/2021	14/10/2021	14/10/2021	14/10/2021
Calcium - Dissolved	mg/L	1	1	1	<0.5	<0.5
Potassium - Dissolved	mg/L	1	1	1	0.7	<0.5
Sodium - Dissolved	mg/L	5	4	4	4	5
Magnesium - Dissolved	mg/L	0.9	0.6	0.7	<0.5	0.9
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	<5	<5	<5	<5	<5
Bicarbonate Alkalinity as $CaCO_3$	mg/L	14	8	9	<5	<5
Carbonate Alkalinity as $CaCO_3$	mg/L	<5	<5	<5	<5	<5
Total Alkalinity as $CaCO_3$	mg/L	14	8	9	<5	<5
Sulphate, SO4	mg/L	1	1	1	1	2
Chloride, Cl	mg/L	4	4	4	4	6
Ionic Balance	%	-8.0	1.0	-2.0	12	12

Ion Balance						
Our Reference	UNITS	280362-6	280362-7	280362-8	280362-9	280362-10
Your Reference		7822/SW02	7822/MW401	7822/MW302A	7822/MW302B	7822/MW301A
Date Sampled		13/10/2021	13/10/2021	13/10/2021	13/10/2021	13/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	14/10/2021	14/10/2021	14/10/2021	14/10/2021	14/10/2021
Date analysed	-	14/10/2021	14/10/2021	14/10/2021	14/10/2021	14/10/2021
Calcium - Dissolved	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Potassium - Dissolved	mg/L	<0.5	1	1	<0.5	1
Sodium - Dissolved	mg/L	4	6.1	5	5.0	4
Magnesium - Dissolved	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	<5	<5	<5	<5	<5
Bicarbonate Alkalinity as $CaCO_3$	mg/L	5	<5	7	<5	<5
Carbonate Alkalinity as $CaCO_3$	mg/L	<5	<5	<5	<5	<5
Total Alkalinity as $CaCO_3$	mg/L	5	<5	7	<5	<5
Sulphate, SO4	mg/L	<1	4	2	2	2
Chloride, Cl	mg/L	4	5	4	4	4
Ionic Balance	%	-11	13	-13	18	9.0

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Ion Balance					
Our Reference		280362-11	280362-12	280362-13	280362-14
Your Reference	UNITS	7822/MW301B	7822/MB02	7822/MB03	7822/MW201
Date Sampled		13/10/2021	13/10/2021	13/10/2021	13/10/2021
Type of sample		Water	Water	Water	Water
Date prepared	-	14/10/2021	14/10/2021	14/10/2021	14/10/2021
Date analysed	-	14/10/2021	14/10/2021	14/10/2021	14/10/2021
Calcium - Dissolved	mg/L	<0.5	0.8	0.9	<0.5
Potassium - Dissolved	mg/L	1	2	2	<0.5
Sodium - Dissolved	mg/L	4	5.1	3	5.9
Magnesium - Dissolved	mg/L	<0.5	<0.5	1	<0.5
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	<5	<5	<5	<5
Bicarbonate Alkalinity as $CaCO_3$	mg/L	<5	7	5	5
Carbonate Alkalinity as $CaCO_3$	mg/L	<5	<5	<5	<5
Total Alkalinity as $CaCO_3$	mg/L	<5	7	5	5
Sulphate, SO4	mg/L	2	2	1	2
Chloride, Cl	mg/L	4	5	4	4
Ionic Balance	%	13	-4.0	14	-1.0

Miscellaneous Inorganics						
Our Reference		280362-1	280362-2	280362-3	280362-4	280362-5
Your Reference	UNITS	7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		13/10/2021	13/10/2021	13/10/2021	13/10/2021	13/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	15/10/2021	15/10/2021	15/10/2021	15/10/2021	15/10/2021
Date analysed	-	15/10/2021	15/10/2021	15/10/2021	15/10/2021	15/10/2021
Total Nitrogen in water	mg/L	0.2	0.3	0.4	<0.1	<0.1
NOx as N in water	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005
Ammonia as N in water	mg/L	<0.005	0.005	<0.005	<0.005	<0.005
Phosphate as P in water	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005

Miscellaneous Inorganics						
Our Reference		280362-6	280362-7	280362-8	280362-9	280362-10
Your Reference	UNITS	7822/SW02	7822/MW401	7822/MW302A	7822/MW302B	7822/MW301A
Date Sampled		13/10/2021	13/10/2021	13/10/2021	13/10/2021	13/10/202
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	15/10/2021	15/10/2021	15/10/2021	15/10/2021	15/10/2021
Date analysed	-	15/10/2021	15/10/2021	15/10/2021	15/10/2021	15/10/2021
Total Nitrogen in water	mg/L	<0.1	<0.1	0.1	0.3	<0.1
NOx as N in water	mg/L	<0.005	0.03	<0.005	<0.005	0.02
Ammonia as N in water	mg/L	<0.005	<0.005	0.006	0.006	0.008
Phosphate as P in water	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005

Miscellaneous Inorganics					
Our Reference		280362-11	280362-12	280362-13	280362-14
Your Reference	UNITS	7822/MW301B	7822/MB02	7822/MB03	7822/MW201
Date Sampled		13/10/2021	13/10/2021	13/10/2021	13/10/2021
Type of sample		Water	Water	Water	Water
Date prepared	-	15/10/2021	15/10/2021	15/10/2021	15/10/2021
Date analysed	-	15/10/2021	15/10/2021	15/10/2021	15/10/2021
Total Nitrogen in water	mg/L	0.3	<0.1	1.6	0.6
NOx as N in water	mg/L	<0.005	0.007	1.5	0.54
Ammonia as N in water	mg/L	0.007	0.026	0.026	<0.005
Phosphate as P in water	mg/L	<0.005	<0.005	<0.005	<0.005

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Metals in Waters - Acid extractable						
Our Reference		280362-1	280362-2	280362-3	280362-4	280362-5
Your Reference	UNITS	7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		13/10/2021	13/10/2021	13/10/2021	13/10/2021	13/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	15/10/2021	15/10/2021	15/10/2021	15/10/2021	15/10/2021
Date analysed	-	15/10/2021	15/10/2021	15/10/2021	15/10/2021	15/10/2021
Phosphorus - Total	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05

Metals in Waters - Acid extractable						
Our Reference		280362-6	280362-7	280362-8	280362-9	280362-10
Your Reference	UNITS	7822/SW02	7822/MW401	7822/MW302A	7822/MW302B	7822/MW301A
Date Sampled		13/10/2021	13/10/2021	13/10/2021	13/10/2021	13/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	15/10/2021	15/10/2021	15/10/2021	15/10/2021	15/10/2021
Date analysed	-	15/10/2021	15/10/2021	15/10/2021	15/10/2021	15/10/2021
Phosphorus - Total	mg/L	<0.05	<0.05	0.6	<0.05	<0.05

Metals in Waters - Acid extractable					
Our Reference		280362-11	280362-12	280362-13	280362-14
Your Reference	UNITS	7822/MW301B	7822/MB02	7822/MB03	7822/MW201
Date Sampled		13/10/2021	13/10/2021	13/10/2021	13/10/2021
Type of sample		Water	Water	Water	Water
Date prepared	-	15/10/2021	15/10/2021	15/10/2021	15/10/2021
Date analysed	-	15/10/2021	15/10/2021	15/10/2021	15/10/2021
Phosphorus - Total	mg/L	<0.05	<0.05	<0.05	<0.05

Method ID	Methodology Summary
Inorg-006	Alkalinity - determined titrimetrically in accordance with APHA latest edition, 2320-B.
Inorg-040	The concentrations of the major ions (mg/L) are converted to milliequivalents and summed. The ionic balance should be within +/- 10% ie total anions = total cations +/-10%.
Inorg-055	Nitrate - determined colourimetrically. Waters samples are filtered on receipt prior to analysis. Soils are analysed following a water extraction.
Inorg-055/062/127	Total Nitrogen - Calculation sum of TKN and oxidised Nitrogen. Alternatively analysed by combustion and chemiluminescence.
Inorg-057	Ammonia - determined colourimetrically, based on APHA latest edition 4500-NH3 F. Waters samples are filtered on receipt prior to analysis. Soils are analysed following a KCl extraction.
Inorg-060	Phosphate determined colourimetrically based on EPA365.1 and APHA latest edition 4500 P E. Waters samples are filtered on receipt prior to analysis. Soils are analysed following a water extraction.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Waters samples are filtered on receipt prior to analysis. Alternatively determined by colourimetry/turbidity using Discrete Analyser.
Metals-020	Determination of various metals by ICP-AES.
Metals-021	Determination of Mercury by Cold Vapour AAS.
Metals-022	Determination of various metals by ICP-MS.
Org-020	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-FID. F2 = (>C10-C16)-Naphthalene as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater (HSLs Tables 1A (3, 4)). Note Naphthalene is determined from the VOC analysis.
Org-022/025	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS/GC-MSMS. Benzo(a)pyrene TEQ as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater - 2013.
Org-023	Water samples are analysed directly by purge and trap GC-MS.
Org-023	Soil samples are extracted with methanol and spiked into water prior to analysing by purge and trap GC-MS. Water samples are analysed directly by purge and trap GC-MS. F1 = (C6-C10)-BTEX as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater.

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QUALITY CONTROL: vTRH(C6-C10)/BTEXN in Water						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W2	[NT]
Date extracted	-			15/10/2021	1	15/10/2021	18/10/2021		15/10/2021	
Date analysed	-			18/10/2021	1	18/10/2021	18/10/2021		18/10/2021	
TRH C_6 - C_9	µg/L	10	Org-023	<10	1	<10	<10	0	102	
TRH C_6 - C_{10}	µg/L	10	Org-023	<10	1	<10	<10	0	102	
Benzene	µg/L	1	Org-023	<1	1	<1	<1	0	95	
Toluene	µg/L	1	Org-023	<1	1	<1	<1	0	96	
Ethylbenzene	µg/L	1	Org-023	<1	1	<1	<1	0	105	
m+p-xylene	µg/L	2	Org-023	<2	1	<2	<2	0	108	
o-xylene	µg/L	1	Org-023	<1	1	<1	<1	0	105	
Naphthalene	µg/L	1	Org-023	<1	1	<1	<1	0		
Surrogate Dibromofluoromethane	%		Org-023	98	1	98	101	3	101	
Surrogate toluene-d8	%		Org-023	100	1	99	98	1	101	
Surrogate 4-BFB	%		Org-023	105	1	103	103	0	103	

QUALITY CONTROL: vTRH(C6-C10)/BTEXN in Water						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date extracted	-				11	15/10/2021	18/10/2021			
Date analysed	-				11	18/10/2021	18/10/2021			
TRH C_6 - C_9	µg/L	10	Org-023		11	<10	<10	0		
TRH C_6 - C_{10}	µg/L	10	Org-023		11	<10	<10	0		
Benzene	µg/L	1	Org-023		11	<1	<1	0		
Toluene	µg/L	1	Org-023		11	<1	<1	0		
Ethylbenzene	µg/L	1	Org-023		11	<1	<1	0		
m+p-xylene	µg/L	2	Org-023		11	<2	<2	0		
o-xylene	µg/L	1	Org-023		11	<1	<1	0		
Naphthalene	µg/L	1	Org-023		11	<1	<1	0		
Surrogate Dibromofluoromethane	%		Org-023		11	99	103	4		
Surrogate toluene-d8	%		Org-023		11	98	99	1		
Surrogate 4-BFB	%		Org-023		11	103	101	2		

QUALITY CONTROL: svTRH (C10-C40) in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W2	280362-2
Date extracted	-			18/10/2021	1	18/10/2021	18/10/2021		18/10/2021	18/10/2021
Date analysed	-			19/10/2021	1	19/10/2021	19/10/2021		19/10/2021	19/10/2021
TRH C_{10} - C_{14}	µg/L	50	Org-020	<50	1	<50	<50	0	114	113
TRH C_{15} - C_{28}	µg/L	100	Org-020	<100	1	<100	<100	0	112	119
TRH C_{29} - C_{36}	µg/L	100	Org-020	<100	1	<100	<100	0	94	115
TRH >C_{10} - C_{16}	µg/L	50	Org-020	<50	1	<50	<50	0	114	113
TRH >C_{16} - C_{34}	µg/L	100	Org-020	<100	1	<100	<100	0	112	119
TRH >C_{34} - C_{40}	µg/L	100	Org-020	<100	1	<100	<100	0	94	115
Surrogate o-Terphenyl	%		Org-020	84	1	83	94	12	93	81

QUALITY CONTROL: svTRH (C10-C40) in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date extracted	-				11	18/10/2021	18/10/2021			
Date analysed	-				11	19/10/2021	19/10/2021			
TRH C_{10} - C_{14}	µg/L	50	Org-020		11	<50	<50	0		
TRH C_{15} - C_{28}	µg/L	100	Org-020		11	<100	<100	0		
TRH C_{29} - C_{36}	µg/L	100	Org-020		11	<100	<100	0		
TRH >C_{10} - C_{16}	µg/L	50	Org-020		11	<50	<50	0		
TRH >C_{16} - C_{34}	µg/L	100	Org-020		11	<100	<100	0		
TRH >C_{34} - C_{40}	µg/L	100	Org-020		11	<100	<100	0		
Surrogate o-Terphenyl	%		Org-020		11	77	98	24		

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QUALITY CONTROL: PAHs in Water						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W2	280362-12
Date extracted	-			18/10/2021	1	18/10/2021	18/10/2021		18/10/2021	18/10/2021
Date analysed	-			19/10/2021	1	19/10/2021	19/10/2021		19/10/2021	19/10/2021
Naphthalene	µg/L	1	Org-022/025	<1	1	<1	<1	0	96	93
Acenaphthylene	µg/L	1	Org-022/025	<1	1	<1	<1	0		
Acenaphthene	µg/L	1	Org-022/025	<1	1	<1	<1	0	75	75
Fluorene	µg/L	1	Org-022/025	<1	1	<1	<1	0	86	88
Phenanthrene	µg/L	1	Org-022/025	<1	1	<1	<1	0	112	116
Anthracene	µg/L	1	Org-022/025	<1	1	<1	<1	0		
Fluoranthene	µg/L	1	Org-022/025	<1	1	<1	<1	0	88	88
Pyrene	µg/L	1	Org-022/025	<1	1	<1	<1	0	86	91
Benzo(a)anthracene	µg/L	1	Org-022/025	<1	1	<1	<1	0		
Chrysene	µg/L	1	Org-022/025	<1	1	<1	<1	0	72	78
Benzo(b,j+k)fluoranthene	µg/L	2	Org-022/025	<2	1	<2	<2	0		
Benzo(a)pyrene	µg/L	1	Org-022/025	<1	1	<1	<1	0	72	94
Indeno(1,2,3-c,d)pyrene	µg/L	1	Org-022/025	<1	1	<1	<1	0		
Dibenzo(a,h)anthracene	µg/L	1	Org-022/025	<1	1	<1	<1	0		
Benzo(g,h,i)perylene	µg/L	1	Org-022/025	<1	1	<1	<1	0		
Surrogate *p*-Terphenyl-d14	%		Org-022/025	87	1	92	90	2	93	94

QUALITY CONTROL: PAHs in Water						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W3	[NT]
Date extracted	-				11	18/10/2021	18/10/2021		18/10/2021	
Date analysed	-				11	19/10/2021	19/10/2021		19/10/2021	
Naphthalene	µg/L	1	Org-022/025		11	<1	<1	0	93	
Acenaphthylene	µg/L	1	Org-022/025		11	<1	<1	0		
Acenaphthene	µg/L	1	Org-022/025		11	<1	<1	0	77	
Fluorene	µg/L	1	Org-022/025		11	<1	<1	0	88	
Phenanthrene	µg/L	1	Org-022/025		11	<1	<1	0	118	
Anthracene	µg/L	1	Org-022/025		11	<1	<1	0		
Fluoranthene	µg/L	1	Org-022/025		11	<1	<1	0	90	
Pyrene	µg/L	1	Org-022/025		11	<1	<1	0	93	
Benzo(a)anthracene	µg/L	1	Org-022/025		11	<1	<1	0		
Chrysene	µg/L	1	Org-022/025		11	<1	<1	0	78	
Benzo(b,j+k)fluoranthene	µg/L	2	Org-022/025		11	<2	<2	0		
Benzo(a)pyrene	µg/L	1	Org-022/025		11	<1	<1	0	94	
Indeno(1,2,3-c,d)pyrene	µg/L	1	Org-022/025		11	<1	<1	0		
Dibenzo(a,h)anthracene	µg/L	1	Org-022/025		11	<1	<1	0		
Benzo(g,h,i)perylene	µg/L	1	Org-022/025		11	<1	<1	0		
Surrogate *p*-Terphenyl-d14	%		Org-022/025		11	91	83	9	103	

QUALITY CONTROL: HM in water - dissolved						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	280362-2
Date prepared	-			15/10/2021	1	15/10/2021	15/10/2021		15/10/2021	15/10/2021
Date analysed	-			18/10/2021	1	18/10/2021	18/10/2021		18/10/2021	18/10/2021
Arsenic-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0		97
Cadmium-Dissolved	µg/L	0.1	Metals-022	<0.1	1	<0.1	<0.1	0		95
Chromium-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0		98
Copper-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0		97
Lead-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0		96
Mercury-Dissolved	µg/L	0.05	Metals-021	<0.05	1	<0.05	<0.05	0	98	101
Nickel-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0		97
Zinc-Dissolved	µg/L	1	Metals-022	<1	1	<1	1	0		98

QUALITY CONTROL: HM in water - dissolved						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W2	[NT]
Date prepared	-				11	15/10/2021	15/10/2021		15/10/2021	
Date analysed	-				11	18/10/2021	18/10/2021		18/10/2021	
Arsenic-Dissolved	µg/L	1	Metals-022		11	<1	<1	0	97	
Cadmium-Dissolved	µg/L	0.1	Metals-022		11	<0.1	<0.1	0	96	
Chromium-Dissolved	µg/L	1	Metals-022		11	<1	<1	0	98	
Copper-Dissolved	µg/L	1	Metals-022		11	<1	<1	0	97	
Lead-Dissolved	µg/L	1	Metals-022		11	<1	<1	0	97	
Mercury-Dissolved	µg/L	0.05	Metals-021		11	0.05				
Nickel-Dissolved	µg/L	1	Metals-022		11	<1	<1	0	98	
Zinc-Dissolved	µg/L	1	Metals-022		11	3	2	40	98	

QUALITY CONTROL: HM in water - dissolved						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-				12	15/10/2021	15/10/2021			
Date analysed	-				12	18/10/2021	18/10/2021			
Arsenic-Dissolved	µg/L	1	Metals-022		12	<1				
Cadmium-Dissolved	µg/L	0.1	Metals-022		12	<0.1				
Chromium-Dissolved	µg/L	1	Metals-022		12	<1				
Copper-Dissolved	µg/L	1	Metals-022		12	2				
Lead-Dissolved	µg/L	1	Metals-022		12	<1				
Mercury-Dissolved	µg/L	0.05	Metals-021		12	0.09	0.09	0		
Nickel-Dissolved	µg/L	1	Metals-022		12	<1				
Zinc-Dissolved	µg/L	1	Metals-022		12	15				

Client Reference: P2007822 Bell Quarry

QUALITY CONTROL: HM in water - total					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	280362-2
Date prepared	-			15/10/2021	1	15/10/2021	15/10/2021		15/10/2021	15/10/2021
Date analysed	-			15/10/2021	1	15/10/2021	15/10/2021		15/10/2021	15/10/2021
Arsenic-Total	µg/L	1	Metals-022	<1	1	1	<1	0	109	109
Cadmium-Total	µg/L	0.1	Metals-022	<0.1	1	<0.1	<0.1	0	106	108
Chromium-Total	µg/L	1	Metals-022	<1	1	<1	<1	0	110	109
Copper-Total	µg/L	1	Metals-022	<1	1	<1	<1	0	112	111
Lead-Total	µg/L	1	Metals-022	<1	1	<1	<1	0	103	106
Mercury-Total	µg/L	0.05	Metals-021	<0.05	1	<0.05	<0.05	0	99	99
Nickel-Total	µg/L	1	Metals-022	<1	1	<1	<1	0	110	109
Zinc-Total	µg/L	1	Metals-022	<1	1	<1	<1	0	111	113

QUALITY CONTROL: HM in water - total					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-			[NT]	11	15/10/2021	15/10/2021		[NT]	[NT]
Date analysed	-			[NT]	11	15/10/2021	15/10/2021		[NT]	[NT]
Arsenic-Total	µg/L	1	Metals-022	[NT]	11	1	1	0	[NT]	[NT]
Cadmium-Total	µg/L	0.1	Metals-022	[NT]	11	<0.1	<0.1	0	[NT]	[NT]
Chromium-Total	µg/L	1	Metals-022	[NT]	11	19	18	5	[NT]	[NT]
Copper-Total	µg/L	1	Metals-022	[NT]	11	23	23	0	[NT]	[NT]
Lead-Total	µg/L	1	Metals-022	[NT]	11	13	13	0	[NT]	[NT]
Mercury-Total	µg/L	0.05	Metals-021	[NT]	11	<0.05	[NT]		[NT]	[NT]
Nickel-Total	µg/L	1	Metals-022	[NT]	11	2	2	0	[NT]	[NT]
Zinc-Total	µg/L	1	Metals-022	[NT]	11	5	6	18	[NT]	[NT]

QUALITY CONTROL: HM in water - total					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-			[NT]	12	15/10/2021	15/10/2021		[NT]	[NT]
Date analysed	-			[NT]	12	15/10/2021	15/10/2021		[NT]	[NT]
Arsenic-Total	µg/L	1	Metals-022	[NT]	12	<1	[NT]		[NT]	[NT]
Cadmium-Total	µg/L	0.1	Metals-022	[NT]	12	<0.1	[NT]		[NT]	[NT]
Chromium-Total	µg/L	1	Metals-022	[NT]	12	1	[NT]		[NT]	[NT]
Copper-Total	µg/L	1	Metals-022	[NT]	12	10	[NT]		[NT]	[NT]
Lead-Total	µg/L	1	Metals-022	[NT]	12	<1	[NT]		[NT]	[NT]
Mercury-Total	µg/L	0.05	Metals-021	[NT]	12	<0.05	<0.05	0	[NT]	[NT]
Nickel-Total	µg/L	1	Metals-022	[NT]	12	1	[NT]		[NT]	[NT]
Zinc-Total	µg/L	1	Metals-022	[NT]	12	19	[NT]		[NT]	[NT]

Client Reference: P2007822 Bell Quarry

QUALITY CONTROL: Ion Balance					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	280362-2
Date prepared	-			14/10/2021	1	14/10/2021	14/10/2021		14/10/2021	14/10/2021
Date analysed	-			14/10/2021	1	14/10/2021	14/10/2021		14/10/2021	14/10/2021
Calcium - Dissolved	mg/L	0.5	Metals-020	<0.5	1	1	1	0	98	
Potassium - Dissolved	mg/L	0.5	Metals-020	<0.5	1	1	1	0	93	
Sodium - Dissolved	mg/L	0.5	Metals-020	<0.5	1	5	4	22	91	
Magnesium - Dissolved	mg/L	0.5	Metals-020	<0.5	1	0.9	0.8	12	100	
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	5	Inorg-006	<5	1	<5	<5	0		
Bicarbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	1	14	14	0		
Carbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	1	<5	<5	0		
Total Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	1	14	14	0	103	
Sulphate, SO4	mg/L	1	Inorg-081	<1	1	1	1	0	89	85
Chloride, Cl	mg/L	1	Inorg-081	<1	1	4	4	0	90	86
Ionic Balance	%		Inorg-040		1	-8.0	-13	-48		

QUALITY CONTROL: Ion Balance					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	280362-4
Date prepared	-				10	14/10/2021	14/10/2021			14/10/2021
Date analysed	-				10	14/10/2021	14/10/2021			14/10/2021
Calcium - Dissolved	mg/L	0.5	Metals-020		10	<0.5				125
Potassium - Dissolved	mg/L	0.5	Metals-020		10	1				116
Sodium - Dissolved	mg/L	0.5	Metals-020		10	4				105
Magnesium - Dissolved	mg/L	0.5	Metals-020		10	<0.5				129
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	5	Inorg-006		10	<5	<5	0		
Bicarbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006		10	<5	9	57		
Carbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006		10	<5	<5	0		
Total Alkalinity as $CaCO_3$	mg/L	5	Inorg-006		10	<5	9	57		
Sulphate, SO4	mg/L	1	Inorg-081		10	2	2	0		
Chloride, Cl	mg/L	1	Inorg-081		10	4	4	0		
Ionic Balance	%		Inorg-040		10	9.0				

Client Reference: P2007822 Bell Quarry

QUALITY CONTROL: Ion Balance					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-				14	14/10/2021	14/10/2021			
Date analysed	-				14	14/10/2021	14/10/2021			
Calcium - Dissolved	mg/L	0.5	Metals-020		14	<0.5	<0.5	0		
Potassium - Dissolved	mg/L	0.5	Metals-020		14	<0.5	<0.5	0		
Sodium - Dissolved	mg/L	0.5	Metals-020		14	5.9	6.0	2		
Magnesium - Dissolved	mg/L	0.5	Metals-020		14	<0.5	<0.5	0		
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	5	Inorg-006		14	<5				
Bicarbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006		14	5				
Carbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006		14	<5				
Total Alkalinity as $CaCO_3$	mg/L	5	Inorg-006		14	5				
Sulphate, SO4	mg/L	1	Inorg-081		14	2				
Chloride, Cl	mg/L	1	Inorg-081		14	4				
Ionic Balance	%		Inorg-040		14	-1.0				

Client Reference: P2007822 Bell Quarry

QUALITY CONTROL: Miscellaneous Inorganics					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	280362-2
Date prepared	-			15/10/2021	1	15/10/2021	15/10/2021		15/10/2021	15/10/2021
Date analysed	-			15/10/2021	1	15/10/2021	15/10/2021		15/10/2021	15/10/2021
Total Nitrogen in water	mg/L	0.1	Inorg-055/062/127	<0.1	1	0.2	0.2	0	116	103
NOx as N in water	mg/L	0.005	Inorg-055	<0.005	1	<0.005	<0.005	0	105	108
Ammonia as N in water	mg/L	0.005	Inorg-057	<0.005	1	<0.005	<0.005	0	98	101
Phosphate as P in water	mg/L	0.005	Inorg-060	<0.005	1	<0.005	<0.005	0	117	112

QUALITY CONTROL: Miscellaneous Inorganics					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-				11	15/10/2021	15/10/2021			
Date analysed	-				11	15/10/2021	15/10/2021			
Total Nitrogen in water	mg/L	0.1	Inorg-055/062/127		11	0.3	0.4	29		
NOx as N in water	mg/L	0.005	Inorg-055		11	<0.005				
Ammonia as N in water	mg/L	0.005	Inorg-057		11	0.007				
Phosphate as P in water	mg/L	0.005	Inorg-060		11	<0.005				

Client Reference: P2007822 Bell Quarry

QUALITY CONTROL: Metals in Waters - Acid extractable					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	280362-4
Date prepared	-			15/10/2021	1	15/10/2021	15/10/2021		15/10/2021	15/10/2021
Date analysed	-			15/10/2021	1	15/10/2021	15/10/2021		15/10/2021	15/10/2021
Phosphorus - Total	mg/L	0.05	Metals-020	<0.05	1	<0.05	<0.05	0	108	126

QUALITY CONTROL: Metals in Waters - Acid extractable					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-			[NT]	11	15/10/2021	15/10/2021		[NT]	[NT]
Date analysed	-			[NT]	11	15/10/2021	15/10/2021		[NT]	[NT]
Phosphorus - Total	mg/L	0.05	Metals-020	[NT]	11	<0.05	<0.05	0	[NT]	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from "2018 TLVs and BEIs", as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

Report Comments

Dissolved Metals: no filtered, preserved sample was received, therefore the unpreserved sample was filtered through 0.45µm filter at the lab.
Note: there is a possibility some elements may be underestimated.

The mass inbalance in sample #9 may be caused by other ions that have not been measured.

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CERTIFICATE OF ANALYSIS 280787

Client Details

Client	Martens & Associates Pty Ltd
Attention	R Kightley, Ben McGiffin
Address	Suite 201, 20 George St, Hornsby, NSW, 2077

Sample Details

Your Reference	**P2007822 Bell Quarry**
Number of Samples	13 Water
Date samples received	20/10/2021
Date completed instructions received	20/10/2021

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Please refer to the last page of this report for any comments relating to the results.

Report Details

Date results requested by	27/10/2021
Date of Issue	27/10/2021

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Results Approved By

Diego Bigolin, Inorganics Supervisor
Dragana Tomas, Senior Chemist
Hannah Nguyen, Metals Supervisor
Nick Sarlamis, Assistant Operation Manager
Steven Luong, Organics Supervisor

Authorised By

Nancy

Nancy Zhang, Laboratory Manager

vTRH(C6-C10)/BTEXN in Water

Our Reference		280787-1	280787-2	280787-3	280787-4	280787-5
Your Reference	UNITS	7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		19/10/2021	19/10/2021	19/10/2021	19/10/2021	19/10/2021
Type of sample		Water	Water	Water	Water	Water
Date extracted	-	21/10/2021	21/10/2021	21/10/2021	21/10/2021	21/10/2021
Date analysed	-	21/10/2021	21/10/2021	21/10/2021	21/10/2021	21/10/2021
TRH C_6 - C_9	µg/L	<10	<10	<10	<10	<10
TRH C_6 - C_{10}	µg/L	<10	<10	<10	<10	<10
TRH C_6 - C_{10} less BTEX (F1)	µg/L	<10	<10	<10	<10	<10
Benzene	µg/L	<1	<1	<1	<1	<1
Toluene	µg/L	<1	<1	<1	<1	<1
Ethylbenzene	µg/L	<1	<1	<1	<1	<1
m+p-xylene	µg/L	<2	<2	<2	<2	<2
o-xylene	µg/L	<1	<1	<1	<1	<1
Naphthalene	µg/L	<1	<1	<1	<1	<1
Surrogate Dibromofluoromethane	%	105	105	105	106	105
Surrogate toluene-d8	%	100	99	100	101	100
Surrogate 4-BFB	%	103	104	105	104	102

vTRH(C6-C10)/BTEXN in Water

Our Reference		280787-6	280787-7	280787-8	280787-9	280787-10
Your Reference	UNITS	7822/SW02	7822/MW401	7822/MW302A	7822/MW301A	7822/MW301B
Date Sampled		19/10/2021	19/10/2021	19/10/2021	19/10/2021	19/10/2021
Type of sample		Water	Water	Water	Water	Water
Date extracted	-	21/10/2021	21/10/2021	21/10/2021	21/10/2021	21/10/2021
Date analysed	-	21/10/2021	21/10/2021	21/10/2021	21/10/2021	21/10/2021
TRH C_6 - C_9	µg/L	<10	<10	<10	<10	<10
TRH C_6 - C_{10}	µg/L	<10	<10	<10	<10	<10
TRH C_6 - C_{10} less BTEX (F1)	µg/L	<10	<10	<10	<10	<10
Benzene	µg/L	<1	<1	<1	<1	<1
Toluene	µg/L	<1	<1	<1	<1	<1
Ethylbenzene	µg/L	<1	<1	<1	<1	<1
m+p-xylene	µg/L	<2	<2	<2	<2	<2
o-xylene	µg/L	<1	<1	<1	<1	<1
Naphthalene	µg/L	<1	<1	<1	<1	<1
Surrogate Dibromofluoromethane	%	105	106	104	103	105
Surrogate toluene-d8	%	101	100	100	100	100
Surrogate 4-BFB	%	102	103	104	106	101

vTRH(C6-C10)/BTEXN in Water				
Our Reference		280787-11	280787-12	280787-13
Your Reference	UNITS	7822/MB02	7822/MB03	7822/MW201
Date Sampled		19/10/2021	19/10/2021	19/10/2021
Type of sample		Water	Water	Water
Date extracted	-	21/10/2021	21/10/2021	21/10/2021
Date analysed	-	21/10/2021	21/10/2021	21/10/2021
TRH C_6 - C_9	µg/L	<10	<10	<10
TRH C_6 - C_{10}	µg/L	<10	<10	<10
TRH C_6 - C_{10} less BTEX (F1)	µg/L	<10	<10	<10
Benzene	µg/L	<1	<1	<1
Toluene	µg/L	<1	<1	<1
Ethylbenzene	µg/L	<1	<1	<1
m+p-xylene	µg/L	<2	<2	<2
o-xylene	µg/L	<1	<1	<1
Naphthalene	µg/L	<1	<1	<1
Surrogate Dibromofluoromethane	%	104	107	103
Surrogate toluene-d8	%	100	100	99
Surrogate 4-BFB	%	106	103	102

svTRH (C10-C40) in Water						
Our Reference		280787-1	280787-2	280787-3	280787-4	280787-5
Your Reference	UNITS	7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		19/10/2021	19/10/2021	19/10/2021	19/10/2021	19/10/2021
Type of sample		Water	Water	Water	Water	Water
Date extracted	-	22/10/2021	22/10/2021	22/10/2021	22/10/2021	22/10/2021
Date analysed	-	22/10/2021	22/10/2021	22/10/2021	22/10/2021	22/10/2021
TRH C_{10} - C_{14}	µg/L	<50	<50	<50	<50	<50
TRH C_{15} - C_{28}	µg/L	<100	<100	<100	<100	<100
TRH C_{29} - C_{36}	µg/L	<100	<100	<100	<100	<100
Total +ve TRH (C10-C36)	µg/L	<50	<50	<50	<50	<50
TRH >C_{10} - C_{16}	µg/L	<50	<50	<50	<50	<50
TRH >C_{10} - C_{16} less Naphthalene (F2)	µg/L	<50	<50	<50	<50	<50
TRH >C_{16} - C_{34}	µg/L	<100	<100	<100	<100	<100
TRH >C_{34} - C_{40}	µg/L	<100	<100	<100	<100	<100
Total +ve TRH (>C10-C40)	µg/L	<50	<50	<50	<50	<50
Surrogate o-Terphenyl	%	75	78	75	92	78

svTRH (C10-C40) in Water						
Our Reference		280787-6	280787-7	280787-8	280787-9	280787-10
Your Reference	UNITS	7822/SW02	7822/MW401	7822/MW302A	7822/MW301A	7822/MW301B
Date Sampled		19/10/2021	19/10/2021	19/10/2021	19/10/2021	19/10/2021
Type of sample		Water	Water	Water	Water	Water
Date extracted	-	22/10/2021	22/10/2021	22/10/2021	22/10/2021	22/10/2021
Date analysed	-	22/10/2021	22/10/2021	25/10/2021	25/10/2021	25/10/2021
TRH C_{10} - C_{14}	µg/L	<50	<50	<50	<50	<50
TRH C_{15} - C_{28}	µg/L	<100	<100	<100	<100	<100
TRH C_{29} - C_{36}	µg/L	<100	<100	<100	<100	<100
Total +ve TRH (C10-C36)	µg/L	<50	<50	<50	<50	<50
TRH >C_{10} - C_{16}	µg/L	<50	<50	<50	<50	<50
TRH >C_{10} - C_{16} less Naphthalene (F2)	µg/L	<50	<50	<50	<50	<50
TRH >C_{16} - C_{34}	µg/L	<100	<100	<100	<100	<100
TRH >C_{34} - C_{40}	µg/L	<100	<100	<100	<100	<100
Total +ve TRH (>C10-C40)	µg/L	<50	<50	<50	<50	<50
Surrogate o-Terphenyl	%	72	71	81	82	93

svTRH (C10-C40) in Water				
Our Reference		280787-11	280787-12	280787-13
Your Reference	UNITS	7822/MB02	7822/MB03	7822/MW201
Date Sampled		19/10/2021	19/10/2021	19/10/2021
Type of sample		Water	Water	Water
Date extracted	-	22/10/2021	22/10/2021	22/10/2021
Date analysed	-	25/10/2021	25/10/2021	25/10/2021
TRH C_{10} - C_{14}	µg/L	<50	<50	<50
TRH C_{15} - C_{28}	µg/L	<100	<100	<100
TRH C_{29} - C_{36}	µg/L	<100	<100	<100
Total +ve TRH (C10-C36)	µg/L	<50	<50	<50
TRH >C_{10} - C_{16}	µg/L	<50	<50	<50
TRH >C_{10} - C_{16} less Naphthalene (F2)	µg/L	<50	<50	<50
TRH >C_{16} - C_{34}	µg/L	<100	<100	<100
TRH >C_{34} - C_{40}	µg/L	<100	<100	<100
Total +ve TRH (>C10-C40)	µg/L	<50	<50	<50
Surrogate o-Terphenyl	%	87	85	91

Client Reference: P2007822 Bell Quarry

PAHs in Water						
Our Reference	UNITS	280787-1	280787-2	280787-3	280787-4	280787-5
Your Reference		7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		19/10/2021	19/10/2021	19/10/2021	19/10/2021	19/10/2021
Type of sample		Water	Water	Water	Water	Water
Date extracted	-	22/10/2021	22/10/2021	22/10/2021	22/10/2021	22/10/2021
Date analysed	-	22/10/2021	22/10/2021	22/10/2021	22/10/2021	22/10/2021
Naphthalene	µg/L	<1	<1	<1	<1	<1
Acenaphthylene	µg/L	<1	<1	<1	<1	<1
Acenaphthene	µg/L	<1	<1	<1	<1	<1
Fluorene	µg/L	<1	<1	<1	<1	<1
Phenanthrene	µg/L	<1	<1	<1	<1	<1
Anthracene	µg/L	<1	<1	<1	<1	<1
Fluoranthene	µg/L	<1	<1	<1	<1	<1
Pyrene	µg/L	<1	<1	<1	<1	<1
Benzo(a)anthracene	µg/L	<1	<1	<1	<1	<1
Chrysene	µg/L	<1	<1	<1	<1	<1
Benzo(b,j+k)fluoranthene	µg/L	<2	<2	<2	<2	<2
Benzo(a)pyrene	µg/L	<1	<1	<1	<1	<1
Indeno(1,2,3-c,d)pyrene	µg/L	<1	<1	<1	<1	<1
Dibenzo(a,h)anthracene	µg/L	<1	<1	<1	<1	<1
Benzo(g,h,i)perylene	µg/L	<1	<1	<1	<1	<1
Benzo(a)pyrene TEQ	µg/L	<5	<5	<5	<5	<5
Total +ve PAH's	µg/L	NIL (+)VE	NIL (+)VE	NIL (+)VE	NIL (+)VE	NIL (+)VE
Surrogate p-Terphenyl-d14	%	88	87	85	72	85

Client Reference: P2007822 Bell Quarry

PAHs in Water						
Our Reference		280787-6	280787-7	280787-8	280787-9	280787-10
Your Reference	UNITS	7822/SW02	7822/MW401	7822/MW302A	7822/MW301A	7822/MW301B
Date Sampled		19/10/2021	19/10/2021	19/10/2021	19/10/2021	19/10/2021
Type of sample		Water	Water	Water	Water	Water
Date extracted	-	**22/10/2021**	**22/10/2021**	**22/10/2021**	**22/10/2021**	**22/10/2021**
Date analysed	-	**22/10/2021**	**22/10/2021**	**25/10/2021**	**25/10/2021**	**25/10/2021**
Naphthalene	µg/L	<1	<1	<1	<1	<1
Acenaphthylene	µg/L	<1	<1	<1	<1	<1
Acenaphthene	µg/L	<1	<1	<1	<1	<1
Fluorene	µg/L	<1	<1	<1	<1	<1
Phenanthrene	µg/L	<1	<1	<1	<1	<1
Anthracene	µg/L	<1	<1	<1	<1	<1
Fluoranthene	µg/L	<1	<1	<1	<1	<1
Pyrene	µg/L	<1	<1	<1	<1	<1
Benzo(a)anthracene	µg/L	<1	<1	<1	<1	<1
Chrysene	µg/L	<1	<1	<1	<1	<1
Benzo(b,j+k)fluoranthene	µg/L	<2	<2	<2	<2	<2
Benzo(a)pyrene	µg/L	<1	<1	<1	<1	<1
Indeno(1,2,3-c,d)pyrene	µg/L	<1	<1	<1	<1	<1
Dibenzo(a,h)anthracene	µg/L	<1	<1	<1	<1	<1
Benzo(g,h,i)perylene	µg/L	<1	<1	<1	<1	<1
Benzo(a)pyrene TEQ	µg/L	<5	<5	<5	<5	<5
Total +ve PAH's	µg/L	NIL (+)VE	NIL (+)VE	NIL (+)VE	NIL (+)VE	NIL (+)VE
Surrogate p-Terphenyl-d14	%	86	79	93	94	89

PAHs in Water				
Our Reference		280787-11	280787-12	280787-13
Your Reference	UNITS	7822/MB02	7822/MB03	7822/MW201
Date Sampled		19/10/2021	19/10/2021	19/10/2021
Type of sample		Water	Water	Water
Date extracted	-	22/10/2021	22/10/2021	22/10/2021
Date analysed	-	25/10/2021	25/10/2021	25/10/2021
Naphthalene	µg/L	<1	<1	<1
Acenaphthylene	µg/L	<1	<1	<1
Acenaphthene	µg/L	<1	<1	<1
Fluorene	µg/L	<1	<1	<1
Phenanthrene	µg/L	<1	<1	<1
Anthracene	µg/L	<1	<1	<1
Fluoranthene	µg/L	<1	<1	<1
Pyrene	µg/L	<1	<1	<1
Benzo(a)anthracene	µg/L	<1	<1	<1
Chrysene	µg/L	<1	<1	<1
Benzo(b,j+k)fluoranthene	µg/L	<2	<2	<2
Benzo(a)pyrene	µg/L	<1	<1	<1
Indeno(1,2,3-c,d)pyrene	µg/L	<1	<1	<1
Dibenzo(a,h)anthracene	µg/L	<1	<1	<1
Benzo(g,h,i)perylene	µg/L	<1	<1	<1
Benzo(a)pyrene TEQ	µg/L	<5	<5	<5
Total +ve PAH's	µg/L	NIL (+)VE	NIL (+)VE	NIL (+)VE
Surrogate p-Terphenyl-d14	%	93	96	88

HM in water - dissolved						
Our Reference		280787-1	280787-2	280787-3	280787-4	280787-5
Your Reference	UNITS	7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		19/10/2021	19/10/2021	19/10/2021	19/10/2021	19/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	22/10/2021	22/10/2021	22/10/2021	22/10/2021	22/10/2021
Date analysed	-	22/10/2021	22/10/2021	22/10/2021	22/10/2021	22/10/2021
Arsenic-Dissolved	µg/L	<1	<1	<1	<1	<1
Cadmium-Dissolved	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium-Dissolved	µg/L	<1	<1	<1	<1	<1
Copper-Dissolved	µg/L	<1	<1	<1	<1	<1
Lead-Dissolved	µg/L	<1	<1	<1	<1	<1
Mercury-Dissolved	µg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Nickel-Dissolved	µg/L	<1	<1	<1	<1	<1
Zinc-Dissolved	µg/L	3	<1	2	5	2

HM in water - dissolved						
Our Reference		280787-6	280787-7	280787-8	280787-9	280787-10
Your Reference	UNITS	7822/SW02	7822/MW401	7822/MW302A	7822/MW301A	7822/MW301B
Date Sampled		19/10/2021	19/10/2021	19/10/2021	19/10/2021	19/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	22/10/2021	22/10/2021	22/10/2021	22/10/2021	22/10/2021
Date analysed	-	22/10/2021	22/10/2021	22/10/2021	22/10/2021	22/10/2021
Arsenic-Dissolved	µg/L	<1	<1	<1	<1	<1
Cadmium-Dissolved	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium-Dissolved	µg/L	<1	<1	<1	<1	<1
Copper-Dissolved	µg/L	<1	3	<1	1	<1
Lead-Dissolved	µg/L	<1	<1	<1	<1	<1
Mercury-Dissolved	µg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Nickel-Dissolved	µg/L	<1	<1	<1	<1	<1
Zinc-Dissolved	µg/L	1	7	<1	5	2

HM in water - dissolved				
Our Reference		280787-11	280787-12	280787-13
Your Reference	UNITS	7822/MB02	7822/MB03	7822/MW201
Date Sampled		19/10/2021	19/10/2021	19/10/2021
Type of sample		Water	Water	Water
Date prepared	-	22/10/2021	22/10/2021	22/10/2021
Date analysed	-	22/10/2021	22/10/2021	22/10/2021
Arsenic-Dissolved	µg/L	<1	<1	<1
Cadmium-Dissolved	µg/L	<0.1	<0.1	<0.1
Chromium-Dissolved	µg/L	<1	<1	<1
Copper-Dissolved	µg/L	4	4	11
Lead-Dissolved	µg/L	<1	<1	<1
Mercury-Dissolved	µg/L	<0.05	<0.05	<0.05
Nickel-Dissolved	µg/L	<1	3	1
Zinc-Dissolved	µg/L	10	35	31

HM in water - total						
Our Reference		280787-1	280787-2	280787-3	280787-4	280787-5
Your Reference	UNITS	7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		19/10/2021	19/10/2021	19/10/2021	19/10/2021	19/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	22/10/2021	22/10/2021	22/10/2021	22/10/2021	22/10/2021
Date analysed	-	25/10/2021	25/10/2021	25/10/2021	25/10/2021	25/10/2021
Arsenic-Total	µg/L	<1	<1	<1	<1	<1
Cadmium-Total	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium-Total	µg/L	<1	<1	<1	<1	<1
Copper-Total	µg/L	1	<1	<1	1	<1
Lead-Total	µg/L	<1	<1	<1	2	<1
Mercury-Total	µg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Nickel-Total	µg/L	<1	<1	<1	<1	<1
Zinc-Total	µg/L	3	1	6	2	1

HM in water - total						
Our Reference		280787-6	280787-7	280787-8	280787-9	280787-10
Your Reference	UNITS	7822/SW02	7822/MW401	7822/MW302A	7822/MW301A	7822/MW301B
Date Sampled		19/10/2021	19/10/2021	19/10/2021	19/10/2021	19/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	22/10/2021	22/10/2021	22/10/2021	22/10/2021	22/10/2021
Date analysed	-	25/10/2021	25/10/2021	25/10/2021	25/10/2021	25/10/2021
Arsenic-Total	µg/L	<1	<1	5	<1	<1
Cadmium-Total	µg/L	<0.1	<0.1	0.1	<0.1	<0.1
Chromium-Total	µg/L	<1	<1	14	4	8
Copper-Total	µg/L	<1	5	26	4	8
Lead-Total	µg/L	<1	<1	39	<1	5
Mercury-Total	µg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Nickel-Total	µg/L	<1	<1	5	<1	<1
Zinc-Total	µg/L	2	3	33	4	3

HM in water - total				
Our Reference		280787-11	280787-12	280787-13
Your Reference	UNITS	7822/MB02	7822/MB03	7822/MW201
Date Sampled		19/10/2021	19/10/2021	19/10/2021
Type of sample		Water	Water	Water
Date prepared	-	22/10/2021	22/10/2021	22/10/2021
Date analysed	-	25/10/2021	25/10/2021	25/10/2021
Arsenic-Total	µg/L	<1	<1	<1
Cadmium-Total	µg/L	<0.1	<0.1	<0.1
Chromium-Total	µg/L	2	1	18
Copper-Total	µg/L	8	5	86
Lead-Total	µg/L	<1	<1	4
Mercury-Total	µg/L	0.08	<0.05	<0.05
Nickel-Total	µg/L	2	3	24
Zinc-Total	µg/L	11	28	240

Metals in Waters - Acid extractable						
Our Reference		280787-1	280787-2	280787-3	280787-4	280787-5
Your Reference	UNITS	7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		19/10/2021	19/10/2021	19/10/2021	19/10/2021	19/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	22/10/2021	22/10/2021	22/10/2021	22/10/2021	22/10/2021
Date analysed	-	25/10/2021	25/10/2021	25/10/2021	25/10/2021	25/10/2021
Phosphorus - Total	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05

Metals in Waters - Acid extractable						
Our Reference		280787-6	280787-7	280787-8	280787-9	280787-10
Your Reference	UNITS	7822/SW02	7822/MW401	7822/MW302A	7822/MW301A	7822/MW301B
Date Sampled		19/10/2021	19/10/2021	19/10/2021	19/10/2021	19/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	22/10/2021	22/10/2021	22/10/2021	22/10/2021	22/10/2021
Date analysed	-	25/10/2021	25/10/2021	25/10/2021	25/10/2021	25/10/2021
Phosphorus - Total	mg/L	<0.05	<0.05	0.2	<0.05	<0.05

Metals in Waters - Acid extractable				
Our Reference		280787-11	280787-12	280787-13
Your Reference	UNITS	7822/MB02	7822/MB03	7822/MW201
Date Sampled		19/10/2021	19/10/2021	19/10/2021
Type of sample		Water	Water	Water
Date prepared	-	22/10/2021	22/10/2021	22/10/2021
Date analysed	-	25/10/2021	25/10/2021	25/10/2021
Phosphorus - Total	mg/L	<0.05	<0.05	<0.05

Ion Balance

Our Reference		280787-1	280787-2	280787-3	280787-4	280787-5
Your Reference	UNITS	7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		19/10/2021	19/10/2021	19/10/2021	19/10/2021	19/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	21/10/2021	21/10/2021	21/10/2021	21/10/2021	21/10/2021
Date analysed	-	21/10/2021	21/10/2021	21/10/2021	21/10/2021	21/10/2021
Calcium - Dissolved	mg/L	0.6	0.5	0.5	<0.5	<0.5
Potassium - Dissolved	mg/L	1	1	0.9	0.5	<0.5
Sodium - Dissolved	mg/L	4	4	4	4	5.2
Magnesium - Dissolved	mg/L	<0.5	<0.5	<0.5	<0.5	0.6
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	<5	<5	<5	<5	<5
Bicarbonate Alkalinity as $CaCO_3$	mg/L	11	10	10	9	5
Carbonate Alkalinity as $CaCO_3$	mg/L	<5	<5	<5	<5	<5
Total Alkalinity as $CaCO_3$	mg/L	11	10	10	9	5
Sulphate, SO4	mg/L	1	1	1	22	3
Chloride, Cl	mg/L	6	4	4	4	6
Ionic Balance	%	-29	-25	-23	-60	-12

Ion Balance

Our Reference		280787-6	280787-7	280787-8	280787-9	280787-10
Your Reference	UNITS	7822/SW02	7822/MW401	7822/MW302A	7822/MW301A	7822/MW301B
Date Sampled		19/10/2021	19/10/2021	19/10/2021	19/10/2021	19/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	21/10/2021	21/10/2021	21/10/2021	21/10/2021	21/10/2021
Date analysed	-	21/10/2021	21/10/2021	21/10/2021	21/10/2021	21/10/2021
Calcium - Dissolved	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Potassium - Dissolved	mg/L	<0.5	0.9	0.8	0.9	1
Sodium - Dissolved	mg/L	5	5.7	5	3	3
Magnesium - Dissolved	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	<5	<5	<5	<5	<5
Bicarbonate Alkalinity as $CaCO_3$	mg/L	6	6	8	5	7
Carbonate Alkalinity as $CaCO_3$	mg/L	<5	<5	<5	<5	<5
Total Alkalinity as $CaCO_3$	mg/L	6	6	8	5	7
Sulphate, SO4	mg/L	<1	4	2	2	2
Chloride, Cl	mg/L	7	5	4	4	4
Ionic Balance	%	-19	-13	-18	-21	-23

Client Reference: P2007822 Bell Quarry

Ion Balance				
Our Reference		280787-11	280787-12	280787-13
Your Reference	UNITS	7822/MB02	7822/MB03	7822/MW201
Date Sampled		19/10/2021	19/10/2021	19/10/2021
Type of sample		Water	Water	Water
Date prepared	-	21/10/2021	21/10/2021	21/10/2021
Date analysed	-	21/10/2021	21/10/2021	21/10/2021
Calcium - Dissolved	mg/L	0.6	0.7	<0.5
Potassium - Dissolved	mg/L	1	2	<0.5
Sodium - Dissolved	mg/L	5.3	3	5.9
Magnesium - Dissolved	mg/L	<0.5	0.8	<0.5
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	<5	<5	<5
Bicarbonate Alkalinity as $CaCO_3$	mg/L	9	7	7
Carbonate Alkalinity as $CaCO_3$	mg/L	<5	<5	<5
Total Alkalinity as $CaCO_3$	mg/L	9	7	7
Sulphate, SO4	mg/L	2	1	2
Chloride, Cl	mg/L	5	4	4
Ionic Balance	%	-13	3.0	-8.0

Miscellaneous Inorganics						
Our Reference		280787-1	280787-2	280787-3	280787-4	280787-5
Your Reference	UNITS	7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		19/10/2021	19/10/2021	19/10/2021	19/10/2021	19/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	21/10/2021	21/10/2021	21/10/2021	21/10/2021	21/10/2021
Date analysed	-	21/10/2021	21/10/2021	21/10/2021	21/10/2021	21/10/2021
Total Nitrogen in water	mg/L	0.2	0.3	<0.1	<0.1	<0.1
NOx as N in water	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005
Ammonia as N in water	mg/L	<0.005	<0.005	<0.005	<0.005	0.006
Phosphate as P in water	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005

Miscellaneous Inorganics						
Our Reference		280787-6	280787-7	280787-8	280787-9	280787-10
Your Reference	UNITS	7822/SW02	7822/MW401	7822/MW302A	7822/MW301A	7822/MW301B
Date Sampled		19/10/2021	19/10/2021	19/10/2021	19/10/2021	19/10/20
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	21/10/2021	21/10/2021	21/10/2021	21/10/2021	21/10/2021
Date analysed	-	21/10/2021	21/10/2021	21/10/2021	21/10/2021	21/10/2021
Total Nitrogen in water	mg/L	<0.1	<0.1	0.2	0.1	0.1
NOx as N in water	mg/L	0.02	0.02	<0.005	0.007	0.01
Ammonia as N in water	mg/L	<0.005	0.011	<0.005	0.013	0.006
Phosphate as P in water	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005

Miscellaneous Inorganics				
Our Reference		280787-11	280787-12	280787-13
Your Reference	UNITS	7822/MB02	7822/MB03	7822/MW201
Date Sampled		19/10/2021	19/10/2021	19/10/2021
Type of sample		Water	Water	Water
Date prepared	-	21/10/2021	21/10/2021	21/10/2021
Date analysed	-	21/10/2021	21/10/2021	21/10/2021
Total Nitrogen in water	mg/L	<0.1	15	0.6
NOx as N in water	mg/L	0.01	1.6	0.53
Ammonia as N in water	mg/L	0.020	0.021	<0.005
Phosphate as P in water	mg/L	<0.005	<0.005	<0.005

Client Reference: P2007822 Bell Quarry

Method ID	Methodology Summary
Inorg-006	Alkalinity - determined titrimetrically in accordance with APHA latest edition, 2320-B.
Inorg-040	The concentrations of the major ions (mg/L) are converted to milliequivalents and summed. The ionic balance should be within +/- 10% ie total anions = total cations +/-10%.
Inorg-055	Nitrate - determined colourimetrically. Waters samples are filtered on receipt prior to analysis. Soils are analysed following a water extraction.
Inorg-055/062/127	Total Nitrogen - Calculation sum of TKN and oxidised Nitrogen. Alternatively analysed by combustion and chemiluminescence.
Inorg-057	Ammonia - determined colourimetrically, based on APHA latest edition 4500-NH3 F. Waters samples are filtered on receipt prior to analysis. Soils are analysed following a KCl extraction.
Inorg-060	Phosphate determined colourimetrically based on EPA365.1 and APHA latest edition 4500 P E. Waters samples are filtered on receipt prior to analysis. Soils are analysed following a water extraction.
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Waters samples are filtered on receipt prior to analysis. Alternatively determined by colourimetry/turbidity using Discrete Analyser.
Metals-020	Determination of various metals by ICP-AES.
Metals-021	Determination of Mercury by Cold Vapour AAS.
Metals-022	Determination of various metals by ICP-MS.
Org-020	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-FID. F2 = (>C10-C16)-Naphthalene as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater (HSLs Tables 1A (3, 4)). Note Naphthalene is determined from the VOC analysis.
Org-022/025	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS/GC-MSMS. Benzo(a)pyrene TEQ as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater - 2013.
Org-023	Water samples are analysed directly by purge and trap GC-MS.
Org-023	Soil samples are extracted with methanol and spiked into water prior to analysing by purge and trap GC-MS. Water samples are analysed directly by purge and trap GC-MS. F1 = (C6-C10)-BTEX as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater.

Client Reference: P2007822 Bell Quarry

QUALITY CONTROL: vTRH(C6-C10)/BTEXN in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	[NT]
Date extracted	-			21/10/2021	1	21/10/2021	22/10/2021		21/10/2021	
Date analysed	-			21/10/2021	1	21/10/2021	22/10/2021		21/10/2021	
TRH C_6 - C_9	µg/L	10	Org-023	<10	1	<10	<10	0	100	
TRH C_6 - C_{10}	µg/L	10	Org-023	<10	1	<10	<10	0	100	
Benzene	µg/L	1	Org-023	<1	1	<1	<1	0	96	
Toluene	µg/L	1	Org-023	<1	1	<1	<1	0	95	
Ethylbenzene	µg/L	1	Org-023	<1	1	<1	<1	0	101	
m+p-xylene	µg/L	2	Org-023	<2	1	<2	<2	0	103	
o-xylene	µg/L	1	Org-023	<1	1	<1	<1	0	100	
Naphthalene	µg/L	1	Org-023	<1	1	<1	<1	0		
Surrogate Dibromofluoromethane	%		Org-023	106	1	105	104	1	108	
Surrogate toluene-d8	%		Org-023	100	1	100	100	0	100	
Surrogate 4-BFB	%		Org-023	102	1	103	102	1	100	

QUALITY CONTROL: vTRH(C6-C10)/BTEXN in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date extracted	-				11	21/10/2021	22/10/2021			
Date analysed	-				11	21/10/2021	22/10/2021			
TRH C_6 - C_9	µg/L	10	Org-023		11	<10	<10	0		
TRH C_6 - C_{10}	µg/L	10	Org-023		11	<10	<10	0		
Benzene	µg/L	1	Org-023		11	<1	<1	0		
Toluene	µg/L	1	Org-023		11	<1	<1	0		
Ethylbenzene	µg/L	1	Org-023		11	<1	<1	0		
m+p-xylene	µg/L	2	Org-023		11	<2	<2	0		
o-xylene	µg/L	1	Org-023		11	<1	<1	0		
Naphthalene	µg/L	1	Org-023		11	<1	<1	0		
Surrogate Dibromofluoromethane	%		Org-023		11	104	105	1		
Surrogate toluene-d8	%		Org-023		11	100	101	1		
Surrogate 4-BFB	%		Org-023		11	106	102	4		

Client Reference: P2007822 Bell Quarry

QUALITY CONTROL: svTRH (C10-C40) in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W2	280787-12
Date extracted	-			22/10/2021	1	22/10/2021	22/10/2021		22/10/2021	22/10/2021
Date analysed	-			22/10/2021	1	22/10/2021	22/10/2021		22/10/2021	25/10/2021
TRH C_{10} - C_{14}	µg/L	50	Org-020	<50	1	<50	<50	0	92	98
TRH C_{15} - C_{28}	µg/L	100	Org-020	<100	1	<100	<100	0	92	95
TRH C_{29} - C_{36}	µg/L	100	Org-020	<100	1	<100	<100	0	99	85
TRH >C_{10} - C_{16}	µg/L	50	Org-020	<50	1	<50	<50	0	92	98
TRH >C_{16} - C_{34}	µg/L	100	Org-020	<100	1	<100	<100	0	92	95
TRH >C_{34} - C_{40}	µg/L	100	Org-020	<100	1	<100	<100	0	99	85
Surrogate o-Terphenyl	%		Org-020	76	1	75	76	1	73	85

QUALITY CONTROL: svTRH (C10-C40) in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date extracted	-				11	22/10/2021	22/10/2021			
Date analysed	-				11	25/10/2021	25/10/2021			
TRH C_{10} - C_{14}	µg/L	50	Org-020		11	<50	<50	0		
TRH C_{15} - C_{28}	µg/L	100	Org-020		11	<100	<100	0		
TRH C_{29} - C_{36}	µg/L	100	Org-020		11	<100	<100	0		
TRH >C_{10} - C_{16}	µg/L	50	Org-020		11	<50	<50	0		
TRH >C_{16} - C_{34}	µg/L	100	Org-020		11	<100	<100	0		
TRH >C_{34} - C_{40}	µg/L	100	Org-020		11	<100	<100	0		
Surrogate o-Terphenyl	%		Org-020		11	87	85	2		

QUALITY CONTROL: PAHs in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W2	280787-2
Date extracted	-			22/10/2021	1	22/10/2021	22/10/2021		22/10/2021	22/10/2021
Date analysed	-			22/10/2021	1	22/10/2021	22/10/2021		22/10/2021	22/10/2021
Naphthalene	µg/L	1	Org-022/025	<1	1	<1	<1	0	76	98
Acenaphthylene	µg/L	1	Org-022/025	<1	1	<1	<1	0		
Acenaphthene	µg/L	1	Org-022/025	<1	1	<1	<1	0	63	83
Fluorene	µg/L	1	Org-022/025	<1	1	<1	<1	0	75	95
Phenanthrene	µg/L	1	Org-022/025	<1	1	<1	<1	0	86	114
Anthracene	µg/L	1	Org-022/025	<1	1	<1	<1	0		
Fluoranthene	µg/L	1	Org-022/025	<1	1	<1	<1	0	66	86
Pyrene	µg/L	1	Org-022/025	<1	1	<1	<1	0	70	93
Benzo(a)anthracene	µg/L	1	Org-022/025	<1	1	<1	<1	0		
Chrysene	µg/L	1	Org-022/025	<1	1	<1	<1	0	74	86
Benzo(b,j+k)fluoranthene	µg/L	2	Org-022/025	<2	1	<2	<2	0		
Benzo(a)pyrene	µg/L	1	Org-022/025	<1	1	<1	<1	0	70	88
Indeno(1,2,3-c,d)pyrene	µg/L	1	Org-022/025	<1	1	<1	<1	0		
Dibenzo(a,h)anthracene	µg/L	1	Org-022/025	<1	1	<1	<1	0		
Benzo(g,h,i)perylene	µg/L	1	Org-022/025	<1	1	<1	<1	0		
Surrogate p-Terphenyl-d14	%		Org-022/025	86	1	88	87	1	77	87

QUALITY CONTROL: PAHs in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date extracted	-				11	22/10/2021	22/10/2021			
Date analysed	-				11	25/10/2021	25/10/2021			
Naphthalene	µg/L	1	Org-022/025		11	<1	<1	0		
Acenaphthylene	µg/L	1	Org-022/025		11	<1	<1	0		
Acenaphthene	µg/L	1	Org-022/025		11	<1	<1	0		
Fluorene	µg/L	1	Org-022/025		11	<1	<1	0		
Phenanthrene	µg/L	1	Org-022/025		11	<1	<1	0		
Anthracene	µg/L	1	Org-022/025		11	<1	<1	0		
Fluoranthene	µg/L	1	Org-022/025		11	<1	<1	0		
Pyrene	µg/L	1	Org-022/025		11	<1	<1	0		
Benzo(a)anthracene	µg/L	1	Org-022/025		11	<1	<1	0		
Chrysene	µg/L	1	Org-022/025		11	<1	<1	0		
Benzo(b,j+k)fluoranthene	µg/L	2	Org-022/025		11	<2	<2	0		
Benzo(a)pyrene	µg/L	1	Org-022/025		11	<1	<1	0		
Indeno(1,2,3-c,d)pyrene	µg/L	1	Org-022/025		11	<1	<1	0		
Dibenzo(a,h)anthracene	µg/L	1	Org-022/025		11	<1	<1	0		
Benzo(g,h,i)perylene	µg/L	1	Org-022/025		11	<1	<1	0		
Surrogate p-Terphenyl-d14	%		Org-022/025		11	93	98	5		

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QUALITY CONTROL: HM in water - dissolved					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W2	280787-2
Date prepared	-			22/10/2021	1	22/10/2021	22/10/2021		22/10/2021	22/10/2021
Date analysed	-			22/10/2021	1	22/10/2021	22/10/2021		22/10/2021	22/10/2021
Arsenic-Dissolved	µg/L	1	Metals-022	<1	1	<1			97	
Cadmium-Dissolved	µg/L	0.1	Metals-022	<0.1	1	<0.1			98	
Chromium-Dissolved	µg/L	1	Metals-022	<1	1	<1			99	
Copper-Dissolved	µg/L	1	Metals-022	<1	1	<1			102	
Lead-Dissolved	µg/L	1	Metals-022	<1	1	<1			98	
Mercury-Dissolved	µg/L	0.05	Metals-021	<0.05	1	<0.05	<0.05	0	110	101
Nickel-Dissolved	µg/L	1	Metals-022	<1	1	<1			100	
Zinc-Dissolved	µg/L	1	Metals-022	<1	1	3			101	

QUALITY CONTROL: HM in water - dissolved					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	280787-4
Date prepared	-				3	22/10/2021	22/10/2021			22/10/2021
Date analysed	-				3	22/10/2021	22/10/2021			22/10/2021
Arsenic-Dissolved	µg/L	1	Metals-022		3	<1	<1	0		98
Cadmium-Dissolved	µg/L	0.1	Metals-022		3	<0.1	<0.1	0		103
Chromium-Dissolved	µg/L	1	Metals-022		3	<1	<1	0		88
Copper-Dissolved	µg/L	1	Metals-022		3	<1	<1	0		105
Lead-Dissolved	µg/L	1	Metals-022		3	<1	<1	0		96
Mercury-Dissolved	µg/L	0.05	Metals-021		3	<0.05				
Nickel-Dissolved	µg/L	1	Metals-022		3	<1	<1	0		103
Zinc-Dissolved	µg/L	1	Metals-022		3	2	2	0		109

QUALITY CONTROL: HM in water - dissolved					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-				11	22/10/2021	22/10/2021			
Date analysed	-				11	22/10/2021	22/10/2021			
Arsenic-Dissolved	µg/L	1	Metals-022		11	<1				
Cadmium-Dissolved	µg/L	0.1	Metals-022		11	<0.1				
Chromium-Dissolved	µg/L	1	Metals-022		11	<1				
Copper-Dissolved	µg/L	1	Metals-022		11	4				
Lead-Dissolved	µg/L	1	Metals-022		11	<1				
Mercury-Dissolved	µg/L	0.05	Metals-021		11	<0.05	<0.05	0		
Nickel-Dissolved	µg/L	1	Metals-022		11	<1				
Zinc-Dissolved	µg/L	1	Metals-022		11	10				

QUALITY CONTROL: HM in water - dissolved					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-				12	22/10/2021	22/10/2021			
Date analysed	-				12	22/10/2021	22/10/2021			
Arsenic-Dissolved	µg/L	1	Metals-022		12	<1	<1	0		
Cadmium-Dissolved	µg/L	0.1	Metals-022		12	<0.1	<0.1	0		
Chromium-Dissolved	µg/L	1	Metals-022		12	<1	<1	0		
Copper-Dissolved	µg/L	1	Metals-022		12	4	4	0		
Lead-Dissolved	µg/L	1	Metals-022		12	<1	<1	0		
Mercury-Dissolved	µg/L	0.05	Metals-021		12	<0.05				
Nickel-Dissolved	µg/L	1	Metals-022		12	3	3	0		
Zinc-Dissolved	µg/L	1	Metals-022		12	35	36	3		

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QUALITY CONTROL: HM in water - total					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	280787-2
Date prepared	-			25/10/2021	1	22/10/2021	22/10/2021		25/10/2021	25/10/2021
Date analysed	-			25/10/2021	1	25/10/2021	25/10/2021		25/10/2021	25/10/2021
Arsenic-Total	µg/L	1	Metals-022	<1	1	<1	<1	0	99	102
Cadmium-Total	µg/L	0.1	Metals-022	<0.1	1	<0.1	<0.1	0	101	102
Chromium-Total	µg/L	1	Metals-022	<1	1	<1	<1	0	98	100
Copper-Total	µg/L	1	Metals-022	<1	1	1	1	0	97	101
Lead-Total	µg/L	1	Metals-022	<1	1	<1	<1	0	100	100
Mercury-Total	µg/L	0.05	Metals-021	<0.05	1	<0.05	<0.05	0	102	110
Nickel-Total	µg/L	1	Metals-022	<1	1	<1	<1	0	96	99
Zinc-Total	µg/L	1	Metals-022	<1	1	3	3	0	97	101

QUALITY CONTROL: HM in water - total					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-				11	22/10/2021	22/10/2021			
Date analysed	-				11	25/10/2021	25/10/2021			
Arsenic-Total	µg/L	1	Metals-022		11	<1	<1	0		
Cadmium-Total	µg/L	0.1	Metals-022		11	<0.1	<0.1	0		
Chromium-Total	µg/L	1	Metals-022		11	2	2	0		
Copper-Total	µg/L	1	Metals-022		11	8	8	0		
Lead-Total	µg/L	1	Metals-022		11	<1	<1	0		
Mercury-Total	µg/L	0.05	Metals-021		11	0.08	0.08	0		
Nickel-Total	µg/L	1	Metals-022		11	2	2	0		
Zinc-Total	µg/L	1	Metals-022		11	11	11	0		

QUALITY CONTROL: Metals in Waters - Acid extractable					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	280787-3
Date prepared	-			22/10/2021	1	22/10/2021	22/10/2021		22/10/2021	22/10/2021
Date analysed	-			25/10/2021	1	25/10/2021	25/10/2021		25/10/2021	25/10/2021
Phosphorus - Total	mg/L	0.05	Metals-020	<0.05	1	<0.05	<0.05	0	102	104

QUALITY CONTROL: Metals in Waters - Acid extractable					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-				11	22/10/2021	22/10/2021			
Date analysed	-				11	25/10/2021	25/10/2021			
Phosphorus - Total	mg/L	0.05	Metals-020		11	<0.05	<0.05	0		

QUALITY CONTROL: Ion Balance					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	280787-2
Date prepared	-			21/10/2021	1	21/10/2021	21/10/2021		21/10/2021	21/10/2021
Date analysed	-			21/10/2021	1	21/10/2021	21/10/2021		21/10/2021	21/10/2021
Calcium - Dissolved	mg/L	0.5	Metals-020	<0.5	1	0.6			90	
Potassium - Dissolved	mg/L	0.5	Metals-020	<0.5	1	1			90	
Sodium - Dissolved	mg/L	0.5	Metals-020	<0.5	1	4			96	
Magnesium - Dissolved	mg/L	0.5	Metals-020	<0.5	1	<0.5			94	
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	5	Inorg-006	<5	1	<5				
Bicarbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	1	11				
Carbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	1	<5				
Total Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	1	11			105	
Sulphate, SO4	mg/L	1	Inorg-081	<1	1	1	1	0	90	90
Chloride, Cl	mg/L	1	Inorg-081	<1	1	6	5	18	96	89
Ionic Balance	%		Inorg-040		1	-29				

QUALITY CONTROL: Ion Balance					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	280787-6
Date prepared	-				5	21/10/2021	21/10/2021			21/10/2021
Date analysed	-				5	21/10/2021	21/10/2021			21/10/2021
Calcium - Dissolved	mg/L	0.5	Metals-020		5	<0.5	<0.5	0		94
Potassium - Dissolved	mg/L	0.5	Metals-020		5	<0.5	<0.5	0		96
Sodium - Dissolved	mg/L	0.5	Metals-020		5	5.2	5.2	0		94
Magnesium - Dissolved	mg/L	0.5	Metals-020		5	0.6	0.6	0		98
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	5	Inorg-006		5	<5				
Bicarbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006		5	5				
Carbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006		5	<5				
Total Alkalinity as $CaCO_3$	mg/L	5	Inorg-006		5	5				
Sulphate, SO4	mg/L	1	Inorg-081		5	3				
Chloride, Cl	mg/L	1	Inorg-081		5	6				
Ionic Balance	%		Inorg-040		5	-12				

QUALITY CONTROL: Ion Balance					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-				10	21/10/2021	21/10/2021			
Date analysed	-				10	21/10/2021	21/10/2021			
Calcium - Dissolved	mg/L	0.5	Metals-020		10	<0.5	<0.5	0		
Potassium - Dissolved	mg/L	0.5	Metals-020		10	1	1	0		
Sodium - Dissolved	mg/L	0.5	Metals-020		10	3	3	0		
Magnesium - Dissolved	mg/L	0.5	Metals-020		10	<0.5	<0.5	0		
Hydroxide Alkalinity (OH$^-$) as CaCO$_3$	mg/L	5	Inorg-006		10	<5				
Bicarbonate Alkalinity as CaCO$_3$	mg/L	5	Inorg-006		10	7				
Carbonate Alkalinity as CaCO$_3$	mg/L	5	Inorg-006		10	<5				
Total Alkalinity as CaCO$_3$	mg/L	5	Inorg-006		10	7				
Sulphate, SO4	mg/L	1	Inorg-081		10	2				
Chloride, Cl	mg/L	1	Inorg-081		10	4				
Ionic Balance	%		Inorg-040		10	-23				

QUALITY CONTROL: Ion Balance					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-				11	21/10/2021	21/10/2021			
Date analysed	-				11	21/10/2021	21/10/2021			
Calcium - Dissolved	mg/L	0.5	Metals-020		11	0.6				
Potassium - Dissolved	mg/L	0.5	Metals-020		11	1				
Sodium - Dissolved	mg/L	0.5	Metals-020		11	5.3				
Magnesium - Dissolved	mg/L	0.5	Metals-020		11	<0.5				
Hydroxide Alkalinity (OH$^-$) as CaCO$_3$	mg/L	5	Inorg-006		11	<5				
Bicarbonate Alkalinity as CaCO$_3$	mg/L	5	Inorg-006		11	9				
Carbonate Alkalinity as CaCO$_3$	mg/L	5	Inorg-006		11	<5				
Total Alkalinity as CaCO$_3$	mg/L	5	Inorg-006		11	9				
Sulphate, SO4	mg/L	1	Inorg-081		11	2	2	0		
Chloride, Cl	mg/L	1	Inorg-081		11	5	5	0		
Ionic Balance	%		Inorg-040		11	-13				

QUALITY CONTROL: Miscellaneous Inorganics					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	280787-2
Date prepared	-			21/10/2021	1	21/10/2021	21/10/2021		21/10/2021	21/10/2021
Date analysed	-			21/10/2021	1	21/10/2021	21/10/2021		21/10/2021	21/10/2021
Total Nitrogen in water	mg/L	0.1	Inorg-055/062/127	<0.1	1	0.2	0.2	0	99	102
NOx as N in water	mg/L	0.005	Inorg-055	<0.005	1	<0.005	<0.005	0	107	110
Ammonia as N in water	mg/L	0.005	Inorg-057	<0.005	1	<0.005	<0.005	0	97	104
Phosphate as P in water	mg/L	0.005	Inorg-060	<0.005	1	<0.005	<0.005	0	95	102

QUALITY CONTROL: Miscellaneous Inorganics					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-			[NT]	11	21/10/2021	21/10/2021		[NT]	[NT]
Date analysed	-			[NT]	11	21/10/2021	21/10/2021		[NT]	[NT]
Total Nitrogen in water	mg/L	0.1	Inorg-055/062/127	[NT]	11	<0.1	<0.1	0	[NT]	[NT]
NOx as N in water	mg/L	0.005	Inorg-055	[NT]	11	0.01	0.01	0	[NT]	[NT]
Ammonia as N in water	mg/L	0.005	Inorg-057	[NT]	11	0.020	0.022	10	[NT]	[NT]
Phosphate as P in water	mg/L	0.005	Inorg-060	[NT]	11	<0.005	<0.005	0	[NT]	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from "2018 TLVs and BEIs", as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

Report Comments

Dissolved Metals: no filtered, preserved sample was received, therefore the unpreserved sample was filtered through 0.45μm filter at the lab.
Note: there is a possibility some elements may be underestimated.

The mass inbalance may be caused by other ions that have not been measured.
TRACE METALS: In theory the total metal content should be higher than the dissolved metal content. However, in some samples this is not the case. The sample has been re-analysed for both Total and Dissolved metals and results have been confirmed.

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CERTIFICATE OF ANALYSIS 281301

Client Details

Client	Martens & Associates Pty Ltd
Attention	R Kightley
Address	Suite 201, 20 George St, Hornsby, NSW, 2077

Sample Details

Your Reference	**P2007822 Bell Quarry**
Number of Samples	13 Water
Date samples received	27/10/2021
Date completed instructions received	27/10/2021

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Please refer to the last page of this report for any comments relating to the results.

Report Details

Date results requested by	03/11/2021
Date of Issue	03/11/2021

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Accredited for compliance with ISO/IEC 17025 - Testing. **Tests not covered by NATA are denoted with ***

Results Approved By
Diego Bigolin, Inorganics Supervisor
Dragana Tomas, Senior Chemist
Hannah Nguyen, Metals Supervisor
Priya Samarawickrama, Senior Chemist
Steven Luong, Organics Supervisor

Authorised By

Nancy Zhang, Laboratory Manager

VOCs in water-Low Level		
Our Reference		281301-13
Your Reference	UNITS	7822/MW201
Date Sampled		25/10/2021
Type of sample		Water
Date analysed	-	01/11/2021
MTBE	µg/L	<0.1
Dichlorodifluoromethane	µg/L	<2
Chloromethane	µg/L	<2
Vinyl Chloride	µg/L	<0.2
Bromomethane	µg/L	<2
Chloroethane	µg/L	<2
Trichlorofluoromethane	µg/L	<2
1,1-Dichloroethene	µg/L	<0.1
Trans-1,2-dichloroethene	µg/L	<0.1
1,1-dichloroethane	µg/L	<0.1
Cis-1,2-dichloroethene	µg/L	<0.1
Bromochloromethane	µg/L	<0.5
Chloroform	µg/L	<0.5
2,2-dichloropropane	µg/L	<0.1
1,2-dichloroethane	µg/L	<0.1
1,1,1-trichloroethane	µg/L	<0.1
1,1-dichloropropene	µg/L	<0.1
Carbon tetrachloride	µg/L	<0.1
Benzene	µg/L	<0.1
Dibromomethane	µg/L	<0.5
1,2-dichloropropane	µg/L	<0.1
Trichloroethene	µg/L	<0.1
Bromodichloromethane	µg/L	<0.1
trans-1,3-dichloropropene	µg/L	<0.1
cis-1,3-dichloropropene	µg/L	<0.1
1,1,2-trichloroethane	µg/L	<0.1
Toluene	µg/L	0.3
1,3-dichloropropane	µg/L	<0.1
Dibromochloromethane	µg/L	<0.1
1,2-dibromoethane	µg/L	<0.1
Tetrachloroethene	µg/L	<0.1
1,1,1,2-tetrachloroethane	µg/L	<0.1
Chlorobenzene	µg/L	<0.1
Ethylbenzene	µg/L	<0.1
Bromoform	µg/L	<0.1

VOCs in water-Low Level		
Our Reference		281301-13
Your Reference	UNITS	7822/MW201
Date Sampled		25/10/2021
Type of sample		Water
m+p-xylene	µg/L	<0.2
Styrene	µg/L	<0.1
1,1,2,2-tetrachloroethane	µg/L	<0.1
o-xylene	µg/L	0.2
1,2,3-trichloropropane	µg/L	<0.1
Isopropylbenzene	µg/L	<0.1
Bromobenzene	µg/L	<0.1
n-propyl benzene	µg/L	<0.1
2-chlorotoluene	µg/L	<0.1
4-chlorotoluene	µg/L	<0.1
1,3,5-trimethyl benzene	µg/L	<0.1
Tert-butyl benzene	µg/L	<0.1
1,2,4-trimethyl benzene	µg/L	0.1
1,3-dichlorobenzene	µg/L	<0.1
Sec-butyl benzene	µg/L	<0.1
1,4-dichlorobenzene	µg/L	<0.1
4-isopropyl toluene	µg/L	<0.1
1,2-dichlorobenzene	µg/L	<0.1
n-butyl benzene	µg/L	<0.1
1,2-dibromo-3-chloropropane	µg/L	<0.1
1,2,4-trichlorobenzene	µg/L	<0.1
Hexachlorobutadiene	µg/L	<0.2
1,2,3-trichlorobenzene	µg/L	<0.1
Surrogate Dibromofluoromethane	%	106
Surrogate toluene-d8	%	102
Surrogate 4-BFB	%	96

vTRH(C6-C10)/BTEXN in Water						
Our Reference		281301-1	281301-2	281301-3	281301-4	281301-5
Your Reference	UNITS	7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		25/10/2021	25/10/2021	25/10/2021	25/10/2021	25/10/2021
Type of sample		Water	Water	Water	Water	Water
Date extracted	-	29/10/2021	29/10/2021	29/10/2021	29/10/2021	29/10/2021
Date analysed	-	29/10/2021	29/10/2021	29/10/2021	29/10/2021	29/10/2021
TRH C_6 - C_9	µg/L	<10	<10	<10	<10	<10
TRH C_6 - C_{10}	µg/L	<10	<10	<10	<10	<10
TRH C_6 - C_{10} less BTEX (F1)	µg/L	<10	<10	<10	<10	<10
Benzene	µg/L	<1	<1	<1	<1	<1
Toluene	µg/L	<1	<1	<1	<1	<1
Ethylbenzene	µg/L	<1	<1	<1	<1	<1
m+p-xylene	µg/L	<2	<2	<2	<2	<2
o-xylene	µg/L	<1	<1	<1	<1	<1
Naphthalene	µg/L	<1	<1	<1	<1	<1
Surrogate Dibromofluoromethane	%	110	109	108	108	110
Surrogate toluene-d8	%	101	102	101	101	100
Surrogate 4-BFB	%	109	107	108	108	110

vTRH(C6-C10)/BTEXN in Water						
Our Reference		281301-6	281301-7	281301-8	281301-9	281301-10
Your Reference	UNITS	7822/SW02	7822/MW401	7822/MW302A	7822/MW301A	7822/MW301B
Date Sampled		25/10/2021	25/10/2021	25/10/2021	25/10/2021	25/10/2021
Type of sample		Water	Water	Water	Water	Water
Date extracted	-	29/10/2021	29/10/2021	29/10/2021	29/10/2021	29/10/2021
Date analysed	-	29/10/2021	29/10/2021	29/10/2021	29/10/2021	29/10/2021
TRH C_6 - C_9	µg/L	<10	<10	<10	<10	<10
TRH C_6 - C_{10}	µg/L	<10	<10	<10	<10	<10
TRH C_6 - C_{10} less BTEX (F1)	µg/L	<10	<10	<10	<10	<10
Benzene	µg/L	<1	<1	<1	<1	<1
Toluene	µg/L	<1	<1	<1	<1	<1
Ethylbenzene	µg/L	<1	<1	<1	<1	<1
m+p-xylene	µg/L	<2	<2	<2	<2	<2
o-xylene	µg/L	<1	<1	<1	<1	<1
Naphthalene	µg/L	<1	<1	<1	<1	<1
Surrogate Dibromofluoromethane	%	108	110	110	109	110
Surrogate toluene-d8	%	100	100	101	101	101
Surrogate 4-BFB	%	108	107	108	108	107

vTRH(C6-C10)/BTEXN in Water				
Our Reference		281301-11	281301-12	281301-13
Your Reference	UNITS	7822/MB02	7822/MB03	7822/MW201
Date Sampled		25/10/2021	25/10/2021	25/10/2021
Type of sample		Water	Water	Water
Date extracted	-	29/10/2021	29/10/2021	29/10/2021
Date analysed	-	29/10/2021	29/10/2021	29/10/2021
TRH C_6 - C_9	µg/L	<10	<10	<10
TRH C_6 - C_{10}	µg/L	<10	<10	<10
TRH C_6 - C_{10} less BTEX (F1)	µg/L	<10	<10	<10
Benzene	µg/L	<1	<1	<1
Toluene	µg/L	<1	<1	<1
Ethylbenzene	µg/L	<1	<1	<1
m+p-xylene	µg/L	<2	<2	<2
o-xylene	µg/L	<1	<1	<1
Naphthalene	µg/L	<1	<1	<1
Surrogate Dibromofluoromethane	%	110	109	110
Surrogate toluene-d8	%	100	101	100
Surrogate 4-BFB	%	105	108	107

svTRH (C10-C40) in Water

Our Reference		281301-1	281301-2	281301-3	281301-4	281301-5
Your Reference	UNITS	7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		25/10/2021	25/10/2021	25/10/2021	25/10/2021	25/10/2021
Type of sample		Water	Water	Water	Water	Water
Date extracted	-	28/10/2021	28/10/2021	28/10/2021	28/10/2021	28/10/2021
Date analysed	-	28/10/2021	28/10/2021	28/10/2021	28/10/2021	29/10/2021
TRH C_{10} - C_{14}	µg/L	<50	<50	<50	<50	<50
TRH C_{15} - C_{28}	µg/L	<100	<100	<100	<100	<100
TRH C_{29} - C_{36}	µg/L	<100	<100	<100	<100	<100
Total +ve TRH (C10-C36)	µg/L	<50	<50	<50	<50	<50
TRH >C_{10} - C_{16}	µg/L	<50	<50	<50	<50	<50
TRH >C_{10} - C_{16} less Naphthalene (F2)	µg/L	<50	<50	<50	<50	<50
TRH >C_{16} - C_{34}	µg/L	<100	<100	<100	<100	<100
TRH >C_{34} - C_{40}	µg/L	<100	<100	<100	<100	<100
Total +ve TRH (>C10-C40)	µg/L	<50	<50	<50	<50	<50
Surrogate o-Terphenyl	%	84	95	73	98	108

svTRH (C10-C40) in Water

Our Reference		281301-6	281301-7	281301-8	281301-9	281301-10
Your Reference	UNITS	7822/SW02	7822/MW401	7822/MW302A	7822/MW301A	7822/MW301B
Date Sampled		25/10/2021	25/10/2021	25/10/2021	25/10/2021	25/10/2021
Type of sample		Water	Water	Water	Water	Water
Date extracted	-	28/10/2021	28/10/2021	28/10/2021	28/10/2021	28/10/2021
Date analysed	-	29/10/2021	29/10/2021	29/10/2021	29/10/2021	29/10/2021
TRH C_{10} - C_{14}	µg/L	<50	<50	<50	<50	<50
TRH C_{15} - C_{28}	µg/L	<100	<100	<100	<100	<100
TRH C_{29} - C_{36}	µg/L	<100	<100	<100	<100	<100
Total +ve TRH (C10-C36)	µg/L	<50	<50	<50	<50	<50
TRH >C_{10} - C_{16}	µg/L	<50	<50	<50	<50	<50
TRH >C_{10} - C_{16} less Naphthalene (F2)	µg/L	<50	<50	<50	<50	<50
TRH >C_{16} - C_{34}	µg/L	<100	<100	<100	<100	<100
TRH >C_{34} - C_{40}	µg/L	<100	<100	<100	<100	<100
Total +ve TRH (>C10-C40)	µg/L	<50	<50	<50	<50	<50
Surrogate o-Terphenyl	%	84	85	80	139	85

svTRH (C10-C40) in Water				
Our Reference		281301-11	281301-12	281301-13
Your Reference	UNITS	7822/MB02	7822/MB03	7822/MW201
Date Sampled		25/10/2021	25/10/2021	25/10/2021
Type of sample		Water	Water	Water
Date extracted	-	28/10/2021	28/10/2021	28/10/2021
Date analysed	-	29/10/2021	29/10/2021	29/10/2021
TRH C_{10} - C_{14}	µg/L	<50	<50	95
TRH C_{15} - C_{28}	µg/L	<100	<100	240
TRH C_{29} - C_{36}	µg/L	<100	<100	<100
Total +ve TRH (C10-C36)	µg/L	<50	<50	340
TRH >C_{10} - C_{16}	µg/L	<50	<50	200
TRH >C_{10} - C_{16} less Naphthalene (F2)	µg/L	<50	<50	200
TRH >C_{16} - C_{34}	µg/L	<100	<100	120
TRH >C_{34} - C_{40}	µg/L	<100	<100	<100
Total +ve TRH (>C10-C40)	µg/L	<50	<50	330
Surrogate o-Terphenyl	%	93	97	97

Client Reference: P2007822 Bell Quarry

PAHs in Water - Low Level						
Our Reference		281301-1	281301-2	281301-3	281301-4	281301-5
Your Reference	UNITS	7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		25/10/2021	25/10/2021	25/10/2021	25/10/2021	25/10/2021
Type of sample		Water	Water	Water	Water	Water
Date extracted	-	28/10/2021	28/10/2021	28/10/2021	28/10/2021	28/10/2021
Date analysed	-	29/10/2021	29/10/2021	29/10/2021	29/10/2021	29/10/2021
Naphthalene	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Acenaphthylene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Fluorene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Phenanthrene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Anthracene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Fluoranthene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Pyrene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(a)anthracene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Chrysene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(b,j+k)fluoranthene	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Benzo(a)pyrene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Indeno(1,2,3-c,d)pyrene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Dibenzo(a,h)anthracene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(g,h,i)perylene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(a)pyrene TEQ	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Total +ve PAH's	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Surrogate p-Terphenyl-d14	%	93	105	82	95	104

PAHs in Water - Low Level						
Our Reference		281301-6	281301-7	281301-8	281301-9	281301-10
Your Reference	UNITS	7822/SW02	7822/MW401	7822/MW302A	7822/MW301A	7822/MW301B
Date Sampled		25/10/2021	25/10/2021	25/10/2021	25/10/2021	25/10/2021
Type of sample		Water	Water	Water	Water	Water
Date extracted	-	28/10/2021	28/10/2021	28/10/2021	28/10/2021	28/10/2021
Date analysed	-	29/10/2021	29/10/2021	29/10/2021	29/10/2021	29/10/2021
Naphthalene	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Acenaphthylene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Acenaphthene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Fluorene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Phenanthrene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Anthracene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Fluoranthene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Pyrene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(a)anthracene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Chrysene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(b,j+k)fluoranthene	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Benzo(a)pyrene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Indeno(1,2,3-c,d)pyrene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Dibenzo(a,h)anthracene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(g,h,i)perylene	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Benzo(a)pyrene TEQ	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Total +ve PAH's	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Surrogate p-Terphenyl-d14	%	90	97	80	125	92

PAHs in Water - Low Level				
Our Reference		281301-11	281301-12	281301-13
Your Reference	UNITS	7822/MB02	7822/MB03	7822/MW201
Date Sampled		25/10/2021	25/10/2021	25/10/2021
Type of sample		Water	Water	Water
Date extracted	-	28/10/2021	28/10/2021	28/10/2021
Date analysed	-	29/10/2021	29/10/2021	29/10/2021
Naphthalene	µg/L	<0.2	<0.2	<0.2
Acenaphthylene	µg/L	<0.1	<0.1	<0.1
Acenaphthene	µg/L	<0.1	<0.1	<0.1
Fluorene	µg/L	<0.1	<0.1	<0.1
Phenanthrene	µg/L	<0.1	<0.1	<0.1
Anthracene	µg/L	<0.1	<0.1	<0.1
Fluoranthene	µg/L	<0.1	<0.1	<0.1
Pyrene	µg/L	<0.1	<0.1	<0.1
Benzo(a)anthracene	µg/L	<0.1	<0.1	<0.1
Chrysene	µg/L	<0.1	<0.1	<0.1
Benzo(b,j+k)fluoranthene	µg/L	<0.2	<0.2	<0.2
Benzo(a)pyrene	µg/L	<0.1	<0.1	<0.1
Indeno(1,2,3-c,d)pyrene	µg/L	<0.1	<0.1	<0.1
Dibenzo(a,h)anthracene	µg/L	<0.1	<0.1	<0.1
Benzo(g,h,i)perylene	µg/L	<0.1	<0.1	<0.1
Benzo(a)pyrene TEQ	µg/L	<0.5	<0.5	<0.5
Total +ve PAH's	µg/L	<0.1	<0.1	<0.1
Surrogate p-Terphenyl-d14	%	101	98	129

Client Reference: P2007822 Bell Quarry

Organochlorine Pesticides in Water						
Our Reference		281301-1	281301-2	281301-3	281301-4	281301-5
Your Reference	UNITS	7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		25/10/2021	25/10/2021	25/10/2021	25/10/2021	25/10/2021
Type of sample		Water	Water	Water	Water	Water
Date extracted	-	28/10/2021	28/10/2021	28/10/2021	28/10/2021	28/10/2021
Date analysed	-	29/10/2021	29/10/2021	29/10/2021	29/10/2021	29/10/2021
alpha-BHC	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
HCB	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
beta-BHC	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
gamma-BHC	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Heptachlor	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
delta-BHC	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Aldrin	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Heptachlor Epoxide	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
gamma-Chlordane	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
alpha-Chlordane	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Endosulfan I	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
pp-DDE	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Dieldrin	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Endrin	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Endosulfan II	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
pp-DDD	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Endrin Aldehyde	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
pp-DDT	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Endosulfan Sulphate	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Methoxychlor	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Surrogate TCMX	%	90	96	71	82	98

Organochlorine Pesticides in Water						
Our Reference		281301-6	281301-7	281301-8	281301-9	281301-10
Your Reference	UNITS	7822/SW02	7822/MW401	7822/MW302A	7822/MW301A	7822/MW301B
Date Sampled		25/10/2021	25/10/2021	25/10/2021	25/10/2021	25/10/2021
Type of sample		Water	Water	Water	Water	Water
Date extracted	-	28/10/2021	28/10/2021	28/10/2021	28/10/2021	28/10/2021
Date analysed	-	29/10/2021	29/10/2021	29/10/2021	29/10/2021	29/10/2021
alpha-BHC	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
HCB	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
beta-BHC	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
gamma-BHC	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Heptachlor	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
delta-BHC	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Aldrin	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Heptachlor Epoxide	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
gamma-Chlordane	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
alpha-Chlordane	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Endosulfan I	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
pp-DDE	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Dieldrin	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Endrin	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Endosulfan II	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
pp-DDD	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Endrin Aldehyde	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
pp-DDT	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Endosulfan Sulphate	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Methoxychlor	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Surrogate TCMX	%	89	85	82	125	94

Organochlorine Pesticides in Water				
Our Reference		281301-11	281301-12	281301-13
Your Reference	UNITS	7822/MB02	7822/MB03	7822/MW201
Date Sampled		25/10/2021	25/10/2021	25/10/2021
Type of sample		Water	Water	Water
Date extracted	-	28/10/2021	28/10/2021	28/10/2021
Date analysed	-	29/10/2021	29/10/2021	29/10/2021
alpha-BHC	µg/L	<0.2	<0.2	<0.2
HCB	µg/L	<0.2	<0.2	<0.2
beta-BHC	µg/L	<0.2	<0.2	<0.2
gamma-BHC	µg/L	<0.2	<0.2	<0.2
Heptachlor	µg/L	<0.2	<0.2	<0.2
delta-BHC	µg/L	<0.2	<0.2	<0.2
Aldrin	µg/L	<0.2	<0.2	<0.2
Heptachlor Epoxide	µg/L	<0.2	<0.2	<0.2
gamma-Chlordane	µg/L	<0.2	<0.2	<0.2
alpha-Chlordane	µg/L	<0.2	<0.2	<0.2
Endosulfan I	µg/L	<0.2	<0.2	<0.2
pp-DDE	µg/L	<0.2	<0.2	<0.2
Dieldrin	µg/L	<0.2	<0.2	<0.2
Endrin	µg/L	<0.2	<0.2	<0.2
Endosulfan II	µg/L	<0.2	<0.2	<0.2
pp-DDD	µg/L	<0.2	<0.2	<0.2
Endrin Aldehyde	µg/L	<0.2	<0.2	<0.2
pp-DDT	µg/L	<0.2	<0.2	<0.2
Endosulfan Sulphate	µg/L	<0.2	<0.2	<0.2
Methoxychlor	µg/L	<0.2	<0.2	<0.2
Surrogate TCMX	%	88	86	129

OP Pesticides in Water						
Our Reference	UNITS	281301-1	281301-2	281301-3	281301-4	281301-5
Your Reference		7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		25/10/2021	25/10/2021	25/10/2021	25/10/2021	25/10/2021
Type of sample		Water	Water	Water	Water	Water
Date extracted	-	28/10/2021	28/10/2021	28/10/2021	28/10/2021	28/10/2021
Date analysed	-	29/10/2021	29/10/2021	29/10/2021	29/10/2021	29/10/2021
Dichlorvos	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Dimethoate	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Diazinon	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Chlorpyriphos-methyl	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Ronnel	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Fenitrothion	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Malathion	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Chlorpyriphos	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Parathion	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Bromophos ethyl	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Ethion	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Azinphos-methyl (Guthion)	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Surrogate TCMX	%	90	96	71	82	98

OP Pesticides in Water						
Our Reference	UNITS	281301-6	281301-7	281301-8	281301-9	281301-10
Your Reference		7822/SW02	7822/MW401	7822/MW302A	7822/MW301A	7822/MW301B
Date Sampled		25/10/2021	25/10/2021	25/10/2021	25/10/2021	25/10/2021
Type of sample		Water	Water	Water	Water	Water
Date extracted	-	28/10/2021	28/10/2021	28/10/2021	28/10/2021	28/10/2021
Date analysed	-	29/10/2021	29/10/2021	29/10/2021	29/10/2021	29/10/2021
Dichlorvos	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Dimethoate	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Diazinon	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Chlorpyriphos-methyl	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Ronnel	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Fenitrothion	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Malathion	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Chlorpyriphos	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Parathion	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Bromophos ethyl	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Ethion	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Azinphos-methyl (Guthion)	µg/L	<0.2	<0.2	<0.2	<0.2	<0.2
Surrogate TCMX	%	89	85	82	125	94

OP Pesticides in Water				
Our Reference		281301-11	281301-12	281301-13
Your Reference	UNITS	7822/MB02	7822/MB03	7822/MW201
Date Sampled		25/10/2021	25/10/2021	25/10/2021
Type of sample		Water	Water	Water
Date extracted	-	28/10/2021	28/10/2021	28/10/2021
Date analysed	-	29/10/2021	29/10/2021	29/10/2021
Dichlorvos	µg/L	<0.2	<0.2	<0.2
Dimethoate	µg/L	<0.2	<0.2	<0.2
Diazinon	µg/L	<0.2	<0.2	<0.2
Chlorpyriphos-methyl	µg/L	<0.2	<0.2	<0.2
Ronnel	µg/L	<0.2	<0.2	<0.2
Fenitrothion	µg/L	<0.2	<0.2	<0.2
Malathion	µg/L	<0.2	<0.2	<0.2
Chlorpyriphos	µg/L	<0.2	<0.2	<0.2
Parathion	µg/L	<0.2	<0.2	<0.2
Bromophos ethyl	µg/L	<0.2	<0.2	<0.2
Ethion	µg/L	<0.2	<0.2	<0.2
Azinphos-methyl (Guthion)	µg/L	<0.2	<0.2	<0.2
Surrogate TCMX	%	88	86	129

PCBs in Water		
Our Reference		281301-13
Your Reference	UNITS	7822/MW201
Date Sampled		25/10/2021
Type of sample		Water
Date extracted	-	28/10/2021
Date analysed	-	29/10/2021
Aroclor 1016	µg/L	<2
Aroclor 1221	µg/L	<2
Aroclor 1232	µg/L	<2
Aroclor 1242	µg/L	<2
Aroclor 1248	µg/L	<2
Aroclor 1254	µg/L	<2
Aroclor 1260	µg/L	<2
Surrogate TCMX	%	129

Client Reference: P2007822 Bell Quarry

HM in water - dissolved						
Our Reference		281301-1	281301-2	281301-3	281301-4	281301-5
Your Reference	UNITS	7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		25/10/2021	25/10/2021	25/10/2021	25/10/2021	25/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	28/10/2021	28/10/2021	28/10/2021	28/10/2021	28/10/2021
Date analysed	-	28/10/2021	28/10/2021	28/10/2021	28/10/2021	28/10/2021
Arsenic-Dissolved	µg/L	<1	<1	<1	<1	<1
Cadmium-Dissolved	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium-Dissolved	µg/L	<1	<1	<1	<1	<1
Copper-Dissolved	µg/L	<1	<1	<1	<1	<1
Lead-Dissolved	µg/L	<1	<1	<1	<1	<1
Mercury-Dissolved	µg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Nickel-Dissolved	µg/L	<1	<1	<1	<1	<1
Zinc-Dissolved	µg/L	<1	<1	<1	<1	<1
Aluminium-Dissolved	µg/L	<10	<10	<10	30	40
Iron-Dissolved	µg/L	20	40	190	<10	140
Manganese-Dissolved	µg/L	<5	48	37	<5	5
Antimony-Dissolved	µg/L	<1	<1	<1	<1	<1
Barium-Dissolved	µg/L	4	4	5	4	4
Beryllium-Dissolved	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Boron-Dissolved	µg/L	<20	<20	<20	<20	<20
Cobalt-Dissolved	µg/L	<1	<1	<1	<1	<1
Lithium-Dissolved	µg/L	<1	<1	<1	<1	<1
Molybdenum-Dissolved	µg/L	<1	<1	<1	<1	<1
Selenium-Dissolved	µg/L	<1	<1	<1	<1	<1
Silver-Dissolved	µg/L	<1	<1	<1	<1	<1
Strontium-Dissolved	µg/L	9	7	9	2	3
Thallium-Dissolved	µg/L	<1	<1	<1	<1	<1
Titanium-Dissolved	µg/L	<1	<1	<1	<1	<1
Tin-Dissolved	µg/L	<1	<1	<1	<1	<1
Vanadium-Dissolved	µg/L	<1	<1	<1	<1	<1

Client Reference: P2007822 Bell Quarry

HM in water - dissolved						
Our Reference		281301-6	281301-7	281301-8	281301-9	281301-10
Your Reference	UNITS	7822/SW02	7822/MW401	7822/MW302A	7822/MW301A	7822/MW301B
Date Sampled		25/10/2021	25/10/2021	25/10/2021	25/10/2021	25/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	28/10/2021	28/10/2021	28/10/2021	28/10/2021	28/10/2021
Date analysed	-	28/10/2021	28/10/2021	28/10/2021	28/10/2021	28/10/2021
Arsenic-Dissolved	µg/L	<1	<1	<1	<1	<1
Cadmium-Dissolved	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium-Dissolved	µg/L	<1	<1	<1	<1	<1
Copper-Dissolved	µg/L	<1	1	<1	1	10
Lead-Dissolved	µg/L	<1	<1	<1	<1	<1
Mercury-Dissolved	µg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Nickel-Dissolved	µg/L	<1	<1	<1	3	<1
Zinc-Dissolved	µg/L	2	<1	<1	8	2
Aluminium-Dissolved	µg/L	60	<10	40	<10	30
Iron-Dissolved	µg/L	<10	<10	40	3,000	10
Manganese-Dissolved	µg/L	6	19	8	54	<5
Antimony-Dissolved	µg/L	<1				
Barium-Dissolved	µg/L	5				
Beryllium-Dissolved	µg/L	<0.5				
Boron-Dissolved	µg/L	<20				
Cobalt-Dissolved	µg/L	<1				
Lithium-Dissolved	µg/L	<1				
Molybdenum-Dissolved	µg/L	<1				
Selenium-Dissolved	µg/L	<1				
Silver-Dissolved	µg/L	<1				
Strontium-Dissolved	µg/L	3				
Thallium-Dissolved	µg/L	<1				
Titanium-Dissolved	µg/L	<1				
Tin-Dissolved	µg/L	<1				
Vanadium-Dissolved	µg/L	<1				

HM in water - dissolved				
Our Reference		281301-11	281301-12	281301-13
Your Reference	UNITS	7822/MB02	7822/MB03	7822/MW201
Date Sampled		25/10/2021	25/10/2021	25/10/2021
Type of sample		Water	Water	Water
Date prepared	-	28/10/2021	28/10/2021	28/10/2021
Date analysed	-	28/10/2021	28/10/2021	28/10/2021
Arsenic-Dissolved	µg/L	<1	<1	<1
Cadmium-Dissolved	µg/L	<0.1	<0.1	<0.1
Chromium-Dissolved	µg/L	<1	<1	<1
Copper-Dissolved	µg/L	1	3	40
Lead-Dissolved	µg/L	<1	<1	<1
Mercury-Dissolved	µg/L	<0.05	<0.05	<0.05
Nickel-Dissolved	µg/L	1	3	11
Zinc-Dissolved	µg/L	14	78	77
Aluminium-Dissolved	µg/L	<10	40	<10
Iron-Dissolved	µg/L	210	50	40
Manganese-Dissolved	µg/L	250	610	10

HM in water - total

Our Reference		281301-1	281301-2	281301-3	281301-4	281301-5
Your Reference	UNITS	7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		25/10/2021	25/10/2021	25/10/2021	25/10/2021	25/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	28/10/2021	28/10/2021	28/10/2021	28/10/2021	28/10/2021
Date analysed	-	28/10/2021	28/10/2021	28/10/2021	28/10/2021	28/10/2021
Arsenic-Total	µg/L	<1	<1	<1	<1	<1
Cadmium-Total	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium-Total	µg/L	<1	<1	<1	<1	<1
Copper-Total	µg/L	<1	<1	<1	<1	<1
Lead-Total	µg/L	<1	<1	<1	<1	<1
Mercury-Total	µg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Nickel-Total	µg/L	<1	<1	<1	<1	<1
Zinc-Total	µg/L	1	1	1	<1	<1
Aluminium-Total	µg/L	20	50	20	40	70
Iron-Total	µg/L	190	240	620	<10	250
Manganese-Total	µg/L	35	72	65	<5	6
Antimony-Total	µg/L	<1	<1	<1	<1	<1
Barium-Total	µg/L	7	7	7	3	5
Beryllium-Total	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Boron-Total	µg/L	<20	<20	<20	<20	<20
Cobalt-Total	µg/L	<1	<1	<1	<1	<1
Lithium-Total	µg/L	<1	<1	<1	<1	<1
Molybdenum-Total	µg/L	<1	<1	<1	<1	<1
Selenium-Total	µg/L	<1	<1	<1	<1	<1
Silver-Total	µg/L	<1	<1	<1	<1	<1
Strontium-Total	µg/L	10	7.8	8.8	1.6	2.4
Thallium-Total	µg/L	<1	<1	<1	<1	<1
Titanium-Total	µg/L	<1	1.1	<1	<1	<1
Tin-Total	µg/L	<1	<1	<1	<1	<1
Vanadium-Total	µg/L	<1	<1	<1	<1	<1

Client Reference: P2007822 Bell Quarry

HM in water - total						
Our Reference		281301-6	281301-7	281301-8	281301-9	281301-10
Your Reference	UNITS	7822/SW02	7822/MW401	7822/MW302A	7822/MW301A	7822/MW301B
Date Sampled		25/10/2021	25/10/2021	25/10/2021	25/10/2021	25/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	28/10/2021	28/10/2021	28/10/2021	28/10/2021	28/10/2021
Date analysed	-	28/10/2021	28/10/2021	28/10/2021	28/10/2021	28/10/2021
Arsenic-Total	µg/L	<1	<1	6	<1	<1
Cadmium-Total	µg/L	<0.1	<0.1	0.1	<0.1	<0.1
Chromium-Total	µg/L	<1	<1	7	18	3
Copper-Total	µg/L	1	4	16	8	23
Lead-Total	µg/L	2	<1	37	1	3
Mercury-Total	µg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Nickel-Total	µg/L	<1	<1	4	4	<1
Zinc-Total	µg/L	2	<1	34	5	2
Aluminium-Total	µg/L	100	30	8,900	470	2,900
Iron-Total	µg/L	45	18	13,000	9,000	830
Manganese-Total	µg/L	6	21	280	59	7
Antimony-Total	µg/L	<1	[NA]	[NA]	[NA]	[NA]
Barium-Total	µg/L	6	[NA]	[NA]	[NA]	[NA]
Beryllium-Total	µg/L	<0.5	[NA]	[NA]	[NA]	[NA]
Boron-Total	µg/L	<20	[NA]	[NA]	[NA]	[NA]
Cobalt-Total	µg/L	<1	[NA]	[NA]	[NA]	[NA]
Lithium-Total	µg/L	<1	[NA]	[NA]	[NA]	[NA]
Molybdenum-Total	µg/L	<1	[NA]	[NA]	[NA]	[NA]
Selenium-Total	µg/L	<1	[NA]	[NA]	[NA]	[NA]
Silver-Total	µg/L	<1	[NA]	[NA]	[NA]	[NA]
Strontium-Total	µg/L	2.7	[NA]	[NA]	[NA]	[NA]
Thallium-Total	µg/L	<1	[NA]	[NA]	[NA]	[NA]
Titanium-Total	µg/L	<1	[NA]	[NA]	[NA]	[NA]
Tin-Total	µg/L	<1	[NA]	[NA]	[NA]	[NA]
Vanadium-Total	µg/L	<1	[NA]	[NA]	[NA]	[NA]

HM in water - total				
Our Reference		281301-11	281301-12	281301-13
Your Reference	UNITS	7822/MB02	7822/MB03	7822/MW201
Date Sampled		25/10/2021	25/10/2021	25/10/2021
Type of sample		Water	Water	Water
Date prepared	-	28/10/2021	28/10/2021	28/10/2021
Date analysed	-	28/10/2021	28/10/2021	28/10/2021
Arsenic-Total	µg/L	<1	<1	<1
Cadmium-Total	µg/L	<0.1	<0.1	<0.1
Chromium-Total	µg/L	1	1	4
Copper-Total	µg/L	3	6	53
Lead-Total	µg/L	<1	1	3
Mercury-Total	µg/L	0.06	<0.05	<0.05
Nickel-Total	µg/L	2	4	11
Zinc-Total	µg/L	14	70	59
Aluminium-Total	µg/L	40	90	660
Iron-Total	µg/L	500	810	710
Manganese-Total	µg/L	260	550	12

Cations in water - Total						
Our Reference		281301-1	281301-2	281301-3	281301-4	281301-5
Your Reference	UNITS	7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		25/10/2021	25/10/2021	25/10/2021	25/10/2021	25/10/2021
Type of sample		Water	Water	Water	Water	Water
Date digested	-	28/10/2021	28/10/2021	28/10/2021	28/10/2021	28/10/2021
Date analysed	-	29/10/2021	29/10/2021	29/10/2021	29/10/2021	29/10/2021
Sodium - Total	mg/L	4	4	3	4	5.7
Potassium - Total	mg/L	1	1	1	<0.5	<0.5
Calcium - Total	mg/L	1	0.9	1	<0.5	<0.5
Magnesium - Total	mg/L	0.6	0.5	0.6	<0.5	0.7

Cations in water - Total		
Our Reference		281301-6
Your Reference	UNITS	7822/SW02
Date Sampled		25/10/2021
Type of sample		Water
Date digested	-	28/10/2021
Date analysed	-	29/10/2021
Sodium - Total	mg/L	6.3
Potassium - Total	mg/L	<0.5
Calcium - Total	mg/L	<0.5
Magnesium - Total	mg/L	<0.5

Metals in Water - Dissolved						
Our Reference		281301-1	281301-2	281301-3	281301-4	281301-5
Your Reference	UNITS	7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		25/10/2021	25/10/2021	25/10/2021	25/10/2021	25/10/2021
Type of sample		Water	Water	Water	Water	Water
Date digested	-	28/10/2021	28/10/2021	28/10/2021	28/10/2021	28/10/2021
Date analysed	-	28/10/2021	28/10/2021	28/10/2021	28/10/2021	28/10/2021
Silicon*- Dissolved	mg/L	1.3	1.3	1	1.8	2.6
Sulfur - Dissolved	mg/L	0.5	0.5	0.6	<0.5	1.1

Metals in Water - Dissolved		
Our Reference		281301-6
Your Reference	UNITS	7822/SW02
Date Sampled		25/10/2021
Type of sample		Water
Date digested	-	28/10/2021
Date analysed	-	28/10/2021
Silicon*- Dissolved	mg/L	2.3
Sulfur - Dissolved	mg/L	<0.5

Metals in Waters - Acid extractable

Our Reference		281301-1	281301-2	281301-3	281301-4	281301-5
Your Reference	UNITS	7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		25/10/2021	25/10/2021	25/10/2021	25/10/2021	25/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	28/10/2021	28/10/2021	28/10/2021	28/10/2021	28/10/2021
Date analysed	-	28/10/2021	28/10/2021	28/10/2021	28/10/2021	28/10/2021
Phosphorus - Total	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Silicon*- Total	mg/L	1.5	1.5	1.2	1.9	2.7
Sulfur -Total	mg/L	0.6	0.6	0.6	<0.5	0.8

Metals in Waters - Acid extractable

Our Reference		281301-6	281301-7	281301-8	281301-9	281301-10
Your Reference	UNITS	7822/SW02	7822/MW401	7822/MW302A	7822/MW301A	7822/MW301B
Date Sampled		25/10/2021	25/10/2021	25/10/2021	25/10/2021	25/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	28/10/2021	28/10/2021	28/10/2021	28/10/2021	28/10/2021
Date analysed	-	28/10/2021	28/10/2021	28/10/2021	28/10/2021	28/10/2021
Phosphorus - Total	mg/L	<0.05	<0.05	0.2	<0.05	<0.05
Silicon*- Total	mg/L	2.4				
Sulfur -Total	mg/L	<0.5				

Metals in Waters - Acid extractable

Our Reference		281301-11	281301-12	281301-13
Your Reference	UNITS	7822/MB02	7822/MB03	7822/MW201
Date Sampled		25/10/2021	25/10/2021	25/10/2021
Type of sample		Water	Water	Water
Date prepared	-	28/10/2021	28/10/2021	28/10/2021
Date analysed	-	28/10/2021	28/10/2021	28/10/2021
Phosphorus - Total	mg/L	<0.05	<0.05	<0.05

Miscellaneous Inorganics						
Our Reference		281301-1	281301-2	281301-3	281301-4	281301-5
Your Reference	UNITS	7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		25/10/2021	25/10/2021	25/10/2021	25/10/2021	25/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	28/10/2021	28/10/2021	28/10/2021	28/10/2021	28/10/2021
Date analysed	-	28/10/2021	28/10/2021	28/10/2021	28/10/2021	28/10/2021
Total Nitrogen in water	mg/L	0.3	0.4	0.3	<0.1	<0.1
TKN in water	mg/L	0.3	0.4	0.3	<0.1	<0.1
Nitrate as N in water	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005
Nitrite as N in water	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005
Organic Nitrogen as N	mg/L	0.2	0.3	0.3	<0.2	<0.2
NOx as N in water	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005
Ammonia as N in water	mg/L	0.017	0.028	0.021	0.050	0.027
Phosphate as P in water	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005

Miscellaneous Inorganics						
Our Reference		281301-6	281301-7	281301-8	281301-9	281301-10
Your Reference	UNITS	7822/SW02	7822/MW401	7822/MW302A	7822/MW301A	7822/MW301B
Date Sampled		25/10/2021	25/10/2021	25/10/2021	25/10/2021	25/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	28/10/2021	28/10/2021	28/10/2021	28/10/2021	28/10/2021
Date analysed	-	28/10/2021	28/10/2021	28/10/2021	28/10/2021	28/10/2021
Total Nitrogen in water	mg/L	<0.1	<0.1	0.1	0.9	0.7
TKN in water	mg/L	<0.1	<0.1	0.1	<0.1	0.7
Nitrate as N in water	mg/L	<0.005	0.03	<0.005	0.90	<0.005
Nitrite as N in water	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005
Organic Nitrogen as N	mg/L	<0.2	<0.2	<0.2	<0.2	0.7
NOx as N in water	mg/L	<0.005	0.03	0.005	0.90	<0.005
Ammonia as N in water	mg/L	0.030	0.020	0.025	0.020	0.027
Phosphate as P in water	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005

Miscellaneous Inorganics				
Our Reference	UNITS	281301-11	281301-12	281301-13
Your Reference		7822/MB02	7822/MB03	7822/MW201
Date Sampled		25/10/2021	25/10/2021	25/10/2021
Type of sample		Water	Water	Water
Date prepared	-	28/10/2021	28/10/2021	28/10/2021
Date analysed	-	28/10/2021	28/10/2021	28/10/2021
Total Nitrogen in water	mg/L	0.2	2.1	0.5
TKN in water	mg/L	0.2	0.4	0.2
Nitrate as N in water	mg/L	0.006	1.7	0.54
Nitrite as N in water	mg/L	<0.005	<0.005	<0.005
Organic Nitrogen as N	mg/L	<0.2	0.3	<0.2
NOx as N in water	mg/L	0.008	1.7	0.54
Ammonia as N in water	mg/L	0.033	0.038	0.020
Phosphate as P in water	mg/L	<0.005	<0.005	<0.005

Ion Balance

Our Reference		281301-1	281301-2	281301-3	281301-4	281301-5
Your Reference	UNITS	7822/Pond 1	7822/Pond 2	7822/Upstream	7822/Downstream	7822/SW01
Date Sampled		25/10/2021	25/10/2021	25/10/2021	25/10/2021	25/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	27/10/2021	27/10/2021	27/10/2021	27/10/2021	27/10/2021
Date analysed	-	27/10/2021	27/10/2021	27/10/2021	27/10/2021	27/10/2021
Calcium - Dissolved	mg/L	1	0.9	1	<0.5	<0.5
Potassium - Dissolved	mg/L	1	1	1	0.6	<0.5
Sodium - Dissolved	mg/L	4	3	4	4	5.6
Magnesium - Dissolved	mg/L	0.7	0.5	0.6	<0.5	0.7
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	<5	<5	<5	<5	<5
Bicarbonate Alkalinity as $CaCO_3$	mg/L	6	5	6	<5	<5
Carbonate Alkalinity as $CaCO_3$	mg/L	<5	<5	<5	<5	<5
Total Alkalinity as $CaCO_3$	mg/L	6	5	6	<5	<5
Sulphate, SO4	mg/L	1	1	1	1	3
Chloride, Cl	mg/L	5	5	6	6	8
Ionic Balance	%	4.0	-2.0	2.0	3.0	2.0

Ion Balance

Our Reference		281301-6	281301-7	281301-8	281301-9	281301-10
Your Reference	UNITS	7822/SW02	7822/MW401	7822/MW302A	7822/MW301A	7822/MW301B
Date Sampled		25/10/2021	25/10/2021	25/10/2021	25/10/2021	25/10/2021
Type of sample		Water	Water	Water	Water	Water
Date prepared	-	27/10/2021	27/10/2021	27/10/2021	27/10/2021	27/10/2021
Date analysed	-	27/10/2021	27/10/2021	27/10/2021	27/10/2021	27/10/2021
Calcium - Dissolved	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Potassium - Dissolved	mg/L	<0.5	0.9	0.9	1	<0.5
Sodium - Dissolved	mg/L	6.1	5.6	6.0	4	5
Magnesium - Dissolved	mg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	<5	<5	<5	<5	<5
Bicarbonate Alkalinity as $CaCO_3$	mg/L	<5	<5	5	<5	<5
Carbonate Alkalinity as $CaCO_3$	mg/L	<5	<5	<5	<5	<5
Total Alkalinity as $CaCO_3$	mg/L	<5	<5	5	<5	<5
Sulphate, SO4	mg/L	<1	3	2	3	2
Chloride, Cl	mg/L	9	6	5	5	5
Ionic Balance	%	3.0	6.0	0	-4.0	8.0

Client Reference: P2007822 Bell Quarry

Ion Balance				
Our Reference		281301-11	281301-12	281301-13
Your Reference	UNITS	7822/MB02	7822/MB03	7822/MW201
Date Sampled		25/10/2021	25/10/2021	25/10/2021
Type of sample		Water	Water	Water
Date prepared	-	27/10/2021	27/10/2021	27/10/2021
Date analysed	-	27/10/2021	27/10/2021	27/10/2021
Calcium - Dissolved	mg/L	0.8	1	<0.5
Potassium - Dissolved	mg/L	2	3	<0.5
Sodium - Dissolved	mg/L	5.7	4	6.8
Magnesium - Dissolved	mg/L	<0.5	1	<0.5
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	<5	<5	<5
Bicarbonate Alkalinity as $CaCO_3$	mg/L	5	8	8
Carbonate Alkalinity as $CaCO_3$	mg/L	<5	<5	<5
Total Alkalinity as $CaCO_3$	mg/L	5	8	8
Sulphate, SO4	mg/L	2	2	2
Chloride, Cl	mg/L	7	5	6
Ionic Balance	%	-1.0	4.0	-10

Method ID	Methodology Summary
Ext-054	Analysed by MPL Envirolab
Inorg-006	Alkalinity - determined titrimetrically in accordance with APHA latest edition, 2320-B.
Inorg-040	The concentrations of the major ions (mg/L) are converted to milliequivalents and summed. The ionic balance should be within +/- 10% ie total anions = total cations +/-10%.
Inorg-055	Nitrate - determined colourimetrically. Waters samples are filtered on receipt prior to analysis. Soils are analysed following a water extraction.
Inorg-055	Nitrite - determined colourimetrically based on APHA latest edition NO2- B. Waters samples are filtered on receipt prior to analysis. Soils are analysed following a water extraction.
Inorg-055/062/127	Total Nitrogen - Calculation sum of TKN and oxidised Nitrogen. Alternatively analysed by combustion and chemiluminescence.
Inorg-057	Ammonia - determined colourimetrically, based on APHA latest edition 4500-NH3 F. Waters samples are filtered on receipt prior to analysis. Soils are analysed following a KCl extraction.
Inorg-060	Phosphate determined colourimetrically based on EPA365.1 and APHA latest edition 4500 P E. Waters samples are filtered on receipt prior to analysis. Soils are analysed following a water extraction.
Inorg-062	TKN - determined colourimetrically based on APHA latest edition 4500 Norg. Alternatively, TKN can be derived from calculation (Total N - NOx).
Inorg-081	Anions - a range of Anions are determined by Ion Chromatography, in accordance with APHA latest edition, 4110-B. Waters samples are filtered on receipt prior to analysis. Alternatively determined by colourimetry/turbidity using Discrete Analyser.
Metals-020	Determination of various metals by ICP-AES.
Metals-021	Determination of Mercury by Cold Vapour AAS.
Metals-022	Determination of various metals by ICP-MS.
Org-020	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-FID. F2 = (>C10-C16)-Naphthalene as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater (HSLs Tables 1A (3, 4)). Note Naphthalene is determined from the VOC analysis.
Org-021	Soil samples are extracted with dichloromethane/acetone and waters with dichloromethane and analysed by GC-ECD.
Org-022/025	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS/GC-MSMS.
Org-022/025	Soil samples are extracted with Dichloromethane/Acetone and waters with Dichloromethane and analysed by GC-MS/GC-MSMS. Benzo(a)pyrene TEQ as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater - 2013.
Org-023	Water samples are analysed directly by purge and trap GC-MS.
Org-023	Soil samples are extracted with methanol and spiked into water prior to analysing by purge and trap GC-MS. Water samples are analysed directly by purge and trap GC-MS. F1 = (C6-C10)-BTEX as per NEPM B1 Guideline on Investigation Levels for Soil and Groundwater.

QUALITY CONTROL: VOCs in water-Low Level					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	[NT]
Date analysed	-			01/11/2021					01/11/2021	
MTBE	µg/L	0.1	Ext-054	<0.1						
Dichlorodifluoromethane	µg/L	2	Ext-054	<2						
Chloromethane	µg/L	2	Ext-054	<2						
Vinyl Chloride	µg/L	0.2	Ext-054	<0.2						
Bromomethane	µg/L	2	Ext-054	<2						
Chloroethane	µg/L	2	Ext-054	<2						
Trichlorofluoromethane	µg/L	2	Ext-054	<2						
1,1-Dichloroethene	µg/L	0.1	Ext-054	<0.1					97	
Trans-1,2-dichloroethene	µg/L	0.1	Ext-054	<0.1						
1,1-dichloroethane	µg/L	0.1	Ext-054	<0.1						
Cis-1,2-dichloroethene	µg/L	0.1	Ext-054	<0.1						
Bromochloromethane	µg/L	0.5	Ext-054	<0.5						
Chloroform	µg/L	0.5	Ext-054	<0.5					96	
2,2-dichloropropane	µg/L	0.1	Ext-054	<0.1						
1,2-dichloroethane	µg/L	0.1	Ext-054	<0.1					96	
1,1,1-trichloroethane	µg/L	0.1	Ext-054	<0.1					98	
1,1-dichloropropene	µg/L	0.1	Ext-054	<0.1						
Carbon tetrachloride	µg/L	0.1	Ext-054	<0.1						
Benzene	µg/L	0.1	Ext-054	<0.1					94	
Dibromomethane	µg/L	0.5	Ext-054	<0.5						
1,2-dichloropropane	µg/L	0.1	Ext-054	<0.1						
Trichloroethene	µg/L	0.1	Ext-054	<0.1					99	
Bromodichloromethane	µg/L	0.1	Ext-054	<0.1					97	
trans-1,3-dichloropropene	µg/L	0.1	Ext-054	<0.1						
cis-1,3-dichloropropene	µg/L	0.1	Ext-054	<0.1						
1,1,2-trichloroethane	µg/L	0.1	Ext-054	<0.1						
Toluene	µg/L	0.1	Ext-054	<0.1					97	
1,3-dichloropropane	µg/L	0.1	Ext-054	<0.1						
Dibromochloromethane	µg/L	0.1	Ext-054	<0.1					100	
1,2-dibromoethane	µg/L	0.1	Ext-054	<0.1						
Tetrachloroethene	µg/L	0.1	Ext-054	<0.1						
1,1,1,2-tetrachloroethane	µg/L	0.1	Ext-054	<0.1						
Chlorobenzene	µg/L	0.1	Ext-054	<0.1						
Ethylbenzene	µg/L	0.1	Ext-054	<0.1					96	
Bromoform	µg/L	0.1	Ext-054	<0.1					95	
m+p-xylene	µg/L	0.2	Ext-054	<0.2					93	
Styrene	µg/L	0.1	Ext-054	<0.1						
1,1,2,2-tetrachloroethane	µg/L	0.1	Ext-054	<0.1						
o-xylene	µg/L	0.1	Ext-054	<0.1					91	

QUALITY CONTROL: VOCs in water-Low Level					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	[NT]
1,2,3-trichloropropane	µg/L	0.1	Ext-054	<0.1						
Isopropylbenzene	µg/L	0.1	Ext-054	<0.1						
Bromobenzene	µg/L	0.1	Ext-054	<0.1						
n-propyl benzene	µg/L	0.1	Ext-054	<0.1						
2-chlorotoluene	µg/L	0.1	Ext-054	<0.1						
4-chlorotoluene	µg/L	0.1	Ext-054	<0.1						
1,3,5-trimethyl benzene	µg/L	0.1	Ext-054	<0.1						
Tert-butyl benzene	µg/L	0.1	Ext-054	<0.1						
1,2,4-trimethyl benzene	µg/L	0.1	Ext-054	<0.1						
1,3-dichlorobenzene	µg/L	0.1	Ext-054	<0.1						
Sec-butyl benzene	µg/L	0.1	Ext-054	<0.1						
1,4-dichlorobenzene	µg/L	0.1	Ext-054	<0.1					94	
4-isopropyl toluene	µg/L	0.1	Ext-054	<0.1						
1,2-dichlorobenzene	µg/L	0.1	Ext-054	<0.1						
n-butyl benzene	µg/L	0.1	Ext-054	<0.1						
1,2-dibromo-3-chloropropane	µg/L	0.1	Ext-054	<0.1						
1,2,4-trichlorobenzene	µg/L	0.1	Ext-054	<0.1						
Hexachlorobutadiene	µg/L	0.2	Ext-054	<0.2						
1,2,3-trichlorobenzene	µg/L	0.1	Ext-054	<0.1						
Surrogate Dibromofluoromethane	%		Ext-054	103					103	
Surrogate toluene-d8	%		Ext-054	101					103	
Surrogate 4-BFB	%		Ext-054	98					97	

QUALITY CONTROL: vTRH(C6-C10)/BTEXN in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W2	[NT]
Date extracted	-			29/10/2021	1	29/10/2021	01/11/2021		29/10/2021	[NT]
Date analysed	-			29/10/2021	1	29/10/2021	02/11/2021		29/10/2021	[NT]
TRH C_6 - C_9	µg/L	10	Org-023	<10	1	<10	<10	0	100	[NT]
TRH C_6 - C_{10}	µg/L	10	Org-023	<10	1	<10	<10	0	100	[NT]
Benzene	µg/L	1	Org-023	<1	1	<1	<1	0	105	[NT]
Toluene	µg/L	1	Org-023	<1	1	<1	<1	0	99	[NT]
Ethylbenzene	µg/L	1	Org-023	<1	1	<1	<1	0	97	[NT]
m+p-xylene	µg/L	2	Org-023	<2	1	<2	<2	0	99	[NT]
o-xylene	µg/L	1	Org-023	<1	1	<1	<1	0	97	[NT]
Naphthalene	µg/L	1	Org-023	<1	1	<1	<1	0	[NT]	[NT]
Surrogate Dibromofluoromethane	%		Org-023	109	1	110	97	13	105	[NT]
Surrogate toluene-d8	%		Org-023	101	1	101	99	2	103	[NT]
Surrogate 4-BFB	%		Org-023	107	1	109	104	5	107	[NT]

QUALITY CONTROL: vTRH(C6-C10)/BTEXN in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date extracted	-			[NT]	11	29/10/2021	01/11/2021		[NT]	[NT]
Date analysed	-			[NT]	11	29/10/2021	02/11/2021		[NT]	[NT]
TRH C_6 - C_9	µg/L	10	Org-023	[NT]	11	<10	<10	0	[NT]	[NT]
TRH C_6 - C_{10}	µg/L	10	Org-023	[NT]	11	<10	<10	0	[NT]	[NT]
Benzene	µg/L	1	Org-023	[NT]	11	<1	<1	0	[NT]	[NT]
Toluene	µg/L	1	Org-023	[NT]	11	<1	<1	0	[NT]	[NT]
Ethylbenzene	µg/L	1	Org-023	[NT]	11	<1	<1	0	[NT]	[NT]
m+p-xylene	µg/L	2	Org-023	[NT]	11	<2	<2	0	[NT]	[NT]
o-xylene	µg/L	1	Org-023	[NT]	11	<1	<1	0	[NT]	[NT]
Naphthalene	µg/L	1	Org-023	[NT]	11	<1	<1	0	[NT]	[NT]
Surrogate Dibromofluoromethane	%		Org-023	[NT]	11	110	97	13	[NT]	[NT]
Surrogate toluene-d8	%		Org-023	[NT]	11	100	99	1	[NT]	[NT]
Surrogate 4-BFB	%		Org-023	[NT]	11	105	105	0	[NT]	[NT]

QUALITY CONTROL: svTRH (C10-C40) in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W2	281301-2
Date extracted	-			28/10/2021	1	28/10/2021	28/10/2021		28/10/2021	28/10/2021
Date analysed	-			28/10/2021	1	28/10/2021	28/10/2021		28/10/2021	28/10/2021
TRH C_{10} - C_{14}	µg/L	50	Org-020	<50	1	<50	<50	0	116	116
TRH C_{15} - C_{28}	µg/L	100	Org-020	<100	1	<100	<100	0	110	111
TRH C_{29} - C_{36}	µg/L	100	Org-020	<100	1	<100	<100	0	109	111
TRH >C_{10} - C_{16}	µg/L	50	Org-020	<50	1	<50	<50	0	116	116
TRH >C_{16} - C_{34}	µg/L	100	Org-020	<100	1	<100	<100	0	110	111
TRH >C_{34} - C_{40}	µg/L	100	Org-020	<100	1	<100	<100	0	109	111
Surrogate o-Terphenyl	%		Org-020	98	1	84	84	0	91	95

QUALITY CONTROL: svTRH (C10-C40) in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date extracted	-				11	28/10/2021	28/10/2021			
Date analysed	-				11	29/10/2021	29/10/2021			
TRH C_{10} - C_{14}	µg/L	50	Org-020		11	<50	<50	0		
TRH C_{15} - C_{28}	µg/L	100	Org-020		11	<100	<100	0		
TRH C_{29} - C_{36}	µg/L	100	Org-020		11	<100	<100	0		
TRH >C_{10} - C_{16}	µg/L	50	Org-020		11	<50	<50	0		
TRH >C_{16} - C_{34}	µg/L	100	Org-020		11	<100	<100	0		
TRH >C_{34} - C_{40}	µg/L	100	Org-020		11	<100	<100	0		
Surrogate o-Terphenyl	%		Org-020		11	93	93	0		

Client Reference: P2007822 Bell Quarry

QUALITY CONTROL: PAHs in Water - Low Level					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W2	281301-3
Date extracted	-			28/10/2021	1	28/10/2021	28/10/2021		28/10/2021	28/10/2021
Date analysed	-			29/10/2021	1	29/10/2021	29/10/2021		29/10/2021	29/10/2021
Naphthalene	µg/L	0.2	Org-022/025	<0.2	1	<0.2	<0.2	0	98	91
Acenaphthylene	µg/L	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0		
Acenaphthene	µg/L	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	83	77
Fluorene	µg/L	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	86	88
Phenanthrene	µg/L	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	120	122
Anthracene	µg/L	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0		
Fluoranthene	µg/L	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	97	83
Pyrene	µg/L	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	109	93
Benzo(a)anthracene	µg/L	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0		
Chrysene	µg/L	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	80	72
Benzo(b,j+k)fluoranthene	µg/L	0.2	Org-022/025	<0.2	1	<0.2	<0.2	0		
Benzo(a)pyrene	µg/L	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0	106	100
Indeno(1,2,3-c,d)pyrene	µg/L	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0		
Dibenzo(a,h)anthracene	µg/L	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0		
Benzo(g,h,i)perylene	µg/L	0.1	Org-022/025	<0.1	1	<0.1	<0.1	0		
Surrogate p-Terphenyl-d14	%		Org-022/025	102	1	93	66	34	106	86

QUALITY CONTROL: PAHs in Water - Low Level					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date extracted	-				11	28/10/2021	28/10/2021			
Date analysed	-				11	29/10/2021	29/10/2021			
Naphthalene	µg/L	0.2	Org-022/025		11	<0.2	<0.2	0		
Acenaphthylene	µg/L	0.1	Org-022/025		11	<0.1	<0.1	0		
Acenaphthene	µg/L	0.1	Org-022/025		11	<0.1	<0.1	0		
Fluorene	µg/L	0.1	Org-022/025		11	<0.1	<0.1	0		
Phenanthrene	µg/L	0.1	Org-022/025		11	<0.1	<0.1	0		
Anthracene	µg/L	0.1	Org-022/025		11	<0.1	<0.1	0		
Fluoranthene	µg/L	0.1	Org-022/025		11	<0.1	<0.1	0		
Pyrene	µg/L	0.1	Org-022/025		11	<0.1	<0.1	0		
Benzo(a)anthracene	µg/L	0.1	Org-022/025		11	<0.1	<0.1	0		
Chrysene	µg/L	0.1	Org-022/025		11	<0.1	<0.1	0		
Benzo(b,j+k)fluoranthene	µg/L	0.2	Org-022/025		11	<0.2	<0.2	0		
Benzo(a)pyrene	µg/L	0.1	Org-022/025		11	<0.1	<0.1	0		
Indeno(1,2,3-c,d)pyrene	µg/L	0.1	Org-022/025		11	<0.1	<0.1	0		
Dibenzo(a,h)anthracene	µg/L	0.1	Org-022/025		11	<0.1	<0.1	0		
Benzo(g,h,i)perylene	µg/L	0.1	Org-022/025		11	<0.1	<0.1	0		
Surrogate p-Terphenyl-d14	%		Org-022/025		11	101	78	26		

Client Reference: P2007822 Bell Quarry

QUALITY CONTROL: Organochlorine Pesticides in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W2	281301-3
Date extracted	-			28/10/2021	1	28/10/2021	28/10/2021		28/10/2021	28/10/2021
Date analysed	-			29/10/2021	1	29/10/2021	29/10/2021		29/10/2021	29/10/2021
alpha-BHC	µg/L	0.2	Org-022/025	<0.2	1	<0.2	<0.2	0	90	83
HCB	µg/L	0.2	Org-022/025	<0.2	1	<0.2	<0.2	0		
beta-BHC	µg/L	0.2	Org-022/025	<0.2	1	<0.2	<0.2	0	96	96
gamma-BHC	µg/L	0.2	Org-022/025	<0.2	1	<0.2	<0.2	0		
Heptachlor	µg/L	0.2	Org-022/025	<0.2	1	<0.2	<0.2	0	110	92
delta-BHC	µg/L	0.2	Org-022/025	<0.2	1	<0.2	<0.2	0		
Aldrin	µg/L	0.2	Org-022/025	<0.2	1	<0.2	<0.2	0	102	89
Heptachlor Epoxide	µg/L	0.2	Org-022/025	<0.2	1	<0.2	<0.2	0	112	98
gamma-Chlordane	µg/L	0.2	Org-022/025	<0.2	1	<0.2	<0.2	0		
alpha-Chlordane	µg/L	0.2	Org-022/025	<0.2	1	<0.2	<0.2	0		
Endosulfan I	µg/L	0.2	Org-022/025	<0.2	1	<0.2	<0.2	0		
pp-DDE	µg/L	0.2	Org-022/025	<0.2	1	<0.2	<0.2	0	97	84
Dieldrin	µg/L	0.2	Org-022/025	<0.2	1	<0.2	<0.2	0	118	102
Endrin	µg/L	0.2	Org-022/025	<0.2	1	<0.2	<0.2	0	102	93
Endosulfan II	µg/L	0.2	Org-022/025	<0.2	1	<0.2	<0.2	0		
pp-DDD	µg/L	0.2	Org-022/025	<0.2	1	<0.2	<0.2	0	107	93
Endrin Aldehyde	µg/L	0.2	Org-022/025	<0.2	1	<0.2	<0.2	0		
pp-DDT	µg/L	0.2	Org-022/025	<0.2	1	<0.2	<0.2	0		
Endosulfan Sulphate	µg/L	0.2	Org-022/025	<0.2	1	<0.2	<0.2	0	110	98
Methoxychlor	µg/L	0.2	Org-022/025	<0.2	1	<0.2	<0.2	0		
Surrogate TCMX	%		Org-022/025	92	1	90	68	28	100	84

Client Reference: P2007822 Bell Quarry

QUALITY CONTROL: Organochlorine Pesticides in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date extracted	-			[NT]	11	28/10/2021	28/10/2021		[NT]	[NT]
Date analysed	-			[NT]	11	29/10/2021	29/10/2021		[NT]	[NT]
alpha-BHC	µg/L	0.2	Org-022/025	[NT]	11	<0.2	<0.2	0	[NT]	[NT]
HCB	µg/L	0.2	Org-022/025	[NT]	11	<0.2	<0.2	0	[NT]	[NT]
beta-BHC	µg/L	0.2	Org-022/025	[NT]	11	<0.2	<0.2	0	[NT]	[NT]
gamma-BHC	µg/L	0.2	Org-022/025	[NT]	11	<0.2	<0.2	0	[NT]	[NT]
Heptachlor	µg/L	0.2	Org-022/025	[NT]	11	<0.2	<0.2	0	[NT]	[NT]
delta-BHC	µg/L	0.2	Org-022/025	[NT]	11	<0.2	<0.2	0	[NT]	[NT]
Aldrin	µg/L	0.2	Org-022/025	[NT]	11	<0.2	<0.2	0	[NT]	[NT]
Heptachlor Epoxide	µg/L	0.2	Org-022/025	[NT]	11	<0.2	<0.2	0	[NT]	[NT]
gamma-Chlordane	µg/L	0.2	Org-022/025	[NT]	11	<0.2	<0.2	0	[NT]	[NT]
alpha-Chlordane	µg/L	0.2	Org-022/025	[NT]	11	<0.2	<0.2	0	[NT]	[NT]
Endosulfan I	µg/L	0.2	Org-022/025	[NT]	11	<0.2	<0.2	0	[NT]	[NT]
pp-DDE	µg/L	0.2	Org-022/025	[NT]	11	<0.2	<0.2	0	[NT]	[NT]
Dieldrin	µg/L	0.2	Org-022/025	[NT]	11	<0.2	<0.2	0	[NT]	[NT]
Endrin	µg/L	0.2	Org-022/025	[NT]	11	<0.2	<0.2	0	[NT]	[NT]
Endosulfan II	µg/L	0.2	Org-022/025	[NT]	11	<0.2	<0.2	0	[NT]	[NT]
pp-DDD	µg/L	0.2	Org-022/025	[NT]	11	<0.2	<0.2	0	[NT]	[NT]
Endrin Aldehyde	µg/L	0.2	Org-022/025	[NT]	11	<0.2	<0.2	0	[NT]	[NT]
pp-DDT	µg/L	0.2	Org-022/025	[NT]	11	<0.2	<0.2	0	[NT]	[NT]
Endosulfan Sulphate	µg/L	0.2	Org-022/025	[NT]	11	<0.2	<0.2	0	[NT]	[NT]
Methoxychlor	µg/L	0.2	Org-022/025	[NT]	11	<0.2	<0.2	0	[NT]	[NT]
Surrogate TCMX	%		Org-022/025	[NT]	11	88	82	7	[NT]	[NT]

QUALITY CONTROL: OP Pesticides in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W2	281301-3
Date extracted	-			28/10/2021	1	28/10/2021	28/10/2021		28/10/2021	28/10/2021
Date analysed	-			29/10/2021	1	29/10/2021	29/10/2021		29/10/2021	29/10/2021
Dichlorvos	µg/L	0.2	Org-022/025	<0.2	1	<0.2	<0.2	0	117	111
Dimethoate	µg/L	0.2	Org-022/025	<0.2	1	<0.2	<0.2	0		
Diazinon	µg/L	0.2	Org-022/025	<0.2	1	<0.2	<0.2	0		
Chlorpyriphos-methyl	µg/L	0.2	Org-022/025	<0.2	1	<0.2	<0.2	0		
Ronnel	µg/L	0.2	Org-022/025	<0.2	1	<0.2	<0.2	0	104	89
Fenitrothion	µg/L	0.2	Org-022/025	<0.2	1	<0.2	<0.2	0	96	90
Malathion	µg/L	0.2	Org-022/025	<0.2	1	<0.2	<0.2	0	117	110
Chlorpyriphos	µg/L	0.2	Org-022/025	<0.2	1	<0.2	<0.2	0	113	104
Parathion	µg/L	0.2	Org-022/025	<0.2	1	<0.2	<0.2	0	90	87
Bromophos ethyl	µg/L	0.2	Org-022/025	<0.2	1	<0.2	<0.2	0		
Ethion	µg/L	0.2	Org-022/025	<0.2	1	<0.2	<0.2	0	94	80
Azinphos-methyl (Guthion)	µg/L	0.2	Org-022/025	<0.2	1	<0.2	<0.2	0		
Surrogate TCMX	%		Org-022/025	92	1	90	68	28	100	84

QUALITY CONTROL: OP Pesticides in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date extracted	-				11	28/10/2021	28/10/2021			
Date analysed	-				11	29/10/2021	29/10/2021			
Dichlorvos	µg/L	0.2	Org-022/025		11	<0.2	<0.2	0		
Dimethoate	µg/L	0.2	Org-022/025		11	<0.2	<0.2	0		
Diazinon	µg/L	0.2	Org-022/025		11	<0.2	<0.2	0		
Chlorpyriphos-methyl	µg/L	0.2	Org-022/025		11	<0.2	<0.2	0		
Ronnel	µg/L	0.2	Org-022/025		11	<0.2	<0.2	0		
Fenitrothion	µg/L	0.2	Org-022/025		11	<0.2	<0.2	0		
Malathion	µg/L	0.2	Org-022/025		11	<0.2	<0.2	0		
Chlorpyriphos	µg/L	0.2	Org-022/025		11	<0.2	<0.2	0		
Parathion	µg/L	0.2	Org-022/025		11	<0.2	<0.2	0		
Bromophos ethyl	µg/L	0.2	Org-022/025		11	<0.2	<0.2	0		
Ethion	µg/L	0.2	Org-022/025		11	<0.2	<0.2	0		
Azinphos-methyl (Guthion)	µg/L	0.2	Org-022/025		11	<0.2	<0.2	0		
Surrogate TCMX	%		Org-022/025		11	88	82	7		

Client Reference: P2007822 Bell Quarry

QUALITY CONTROL: PCBs in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W2	[NT]
Date extracted	-			28/10/2021					28/10/2021	
Date analysed	-			29/10/2021					29/10/2021	
Aroclor 1016	µg/L	2	Org-021	<2						
Aroclor 1221	µg/L	2	Org-021	<2						
Aroclor 1232	µg/L	2	Org-021	<2						
Aroclor 1242	µg/L	2	Org-021	<2						
Aroclor 1248	µg/L	2	Org-021	<2						
Aroclor 1254	µg/L	2	Org-021	<2					120	
Aroclor 1260	µg/L	2	Org-021	<2						
Surrogate TCMX	%		Org-021	92					100	

QUALITY CONTROL: HM in water - dissolved					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W10	281301-2
Date prepared	-			28/10/2021	1	28/10/2021	28/10/2021		28/10/2021	28/10/2021
Date analysed	-			28/10/2021	1	28/10/2021	28/10/2021		28/10/2021	28/10/2021
Arsenic-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	93	94
Cadmium-Dissolved	µg/L	0.1	Metals-022	<0.1	1	<0.1	<0.1	0	95	97
Chromium-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	92	85
Copper-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	91	95
Lead-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	87	89
Mercury-Dissolved	µg/L	0.05	Metals-021	<0.05	1	<0.05			106	
Nickel-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	92	94
Zinc-Dissolved	µg/L	1	Metals-022	<1	1	<1	1	0	92	99
Aluminium-Dissolved	µg/L	10	Metals-022	<10	1	<10	<10	0	95	85
Iron-Dissolved	µg/L	10	Metals-022	<10	1	20	30	40	95	81
Manganese-Dissolved	µg/L	5	Metals-022	<5	1	<5	<5	0	93	95
Antimony-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	88	81
Barium-Dissolved	µg/L	1	Metals-022	<1	1	4	5	22	89	90
Beryllium-Dissolved	µg/L	0.5	Metals-022	<0.5	1	<0.5	<0.5	0	89	82
Boron-Dissolved	µg/L	20	Metals-022	<20	1	<20	<20	0	93	76
Cobalt-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	91	92
Lithium-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	93	95
Molybdenum-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	91	74
Selenium-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	92	98
Silver-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	95	95
Strontium-Dissolved	µg/L	1	Metals-022	<1	1	9	10	11	96	97
Thallium-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	90	94
Titanium-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	88	82
Tin-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	95	77
Vanadium-Dissolved	µg/L	1	Metals-022	<1	1	<1	<1	0	93	91

Client Reference: P2007822 Bell Quarry

QUALITY CONTROL: HM in water - dissolved					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	281301-4
Date prepared	-			[NT]	3	28/10/2021	28/10/2021		[NT]	28/10/2021
Date analysed	-			[NT]	3	28/10/2021	28/10/2021		[NT]	28/10/2021
Arsenic-Dissolved	µg/L	1	Metals-022	[NT]	3	<1	[NT]		[NT]	[NT]
Cadmium-Dissolved	µg/L	0.1	Metals-022	[NT]	3	<0.1	[NT]		[NT]	[NT]
Chromium-Dissolved	µg/L	1	Metals-022	[NT]	3	<1	[NT]		[NT]	[NT]
Copper-Dissolved	µg/L	1	Metals-022	[NT]	3	<1	[NT]		[NT]	[NT]
Lead-Dissolved	µg/L	1	Metals-022	[NT]	3	<1	[NT]		[NT]	[NT]
Mercury-Dissolved	µg/L	0.05	Metals-021	[NT]	3	<0.05	<0.05	0	[NT]	107
Nickel-Dissolved	µg/L	1	Metals-022	[NT]	3	<1	[NT]		[NT]	[NT]
Zinc-Dissolved	µg/L	1	Metals-022	[NT]	3	<1	[NT]		[NT]	[NT]
Aluminium-Dissolved	µg/L	10	Metals-022	[NT]	3	<10	[NT]		[NT]	[NT]
Iron-Dissolved	µg/L	10	Metals-022	[NT]	3	190	[NT]		[NT]	[NT]
Manganese-Dissolved	µg/L	5	Metals-022	[NT]	3	37	[NT]		[NT]	[NT]
Antimony-Dissolved	µg/L	1	Metals-022	[NT]	3	<1	[NT]		[NT]	[NT]
Barium-Dissolved	µg/L	1	Metals-022	[NT]	3	5	[NT]		[NT]	[NT]
Beryllium-Dissolved	µg/L	0.5	Metals-022	[NT]	3	<0.5	[NT]		[NT]	[NT]
Boron-Dissolved	µg/L	20	Metals-022	[NT]	3	<20	[NT]		[NT]	[NT]
Cobalt-Dissolved	µg/L	1	Metals-022	[NT]	3	<1	[NT]		[NT]	[NT]
Lithium-Dissolved	µg/L	1	Metals-022	[NT]	3	<1	[NT]		[NT]	[NT]
Molybdenum-Dissolved	µg/L	1	Metals-022	[NT]	3	<1	[NT]		[NT]	[NT]
Selenium-Dissolved	µg/L	1	Metals-022	[NT]	3	<1	[NT]		[NT]	[NT]
Silver-Dissolved	µg/L	1	Metals-022	[NT]	3	<1	[NT]		[NT]	[NT]
Strontium-Dissolved	µg/L	1	Metals-022	[NT]	3	9	[NT]		[NT]	[NT]
Thallium-Dissolved	µg/L	1	Metals-022	[NT]	3	<1	[NT]		[NT]	[NT]
Titanium-Dissolved	µg/L	1	Metals-022	[NT]	3	<1	[NT]		[NT]	[NT]
Tin-Dissolved	µg/L	1	Metals-022	[NT]	3	<1	[NT]		[NT]	[NT]
Vanadium-Dissolved	µg/L	1	Metals-022	[NT]	3	<1	[NT]		[NT]	[NT]

Client Reference: P2007822 Bell Quarry

QUALITY CONTROL: HM in water - dissolved					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-				11	28/10/2021	28/10/2021			
Date analysed	-				11	28/10/2021	28/10/2021			
Arsenic-Dissolved	µg/L	1	Metals-022		11	<1	<1	0		
Cadmium-Dissolved	µg/L	0.1	Metals-022		11	<0.1	<0.1	0		
Chromium-Dissolved	µg/L	1	Metals-022		11	<1	<1	0		
Copper-Dissolved	µg/L	1	Metals-022		11	1	2	67		
Lead-Dissolved	µg/L	1	Metals-022		11	<1	<1	0		
Mercury-Dissolved	µg/L	0.05	Metals-021		11	<0.05				
Nickel-Dissolved	µg/L	1	Metals-022		11	1	1	0		
Zinc-Dissolved	µg/L	1	Metals-022		11	14	14	0		
Aluminium-Dissolved	µg/L	10	Metals-022		11	<10	<10	0		
Iron-Dissolved	µg/L	10	Metals-022		11	210	240	13		
Manganese-Dissolved	µg/L	5	Metals-022		11	250	280	11		

QUALITY CONTROL: HM in water - dissolved					Duplicate				Spike Recovery	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-				12	28/10/2021	28/10/2021			
Date analysed	-				12	28/10/2021	28/10/2021			
Arsenic-Dissolved	µg/L	1	Metals-022		12	<1				
Cadmium-Dissolved	µg/L	0.1	Metals-022		12	<0.1				
Chromium-Dissolved	µg/L	1	Metals-022		12	<1				
Copper-Dissolved	µg/L	1	Metals-022		12	3				
Lead-Dissolved	µg/L	1	Metals-022		12	<1				
Mercury-Dissolved	µg/L	0.05	Metals-021		12	<0.05	<0.05	0		
Nickel-Dissolved	µg/L	1	Metals-022		12	3				
Zinc-Dissolved	µg/L	1	Metals-022		12	78				
Aluminium-Dissolved	µg/L	10	Metals-022		12	40				
Iron-Dissolved	µg/L	10	Metals-022		12	50				
Manganese-Dissolved	µg/L	5	Metals-022		12	610				

QUALITY CONTROL: HM in water - total						Duplicate			Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	281301-2
Date prepared	-			28/10/2021	1	28/10/2021	28/10/2021		28/10/2021	28/10/2021
Date analysed	-			28/10/2021	1	28/10/2021	28/10/2021		28/10/2021	28/10/2021
Arsenic-Total	µg/L	1	Metals-022	<1	1	<1	<1	0	97	100
Cadmium-Total	µg/L	0.1	Metals-022	<0.1	1	<0.1	<0.1	0	98	99
Chromium-Total	µg/L	1	Metals-022	<1	1	<1	<1	0	95	98
Copper-Total	µg/L	1	Metals-022	<1	1	<1	<1	0	95	97
Lead-Total	µg/L	1	Metals-022	<1	1	<1	<1	0	96	96
Mercury-Total	µg/L	0.05	Metals-021	<0.05	1	<0.05	<0.05	0	96	102
Nickel-Total	µg/L	1	Metals-022	<1	1	<1	<1	0	96	98
Zinc-Total	µg/L	1	Metals-022	<1	1	1	<1	0	97	99
Aluminium-Total	µg/L	10	Metals-022	<10	1	20	20	0	98	106
Iron-Total	µg/L	10	Metals-022	<10	1	190	180	5	101	#
Manganese-Total	µg/L	5	Metals-022	<5	1	35	35	0	95	93
Antimony-Total	µg/L	1	Metals-022	<1	1	<1	<1	0	107	113
Barium-Total	µg/L	1	Metals-022	<1	1	7	7	0	98	95
Beryllium-Total	µg/L	0.5	Metals-022	<0.5	1	<0.5	<0.5	0	93	96
Boron-Total	µg/L	20	Metals-022	<20	1	<20	<20	0	94	91
Cobalt-Total	µg/L	1	Metals-022	<1	1	<1	<1	0	94	97
Lithium-Total	µg/L	1	Metals-022	<1	1	<1	<1	0	95	96
Molybdenum-Total	µg/L	1	Metals-022	<1	1	<1	<1	0	96	98
Selenium-Total	µg/L	1	Metals-022	<1	1	<1	<1	0	96	97
Silver-Total	µg/L	1	Metals-022	<1	1	<1	<1	0	101	102
Strontium-Total	µg/L	1	Metals-022	<1	1	10	10	0	100	102
Thallium-Total	µg/L	1	Metals-022	<1	1	<1	<1	0	97	99
Titanium-Total	µg/L	1	Metals-022	<1	1	<1	<1	0	90	92
Tin-Total	µg/L	1	Metals-022	<1	1	<1	<1	0	98	99
Vanadium-Total	µg/L	1	Metals-022	<1	1	<1	<1	0	95	99

Client Reference: P2007822 Bell Quarry

QUALITY CONTROL: HM in water - total					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-				11	28/10/2021	28/10/2021			
Date analysed	-				11	28/10/2021	28/10/2021			
Arsenic-Total	µg/L	1	Metals-022		11	<1	<1	0		
Cadmium-Total	µg/L	0.1	Metals-022		11	<0.1	<0.1	0		
Chromium-Total	µg/L	1	Metals-022		11	1	1	0		
Copper-Total	µg/L	1	Metals-022		11	3	3	0		
Lead-Total	µg/L	1	Metals-022		11	<1	<1	0		
Mercury-Total	µg/L	0.05	Metals-021		11	0.06	0.06	0		
Nickel-Total	µg/L	1	Metals-022		11	2	2	0		
Zinc-Total	µg/L	1	Metals-022		11	14	14	0		
Aluminium-Total	µg/L	10	Metals-022		11	40	40	0		
Iron-Total	µg/L	10	Metals-022		11	500	510	2		
Manganese-Total	µg/L	5	Metals-022		11	260	260	0		

Client Reference: P2007822 Bell Quarry

QUALITY CONTROL: Cations in water - Total					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	281301-3
Date digested	-			28/10/2021	1	28/10/2021	28/10/2021		28/10/2021	28/10/2021
Date analysed	-			29/10/2021	1	29/10/2021	29/10/2021		29/10/2021	29/10/2021
Sodium - Total	mg/L	0.5	Metals-020	<0.5	1	4	4	0	115	110
Potassium - Total	mg/L	0.5	Metals-020	<0.5	1	1	0.9	11	102	103
Calcium - Total	mg/L	0.5	Metals-020	<0.5	1	1	1	0	103	105
Magnesium - Total	mg/L	0.5	Metals-020	<0.5	1	0.6	0.6	0	105	105

Client Reference: P2007822 Bell Quarry

QUALITY CONTROL: Metals in Water - Dissolved					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	281301-2
Date digested	-			28/10/2021	1	28/10/2021	28/10/2021		28/10/2021	28/10/2021
Date analysed	-			28/10/2021	1	28/10/2021	28/10/2021		28/10/2021	28/10/2021
Silicon*- Dissolved	mg/L	0.2	Metals-020	<0.2	1	1.3	1.4	7	109	105
Sulfur - Dissolved	mg/L	0.5	Metals-020	<0.5	1	0.5	0.5	0	100	127

QUALITY CONTROL: Metals in Waters - Acid extractable					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	281301-3
Date prepared	-			28/10/2021	1	28/10/2021	28/10/2021		28/10/2021	28/10/2021
Date analysed	-			28/10/2021	1	28/10/2021	28/10/2021		28/10/2021	28/10/2021
Phosphorus - Total	mg/L	0.05	Metals-020	<0.05	1	<0.05	<0.05	0	117	123
Silicon*- Total	mg/L	0.2	Metals-020	<0.2	1	1.5	1.5	0	117	120
Sulfur -Total	mg/L	0.5	Metals-020	<0.5	1	0.6	0.6	0	110	110

QUALITY CONTROL: Metals in Waters - Acid extractable					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-			[NT]	11	28/10/2021	28/10/2021		[NT]	[NT]
Date analysed	-			[NT]	11	28/10/2021	29/10/2021		[NT]	[NT]
Phosphorus - Total	mg/L	0.05	Metals-020	[NT]	11	<0.05	<0.05	0	[NT]	[NT]

QUALITY CONTROL: Miscellaneous Inorganics					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	281301-2
Date prepared	-			28/10/2021	1	28/10/2021	28/10/2021		28/10/2021	28/10/2021
Date analysed	-			28/10/2021	1	28/10/2021	28/10/2021		28/10/2021	28/10/2021
Total Nitrogen in water	mg/L	0.1	Inorg-055/062/127	<0.1	1	0.3	0.3	0	110	114
TKN in water	mg/L	0.1	Inorg-062	<0.1	1	0.3	0.3	0		
Nitrate as N in water	mg/L	0.005	Inorg-055	<0.005	1	<0.005	<0.005	0	109	111
Nitrite as N in water	mg/L	0.005	Inorg-055	<0.005	1	<0.005	<0.005	0	115	110
Organic Nitrogen as N	mg/L	0.2		<0.2	1	0.2	0.2	0		
NOx as N in water	mg/L	0.005	Inorg-055	<0.005	1	<0.005	<0.005	0	109	111
Ammonia as N in water	mg/L	0.005	Inorg-057	<0.005	1	0.017	0.022	26	112	100
Phosphate as P in water	mg/L	0.005	Inorg-060	<0.005	1	<0.005	<0.005	0	99	108

QUALITY CONTROL: Miscellaneous Inorganics					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-				11	28/10/2021	28/10/2021			
Date analysed	-				11	28/10/2021	28/10/2021			
Total Nitrogen in water	mg/L	0.1	Inorg-055/062/127		11	0.2	0.2	0		
TKN in water	mg/L	0.1	Inorg-062		11	0.2	0.2	0		
Nitrate as N in water	mg/L	0.005	Inorg-055		11	0.006	0.006	0		
Nitrite as N in water	mg/L	0.005	Inorg-055		11	<0.005	<0.005	0		
Organic Nitrogen as N	mg/L	0.2			11	<0.2	<0.2	0		
NOx as N in water	mg/L	0.005	Inorg-055		11	0.008	0.008	0		
Ammonia as N in water	mg/L	0.005	Inorg-057		11	0.033	0.035	6		
Phosphate as P in water	mg/L	0.005	Inorg-060		11	<0.005	<0.005	0		

Client Reference: P2007822 Bell Quarry

QUALITY CONTROL: Ion Balance					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-W1	281301-2
Date prepared	-			27/10/2021	1	27/10/2021	27/10/2021		27/10/2021	27/10/2021
Date analysed	-			27/10/2021	1	27/10/2021	27/10/2021		27/10/2021	27/10/2021
Calcium - Dissolved	mg/L	0.5	Metals-020	<0.5	1	1	1	0	96	128
Potassium - Dissolved	mg/L	0.5	Metals-020	<0.5	1	1	1	0	96	129
Sodium - Dissolved	mg/L	0.5	Metals-020	<0.5	1	4	4	0	107	128
Magnesium - Dissolved	mg/L	0.5	Metals-020	<0.5	1	0.7	0.6	15	97	129
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	5	Inorg-006	<5	1	<5				
Bicarbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	1	6				
Carbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	1	<5				
Total Alkalinity as $CaCO_3$	mg/L	5	Inorg-006	<5	1	6			105	
Sulphate, SO4	mg/L	1	Inorg-081	<1	1	1	1	0	111	111
Chloride, Cl	mg/L	1	Inorg-081	<1	1	5	5	0	113	120
Ionic Balance	%		Inorg-040		1	4.0				

QUALITY CONTROL: Ion Balance					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	[NT]
Date prepared	-				11	27/10/2021	27/10/2021			
Date analysed	-				11	27/10/2021	27/10/2021			
Calcium - Dissolved	mg/L	0.5	Metals-020		11	0.8	0.8	0		
Potassium - Dissolved	mg/L	0.5	Metals-020		11	2	1	67		
Sodium - Dissolved	mg/L	0.5	Metals-020		11	5.7	5.3	7		
Magnesium - Dissolved	mg/L	0.5	Metals-020		11	<0.5	<0.5	0		
Hydroxide Alkalinity (OH^-) as $CaCO_3$	mg/L	5	Inorg-006		11	<5				
Bicarbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006		11	5				
Carbonate Alkalinity as $CaCO_3$	mg/L	5	Inorg-006		11	<5				
Total Alkalinity as $CaCO_3$	mg/L	5	Inorg-006		11	5				
Sulphate, SO4	mg/L	1	Inorg-081		11	2	2	0		
Chloride, Cl	mg/L	1	Inorg-081		11	7	7	0		
Ionic Balance	%		Inorg-040		11	-1.0				

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from "2018 TLVs and BEIs", as published by ACGIH (where available). Limit provided for Nickel is a precautionary guideline as per Position Paper prepared by AIOH Exposure Standards Committee, 2016.

Guideline limits for Rinse Water Quality reported as per analytical requirements and specifications of AS 4187, Amdt 2 2019, Table 7.2

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals (not SPOCAS); 60-140% for organics/SPOCAS (+/-50% surrogates) and 10-140% for labile SVOCs (including labile surrogates), ultra trace organics and speciated phenols is acceptable.

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Analysis of aqueous samples typically involves the extraction/digestion and/or analysis of the liquid phase only (i.e. NOT any settled sediment phase but inclusive of suspended particles if present), unless stipulated on the Envirolab COC and/or by correspondence. Notable exceptions include certain Physical Tests (pH/EC/BOD/COD/Apparent Colour etc.), Solids testing, total recoverable metals and PFAS where solids are included by default.

Samples for Microbiological analysis (not Amoeba forms) received outside of the 2-8°C temperature range do not meet the ideal cooling conditions as stated in AS2031-2012.

Report Comments

TRH Water(C10-C40) NEPM - # Percent recovery for the surrogate/matrix spike is not possible to report as the high concentration of analytes in sample #13 have caused interference.

Dissolved Metals: no filtered, preserved sample was received, therefore the unpreserved sample was filtered through 0.45µm filter at the lab.
Note: there is a possibility some elements may be underestimated.

8 HM in water - Total - # Percent recovery is not applicable due to the high concentration of the element/s in the sample/s. However an acceptable recovery was obtained for the LCS.

Low level VOC + 281301-13 vTRH/BTEXN analysed by MPL report # 271424

Appendix E

Revised Water Resources Assessment

Bell Quarry Rehabilitation Project

Revised Water Resources Assessment

Bell Quarry Rehabilitation Project Pty Ltd

19 November 2021

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Definitions and abbreviations

Table 1.1 outlines various definitions of key terms used throughout this memo.

Table 1.1 *Definitions*

Term	Definition
Clean water	Water which runs off rehabilitated areas and water which is stored in the ponds and not influenced by leachate, contacted water or potentially sediment laden water
Contact water	Water which runoffs the exposed fill
Field capacity	The amount of soil moisture held in the soil after excess water has drained away
Groundwater	Water within the in-situ geology
Leachate	Water which seeps through the proposed fill
Potentially sediment laden water	Water which runoffs disturbed areas of the site including those undergoing rehabilitation

Table 1.2 outlines the abbreviations used throughout this memo.

Table 1.2 *Abbreviations*

Abbreviation	Definition
1D	One-dimensional
AHD	Australian Height Datum
ANZECC	Australian and New Zealand Environment and Conservation Council
ANZG	Australian and New Zealand Guidelines
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ASLP	Australian Standard Leaching Procedure
ASS	Acid Sulfate Soils
BGL	Below ground level
BTEX	Benzene, toluene, ethylbenzene and xylene
CRPs	Current recommended practices
CV	Curriculum vitae
DDT	Dichlorodiphenyltrichloroethane
DGV	Default guideline value
DO	Dissolved oxygen
EC	Electrical conductivity
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
ENM	Excavated natural material
EPA	Environment Protection Authority
GMP	Groundwater management plan
GRI	Geosynthetic Research Institute
Ha	Hectares

Abbreviation	Definition
HDPE	High density polyethylene
HELP	Hydrologic Evaluation of Landfill Performance
IWMEM	Industrial Waste Management Evaluation Model
K	Hydraulic conductivity
LLDPE	Linear low density polyethylene
LOR	Laboratory limit of reporting
MB	Monitoring bore
MW	Monitoring well
NA	Not available
NARCliM	NSW Government Climate Change modelling
NorBe	Neutral or Beneficial impact
OCP	Organochlorine pesticide
OEH	Office of Environment and Heritage
OPP	Organophosphorus pesticide
PAH	Polycyclic aromatic hydrocarbon
PASS	Potential acid sulfate soils
PCB	Polychlorinated biphenyl
POEO Act	*Protection of the Environment Operations Act 1997*
POEO Regulation	*Protection of the Environment Operations (Waste) Regulation 2014*
SEPP	State Environmental Planning Policy
SOFAC	Statement of Facts and Contentions
SSTLs	Sie specific trigger levels
SWL	Standing water level
TARP	Trigger action response plan
TCLP	Toxicity characteristics leaching procedure
TRH	Total recoverable hydrocarbons
TSS	Total suspended solids
USEPA	United States Environmental Protection Agency
UCPR	*Uniform Civil Procedure Rules 2005*
VENM	Virgin excavated natural material
WMP	Waste management plan
WRA	Water Resources Assessment
WSP	Water Sharing Plan

1. Introduction

1.1 Background

Bell Quarry Rehabilitation Project Pty Ltd (the Applicant) seeks to rehabilitate the Bell Quarry site, located on Sandham Road at Newnes Junction, approximately ten kilometres east of Lithgow in NSW. The development application seeks (DA) to achieve the final rehabilitated landform via importation of virgin excavated natural material (VENM), excavated natural material (ENM) or comparable material (that meets an exemption pursuant to clauses 91 and 92 of the *Protection of the Environmental Operations (Waste) Regulation 2014*), sourced from earthworks projects across Sydney and the local regional area (the Project).

The DA (294/18) is Designated Development and is also defined as Regional Development under clause 7, Schedule 7 of the State Environmental Planning Policy (State and Regional Development) 2011 (SRD SEPP). The DA was notified and assessed by Lithgow City Council (Council), and subject to consent by the Western Regional Planning Panel (WRPP).

An Environmental Impact Statement (EIS) was prepared by GHD Pty Ltd (GHD) to support the DA and submitted to Council in October 2018. The DA and EIS were placed on exhibition for a 60 day period from 19 January to 20 March 2019. A Response to Submissions (RtS) Report was prepared by GHD in June 2019 to address the issues raised in submissions during exhibition and additional responses were provided to Council in October and November 2019.

The WRPP refused the DA on 6 April 2020 following a public panel meeting. One of the keys reasons for the refusal was based around the perceived risk for adverse environmental impacts upon the downstream receiving environment in the Wollongambe River catchment and the Greater Blue Mountains World Heritage Area.

1.2 Site setting

Sand and sandstone extraction activities commenced at the Bell Quarry site in 1967. The quarry operated under a development consent issued by Lithgow City Council in 1994 and an Environment Protection Licence (EPL) issued by the NSW Environment Protection Authority. The extraction activities have now ceased and the EPL was surrendered in October 2014.

The site is located in close proximity to other extractive industries and rural residential properties in surrounding area. The Clarence Colliery pit top, rail loop and loading facilities are located around 750 metres to the north and the Hansen Quarry is located to the west of the mining operations. The approved Newnes Kaolin Mine is located between the colliery and the northern extent of Bell Quarry, however mining operation at this site have not commenced.

The Blue Mountains National Park is located to the east of Clarence Colliery and is one of the eight protected areas making up the World Heritage Listed Greater Blue Mountains Area (UNESCO 2013). The Newnes State Forest is located to the north and west of the site.

The Bell Quarry is located within the upper reaches of the Wollangambe River catchment. This river drains towards the east where it eventually drains into the Colo River which forms part of the broader Hawkesbury-Nepean catchment area. All water drains to the Wollongambe River catchment and the site (northern parcel and subject to this DA) does not form part of Sydney's drinking water catchment area.

The existing quarry pit contains a number of voids that are currently filled with water from combination of groundwater seepage and surface water runoff. An ephemeral tributary of the Wollangambe River runs in a north-easterly direction through the site and has its headwaters in the vicinity of the rail line upstream of the site. Surface flows from this area of the catchment now enter the site at the western edge of the north void and flow through the site to where it discharges from the site into a small sediment basin located partially within the adjoining Blue Mountains National Park.

Approximately 200 metres downstream of the water-filled voids the drainage line enters a swamp where under dry weather conditions, flows are predominantly subsurface. The swamp occupies the majority of the drainage line upstream of the confluence with a similar tributary, which runs to the north of the site. Downstream of this confluence the tributary enters a meandering reach which is somewhat confined by sandstone outcropping, which continues for approximately 1.5 kilometres before the confluence with the Wollangambe River.

Martens and Associates (Martens 2021) have identified that the groundwater from the quarry is hydraulically disconnected from the swamp downgradient of the Bell Quarry site.

1.3 Project overview

The development application seeks to rehabilitate the subject land, with the final rehabilitated landform to be achieved via importation of material sourced across Sydney and the local regional area which meets:

- the definition of virgin excavated natural material (VENM) as defined by the POEO Act from time to time
- the criteria of excavated natural material (ENM) as set out in the Excavated Natural Material Order and Exemption 2014 issued by the Environmental Protection Authority under clause 93 of the Protection of the Environmental Operations (Waste) Regulation 2014, or
- an exemption granted by the Environment Protection Authority pursuant to clauses 91 and 92 of the Protection of the Environmental Operations (Waste) Regulation 2014) and which specifically relates to the Land. This material is referred to below as comparable material.

Collectively these are referred to as fill from herein. The rehabilitated landform will be revegetated in stages. This is defined as the Project.

The Project aligns with NSW Government's key policy priority actions to increase recycling and reuse of materials and limiting the need for new landfills and reduce landfill disposal.

The key objectives for the Project continue to include:

- Rehabilitate the site to a condition closely representing the pre-quarry original landform and that of the adjoining Blue Mountains National Park.
- Maximise resource recovery through diversion of VENM/ENM and comparable materials away from landfill for beneficial reuse for site rehabilitation.
- Undertake the rehabilitation works to be sympathetic to the surrounding land-use and environmental setting.
- Provide ongoing local employment opportunities.
- Revegetate the site with locally endemic species to provide effective integration with the surrounding landscape.

The rehabilitation process will involve:

- Importation of approximately 992,550 cubic metres of material (made up of 966,600 m^3 of fill with the remainder sidewall liner material [1]).
- Vehicle haulage at a rate of up to 140,000 tonnes per annum (tpa).
- Staged emplacement and compaction of soil material within the existing quarry voids.
- Shaping of fill to closely represent the pre-quarry landform and to allow surface water drainage across the final landform.
- Development of a water management system including management plans to control surface water discharges throughout the rehabilitation program and from the final landform.
- Revegetation of the site with locally endemic species to provide effective integration with the surrounding landscape.

1.4 Amendments to water management

A revised water management system has been developed for the site incorporating:

- Management of surface of water flows in three separate streams including:
    - Clean surface water from upstream catchment areas will be conveyed through and around the site to prevent interaction with site operations.
    - Sediment laden run-off from disturbed areas comprising naturally occurring site soils will be treated in sediment basins prior to release to receiving waters.

---

[1] Materials for liner preparation (groundwater depressurisation and seal bearing layer), intermediate cover and final capping works (assuming 600mm thick) are assumed to be won on site from within the proposed fill footprint area

  - Contact water comprising any surface water flows that have come in contact with emplacement material will be captured in a contact water pond for reuse via on-site irrigation to prevent discharge of surface water from the site.
- Inclusion of an engineered barrier system (liner and drainage layers) in the base, sidewalls and cap to create a barrier to groundwater flow and infiltration of rainfall / surface water into the emplaced material.
- The water management system also includes provision for installation of a water treatment plant to be triggered based upon storage levels in a contact water pond reaching 45% of capacity. The water treatment plant will ensure any contact water or the leachate can be released from the site and is treated to background water quality prior to discharge.

A key change for the assessment approach is in relation to the management of any contact water running off the active emplacement areas. Separation of clean and potentially sediment laden flows from the contact water has enabled all contact water to be retained on site and stored within a re-purposed eastern void for reuse on site.

The site water balance indicates all contact water can be retained on site for the life of the project under historical and potential future climate scenarios. Contingency for the provision of a water treatment plant has also been included as part of the Supplementary EIS in the event that the contact water pond reaches 45% capacity to ensure that any releases from the site are treated to background water quality and achieve a neutral or beneficial effect for the catchment.

Additional surface and groundwater monitoring has been undertaken and demonstrated that there is no direct connection between groundwater flows from the quarry site and a hanging swamp located approximately 200 metres downslope. The adoption of lining system within the emplacement cell will also limit the potential for leachate within emplacement cell to impact upon the deeper local or regional groundwater systems and to also achieve a neutral or beneficial effect for the catchment.

1.5 Purpose

The purpose of this Revised Water Resources Assessment is to update and complement the Water Resources Assessment presented as Appendix C of the Bell Quarry Rehabilitation Project Environmental Impact Statement (GHD 2018). The assessment considers the potential impacts associated with the revised water management strategy proposed for the development and should be read in conjunction with a hydrological assessment prepared for the proposed development by Martens & Associates.

Furthermore, this Revised Water Resources Assessment has been developed to specifically assess and address the Statement of Facts and Contentions (SOFAC) with respect to the concern that the project presents an unacceptable risk to water quality during the operations and post closure period.

The relevant contentions addressed in this Report are outlined in Table 1.1, together with a summary of the issue and an overview of how it is addressed.

Table 1.1 SOFACs and overview responses

Contention(s)	Description of issues	Overview of response
1(ii)	The concern is that the development will have an unacceptable environmental impacts on the adjoining Blue Mountains National Park, the Greater Blue Mountains World Heritage Area and the Wollangambe and Colo River systems through the dewatering process nor the importation of fill over the life of the project and beyond.	The dewatering works will be undertaken in a manner such that there is a negligible risk of impacting on the swamp as the flow rates will be varied and less than the swamp experiences in high rainfall conditions. This is addressed in section 5.5.2 of this Report and by Martens. Furthermore, the project will achieve a neutral or beneficial effect on water quality in the catchment. This will be achieved by range of measures assessed and described in this report (and supporting documentation) including: – The approach documented in the EIS where surface waters were mixed and released from site has been revised. A containment approach is instead proposed, and it is considered that it is

Contention(s)	Description of issues	Overview of response
		very likely full containment onsite will be achieved for contact water for the life of the project – Sediment and erosion control measures have been increased in accordance with 'sensitive' environments criterion – A contingency water treatment plant that if needed will be able to treat excess contact water and leachate to background water quality levels before it is released from the site – An engineered barrier system on the floor and walls of the emplacement area to separate leachate from the surrounding groundwater – A capping barrier to minimise the infiltration of rainfall into the fill These assessments and findings are contained in this Report.
2(i), (ii), (v), (vi)	This contention relates to the concern that the project will adversely impact downstream water quality.	See above.
3	This contention relates to the concern that the project will adversely impact downstream water quality.	See above
6(c)	This contention relates to the concern that the project will adversely impact downstream water quality.	See above

Additional contentions are addressed by Martens in their Hydrological Assessment (Martens, 2021).

2. Proposed development

2.1 Surface water management

A revised surface water management system has been developed involving management of surface water within the site in three separate streams:

- Water from upstream catchment (off-site) areas: This water shall be conveyed through/around the site without interaction with site waters wherever practicable, with direct discharge to the downstream receiving system. Where mixing of upstream and site waters is unavoidable, (for example, a cascade of upstream waters currently enters the western void of the site) the upstream waters shall mix only with sediment-laden water (not contact water). Where this mixing occurs the sediment laden water management approach shall include the volumetric contribution of the upstream waters.
- Sediment laden water: This is runoff from areas where disturbed, non-vegetated soil is present but does not consist of foreign imported fill material. In these areas runoff is to be managed in accordance with *Managing Urban Stormwater: Soils and Construction Volume 1, Landcom 2004 and Volume 2, DECC 2008*. The requirements within the documents that apply to a "sensitive" receiving environment would be adopted.
- Contact water: This water comprises any surface water that has interacted with emplacement material and will be captured in a contact water pond for reuse via on-site irrigation to prevent discharge of surface water from the site. There will be no discharges of surface contact waters would occur other than when treated to background water quality conditions.

2.2 Fill importation

2.2.1 Acceptance criteria

The development application seeks to achieve the final rehabilitated landform via importation of virgin excavated natural material (VENM), excavated natural material (ENM) and comparable material sourced from earthworks projects across Sydney and the local regional area (the Project).

The NSW EPA considers fill material as a valuable resource for the construction and infrastructure sectors in NSW and as such encourages the recovery of resources from waste to be used as fill where it is beneficial and poses minimal risk of harm to the environment and or human health (NSW EPA, 2017).

To implement recovery of resources from waste the EPA has the powers under the POEO Waste Regulation to pre-classify waste and provided exemptions (via waste resource recovery orders and exemptions). Virgin excavated natural material (VENM) and excavated natural material (ENM) have been classified by the EPA as materials that should be preferentially used for beneficial purposes as opposed to going to a licensed landfill. These are type of materials that will primarily be accepted at the project site, together with any material subject to a specific resource recovery order and exemption, where sought and granted by the EPA.

As indicated on the EPA website[2], the Protection of the Environment Operations Act 1997 (POEO Act) defines VENM as:

"*Natural material (such as clay, gravel, sand, soil or rock fines):*

a. *that has been excavated or quarried from areas that are not contaminated with manufactured chemicals, or with process residues, as a result of industrial, commercial, mining or agricultural activities and*

b. *that does not contain any sulfidic ores or soils or any other waste*

and includes excavated natural material that meets such criteria for virgin excavated natural material as may be approved for the time being pursuant to an EPA Gazettal notice.'

Virgin excavated natural material (VENM) is a waste that has been pre-classified as general solid waste (non-putrescible)."

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[2] Virgin excavated natural material (nsw.gov.au)

Within the ENM order (2014)[3], ENM is defined as:

"naturally occurring rock and soil (including but not limited to materials such as sandstone, shale, clay and soil) that has:

a. been excavated from the ground, and

b. contains at least 98% (by weight) natural material, and

c. does not meet the definition of Virgin Excavated Natural Material in the Act.

Excavated natural material does not include material located in a hotspot; that has been processed; or that contains asbestos, Acid Sulfate Soils (ASS), Potential Acid Sulfate soils (PASS) or sulfidic ores."

These definitions indicate that the material, while pre-classified as waste will be predominantly natural material that is not contaminated.

All fill material will meet the definition of either VENM, ENM or comparable material permitted under a specific resource recovery order and associated exemption.

2.2.2 Waste classes and environmental risk of harm

Emplacement material permitted to be accepted at the site is materially different to waste that has been generate at a site where potentially contaminating activities have or are occurring, and which would be required to be classified in accordance with the NSW EPA Waste Classification Guidelines (NSW EPA, 2014a) and transferred to landfill licensed to accept the classified waste.

VENM, ENM and comparable material permitted under a specific resource recovery order and associated exemption when applied to land are exempt from the licensing requirements under the POEO Act. These licensing exemptions reflect the intrinsic lower risk of environmental impact that these waste types present when applied to land compared to other waste classified as general solid waste, special waste and restricted waste.

As described above, VENM is material not contaminated with any man-made substances and does not contain sulphidic (acid forming) material or any other waste. The ENM Order states that ENM must comprise at least 98% natural material and other limiting criteria as discussed below. An application for comparable material in the form of a specific resource recovery order and associated exemption must demonstrate as a minimum that the material

- is fit for purpose in its proposed use,
- poses minimal risk of harm to the environment or human health; and
- is not intended to be land applied as a means of disposal (i.e., a landfilling activity).

The ENM Order outlines the maximum concentrations of substances and other attributes for acceptable ENM material, whilst the NSW EPA Waste Classification Guidelines (NSW EPA, 2014) identifies the maximum contaminant concentrations for general solid waste permitted at landfills licensed by the EPA. Special waste includes asbestos and restricted waste has higher contaminant concentrations than general solid waste.

For the substances that are present in both the Order and guidelines for general solid waste, it can be seen that the maximum concentrations for all substances in the NSW EPA Waste Classification Guidelines based on specific contaminant concentrations are greater than the maximum average concentrations in the ENM order.

There are, however, three substances which have a higher absolute maximum concentration in the NSW EPA ENM order compared to the maximum values for general solid waste in the NSW EPA Waste Classification Guidelines. This occurs for Nickel, Benzo(a)pyrene and chromium. However, on average, these concentrations are still less than those for general solid waste.

The VENM and ENM sought to be accepted at the site will be required to meet the definition of VENM in the POEO Act and the criteria outlined in the ENM Order, respectively . Any comparable material will be required to obtain a specific resource recovery order and exemption from the EPA by demonstrating that it poses minimal risk of harm to the environment or human health and addresses any other criteria stipulated by the EPA.These waste types (VENM, ENM and comparable material) present a lower risk of causing an environmental impact than waste that is able to be accepted at a licensed general solid waste landfill facility.

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[3] the excavated natural material order 2014 (nsw.gov.au)

Furthermore, additional mitigation measures, monitoring and if needed adaptive controls are proposed for the Project to ensure that the risk of environmental impact is negligible. These are described throughout this Report and the Environmental Management Plan (GHD 2021).

Table 2.1 ***Comparison of criteria in the ENM order (NSW EPA, 2014b) and the NSW EPA Waste Classification Guidelines (NSW EPA, 2014a)***

Substance	NSW EPA ENM order		NSW EPA Waste Classification Guidelines	General solid waste criteria in relation to absolute maximum ENM concentration
	Maximum average concentration for characterisation (mg/kg 'dry weight' unless otherwise specified)	Absolute maximum concentration (mg/kg 'dry weight' unless otherwise specified)	Maximum values of specific contaminant concentration for classification without TCLP. General solid waste (mg/kg)	
Mercury	0.5	1	4	4 x larger
Cadmium	0.5	1	20	20 x larger
Lead	50	100	100	Same value
Arsenic	20	40	100	2.5 x larger
Chromium (total)	75	150	100[4]	0.66 x smaller*
Copper	100	200	No value specified	-
Nickel	30	60	40	0.66 x smaller*
Zinc	150	300	No value specified	-
Electrical conductivity	1.5 dS/m	3 dS/m	No value specified	-
pH	5 to 9 [5]	4.5 to 10[6]	No value specified	-
Total Polycyclic Aromatic hydrocarbons	20	40	200	5 x larger
Benzo(a)pyrene	0.5	1	0.8	0.8 x smaller*
Benzene	NA	0.5	10	20 x larger
Toluene	NA	65	288	4.4 x larger
Ethyl-benzene	NA	25	600	24 x larger
Xylene	NA	15	1,000	66.7 x larger
Total Petroleum Hydrocarbons C_{10} – C_{36}	250	500	10,000	20 x larger
Rubber, plastic, bitumen, paper, cloth, paint and wood	0.05%	0.10%	No value specified	-

* Maximum average concentrations are lower than for general solid waste

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[4] Cr(VI)

[5] The ranges given for pH are for the minimum and maximum acceptable pH values in the excavated natural material

[6] The ranges given for pH are for the minimum and maximum acceptable pH values in the excavated natural material

2.2.3 Emplacement activities

2.2.3.1 Overview

The emplacement activities will be largely as described in the original DA and located within the disturbance footprint of the former Bell Quarry. Key changes in relation to the emplacement activities are described below:

- The proposed fill staging has been altered to reflect the revised surface water management system.
- The footprint of the landform has been slightly but remains fully within the footprint included in the original DA and the maximum height of the final landform has not been altered.
- The eastern void is to be retained throughout the filling of the first 4 stages to allow for storage of contact water prior to disposal via irrigation (or, in the unlikely event a treatment plant is required, via treat and release).
- The fill footprint and final landform in the southern void have been adjusted to provide an alternative access which is developed as part of the filling of Stage 1.
- All areas proposed to be filled will be lined with HDPE geomembrane (or equivalent) on the base and clay on the sidewalls where they are adjacent to the natural substrate (i.e., in the pits).
- The basal lining of each stage includes a geonet drainage geocomposite (or equivalent) and riser to allow extraction of seepage (if required).
- Groundwater diversion system to promote groundwater movement down-gradient of the basal liner.
- A temporary clean water diversion system will be constructed to the west of the site to allow diversion of upstream catchment around active emplacement areas.
- The contact water dam will be lined with a geomembrane (or equivalent).
- Areas proposed to be filled will be capped with LLDPE geomembrane (or equivalent), overlaid with a subsurface drainage system and revegetated.
- Areas of the site have been identified for excavation works to supply site won material for site intermediate capping and a minimum of 600 mm of final capping materials.
- Excavation areas are within the extents of the proposed filling works and includes areas in the northern portion of the site as described in the original DA and a former deposition area in the eastern portion of the site.
- A stockpile of site won material is to be placed in the northeast corner of the site (for the later stages use).

2.2.3.2 Work stages

The rehabilitation work is split into Site Establishment works and four stages of filling works as described in detail in the Supplementary EIS Report. A summary of staged quantities is included in Table 2.2 and detailed Staging Plans are presented in the Supplementary EIS Report.

Table 2.2 *Staged quantities and areas (subject to detailed design)*

	Excavation[7] (m^3)	Volume[8] (m^3)	Base lining area** (m^2)	Sidewalll lining area** (m^2)	Active filling area* (m^2)	New intermediate cover area** (m^2)	Final cap area** (m^2)
Stage 1A		104,300	4,100	11,740	12,400	-	-
Stage 1B			-	4,500	12,400	7,390	5840
Stage 2		48,800	11,800	-	12,560	1,820	11,880
Stage 3a		89,850	10,500	3,600	17,900[9]	4,400[5]	0
Stage 3b		244,200	-	10,450	16,700[5]	8,870[5]	11,690
Stage 3c		25,800	-	-	7,660	-	8,150
Stage 3d		169,050	-	8,160	6,500	4,340	10,150
Stage 4	Up to 60,500	255,250	3,800	13,500	15,180[5]	-	22,230
Total	***60,500***	***1,053,050***	***30,200***	***51,950***	**-**	***26,820***	***69,930***

* plan area

** slope area

2.2.3.3 Final cover and liner system

The profile of the final cover and basal and side wall liners are described below:

Final cover profile (top to bottom):

- Revegetation layer suitable for the establishment and long-term viability of vegetation.
- Subsurface drainage layer to ensure stability of the revegetation layer and minimise infiltration.
- Geosynthetic barrier system that will minimise infiltration to as low as reasonably practicable and prevent 'bath tubbing' above the basal liner.
- Seal bearing layer to support the geosynthetic barrier layer.

Basal and sidewall liner profile (top to bottom):

- Compacted clay sidewall barrier progressively placed in lifts to minimise the horizontal migration of leachate out of the fill and seepage of groundwater into the fill.
- Geonet drainage geocomposite (or equivalent) to minimise damage of the basal liner barrier system and allow monitoring of leachate in the cells.
- Geosynthetic basal barrier layer to form a barrier between the placed fill and the groundwater, soil and substrata and minimise seepage to as low as reasonably practicable.
- Seal bearing layer to support the geosynthetic barrier layer.
- Groundwater diversion system to promote groundwater movement.

A construction quality assurance (CQA) Plan for the liner system will be developed that outlines the material specifications, installation and testing requirements.

Individual components of each of these systems are summarised in Table 2.3 and are described below.

Table 2.3 *Preliminary liner and capping specification*

Name	Layer Type	Thickness (mm)	Notes
Revegetation layer	Soil for vegetation	600	Site won material

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[7] Excavation represents the stage/area where the excavation is achieved. It does not represent the timing of excavation works. All other values in this table assume that this excavation work is undertaken as required.

[8] Volume represents volume from existing surface or design excavation surface to top of final cap. Stage fill capacities must also consider airspace lost to lining, cover and capping works.

[9] Where the entire stage catchment area is greater than 1.3 ha, filling works will be staged and intermediate cover used to maintain an actual contact water area of less than 1.3 ha at any time. Additional intermediate cover material may be required to achieve this requirement. Additional onsite soil generation has been included for this purpose.

Name	Layer Type	Thickness (mm)	Notes
Subsurface drainage layer	Geonet drainage geocomposite	To be determined as part of detailed design	Designed to prevent saturation of the revegetation layer and minimise infiltration into the fill
Final cover barrier layer	Textured Linear Low Density Polyethylene (LLDPE) Geomembrane (or equivalent)	2	Manufactured in accordance with GRI - GM17 Standard Specification for "Test Methods, Test Properties and Testing Frequency for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes" (Geosynthetic Institute, 2019)
Seal bearing layer / intermediate cover layer	Cohesive soil material	300	Site won material made up of fine-grained material or if coarse material with a protection geotextile
Fill	VENM, ENM or material in accordance with a specific resource recovery order/exemption	Variable	Imported material
Sidewall barrier layer	Compacted clay material	500	Permeability of less than 10^{-9} m/s
Subsurface drainage layer	Geonet drainage geocomposite	To be determined as part of detailed design	Designed to protect the liner and allow extraction of seepage to prevent saturation of the fill causing bath-tubbing during operation
Basal barrier layer	High Density Polyethylene (HDPE) Geomembrane (or equivalent)	2	Manufactured in accordance with GRI - GM13 Standard Specification for "Test Methods, Test Properties and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes" (Geosynthetic Research Institute, 2003)
Seal bearing layer	Cohesive soil material	300	Compacted site won material
Groundwater depressurisation layer	Free draining material	300	Free draining site won material

2.2.3.4 Groundwater diversion system

A groundwater diversion system will be included in the design of the basal lining in the pits to minimise the possibility of liner uplift and allow the flow of groundwater beneath and around the liner. The system will consist of a minimum of 300 mm of free draining site won or imported material with a similar geochemistry to the surrounding landscape. During detailed design of the basal liner the risk of liner uplift will be assessed and, if required, a sump and riser installed to allow depressurisation of the liner.

2.2.3.5 Leachate levels

Numerical groundwater modelling was performed Martens and Associates (2021).

The modelling established that, taking into consideration groundwater inflow and outflow, infiltration from the cap and seepage through the liner, over the long term, leachate levels are expected to rise and equalise with the surrounding groundwater table level (approximately 1037.5 mAHD).

The basal drainage layer at the base of the quarry void would allow monitoring of leachate in the fill. Monitoring of leachate levels at the riser will be undertaken to confirm that leachate is not accumulating/increasing within the quarry void creating a bathtub effectAs the site is being progressively capped and revegetated leachate levels will be able to be monitored during site operations. Monitoring and corrective actions (if needed) are outlined Section 6.5 of this Report.

2.2.3.6 Irrigation management

Contact water will result from runoff from active emplacement areas and minor quantities from any vehicle washdown. All contact water will be contained within the site or treated and discharged at background water quality conditions. Irrigation of contact water will only be applied within the contact water catchment.

Contact water will be contained by installation of diversion bunds and drained to the contact water storage. The accumulated contact water will be collected for irrigation within the emplacement area by:

- Tanker through application to the active placement area for dust suppression and moisture conditioning to achieve target compaction rates.
- Mobile sprinklers that will be located within the emplacement area outside of haulage routes.

The operation of the sprinklers will consider irrigation demand, wind speed and prevailing wind direction and elevation with the aim to prevent spray drift outside of the emplacement areas or exposure to workers. Irrigation activities will not take place during wet weather periods or during high wind speed condition depending on the elevation of the emplacement area. The mobile sprinklers will be sited within the emplacement area based on fill moisture monitoring by conductivity meter. The irrigation rate will be developed to minimise runoff, and to not exceed the capacity of the fill to absorb the contact water.

3. Existing Environment

3.1 Introduction

The purpose of this section is to complement the surface water and groundwater conditions presented in the EIS water resources assessment (GHD, 2018) using additional site data from site investigations undertaken by Martens and Associates since February 2021. Additional conceptualisation of surface and hydrogeological environment is provided in the EIS water resources assessment and in Martens (2021) Water Assessment and should be read in conjunction with the information provided in this section.

3.2 Surface water

As outlined in the previous EIS Water Resources Assessment, an ephemeral tributary of the Wollangambe River runs in a north-easterly direction from the project site. The quarry intersected this tributary's catchment, which has its headwaters in the vicinity of the rail line upstream of the site. Surface flows from this area of the catchment now enter the site at the western edge of the north void, where some erosion form high flow events is evident.

Water is discharged from the site through an established sediment basin on the external eastern edge of the site, which is located partially within adjoining national park surveyed boundary. The sediment basin contains considerable reed growth and aquatic vegetation and discharges into a drainage line that forms a continuation of the ephemeral tributary downstream of the site.

Downstream of the site, the drainage line enters a swamp. The swamp occupies the majority of the drainage line upstream of the confluence with a similar tributary, which runs to the north of the site. Downstream of this confluence the tributary enters a meandering reach which is somewhat confined by sandstone outcropping, which continues for approximately 1.5 kilometres before the confluence with the Wollangambe river.

The Wollangambe River winds eastwards through narrow canyons and is one of four major tributaries of the Colo River.

Martens and Associates (2021) have undertaken additional hydrological investigations for the project including analysis of surface water connectivity to the swamp. The investigations characterise the flow regime as follows:

- Flows to the hanging swamp appear to be directly related to incidence of local rainfall (i.e., flows appear to rely on surface flows from rainfall as opposed to base flows from groundwater).
- Local catchments have a relative rapid response with flows commencing not long after commencement of precipitation. This may be explained by the relatively shallow sandy catchment soils and frequent bedrock outcropping leading to runoff occurring relatively quickly following precipitation.
- Smaller flows upslope of the existing voids are captured by the voids, with overflows being directed to the hanging swamp downslope.
- Water levels in the voids are influenced largely by groundwater inflows and evaporation.
- Flows tend to be relatively minor (of the order of < 5 L/s) for most of the monitoring period, with the average flow rate skewed by less frequent flow events (median flows much less than average flows).

The previous EIS Water Resources Assessment (GHD 2018) also outlines surface water quality sampling results from both historical OEH (2015) investigations and sampling undertaken at the site. The results indicated generally a high-water quality of surface water in the reference sites compared at the time to downstream in the Wollongambe as a result of past discharges from the nearby Clarence Colliery.

In addition to this sampling further information is now available subsequent to the EIS Water Resources Assessment and presented in *Martens and Associates, 2021*. The surface water quality monitoring found the following:

- Water quality of overflows from the quarry voids is generally of relatively good quality when compared with trigger values given in the National Water Quality Management Strategy (2000) Australian and New Guidelines for Fresh and Marine Water Quality.

- Nutrient, heavy metal and hydrocarbon concentrations in surface discharges from the Site are low to below detection, indicating that the existing quarry and associated accesses are not significantly impacting on surface water quality downstream at the hanging swamp.
- Surface water is generally slightly acidic, most likely as a result of local geology.

3.3 Groundwater

Martens and Associates (2021) have undertaken additional groundwater investigations, which have been used to update the conceptualisation of the groundwater system for this assessment. The additional site data includes:

- Installation of groundwater monitoring wells to monitor groundwater elevations at the site and at the swamp downgradient of the site.
- Collection of groundwater samples from the wells to characterise baseline water quality.

The updated hydrogeological conceptualisation using this data is provided in the following sub-sections.

3.3.1 Groundwater quality

Groundwater monitoring was undertaken between September 2017 to October 2021 at both on and off-site wells MB02, MB03, MW021, MW301A, MW301B, MW302A, MW302B and MW401 (locations shown in Figure 3.1). Groundwater monitoring results are provided in Appendix A, with a summary of these results presented in Table 3.1. Background groundwater quality information was also available within groundwater investigations completed for the approval of the Newnes Junction Sand & Kaolin Extraction Project located immediately to the north of the site (GSS Environmental, 2011). Where applicable this information has also been summarised in Table 3.1.

Paper Size ISO A4

0 25 50 75 100

Meters

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Bell Quarry Rehabilitation Project Pty Ltd
Bell Quarry Appeal

Surface Water Monitoring Locations

Project No. 12541317
Revision No. B
Date 2/11/2021

FIGURE 3.1

\ghdnet\ghd\AU\Sydney\Projects\21\12541317\GIS\Maps\Deliverables\21_12541317_001_SurfaceMonitoringLocations.mxd

Data source: Groundwater monitoring locations: Martens; © Department of Customer Service 2020. Created by: mfredle

A piper plot was also created to help characterise the relationships between groundwater wells and surface water and the uniformity of groundwater quality within the aquifers (Figure 3.2).

Table 3.1 ***Summary of groundwater quality results (September 20127 – October 2021)***

Analyte	Units	DGV(1)(7)	%Values That Exceed the DGV	Mean ± Std (8)(9)	Min-Max	Comments
pH	pH units	6-5-7.5(2)	100	Not calculated	5.92-7.2	pH was only measured at MB02 and MB03 during the first two monitoring events. An average groundwater pH of 5.05 was measured as part of Newnes Kaolin WMP for the neighbouring site.
Electrical conductivity (EC)	µS/cm	NA	-	Not calculated(	52-164	EC was only measured at MB02 and MB03 during the first two monitoring events
Total dissolved solids	mg/L	NA	-	90±83	30 - 216	An average groundwater TDS of 84 mg/L was measured as part of Newnes Kaolin WMP (GSS Environmental, 2011) for the neighbouring site
Calcium	mg/L	NA	-	Not calculated	<0.05-13	Concentrations were commonly less than the Limit of laboratory reporting (LOR)
Magnesium	mg/L	NA	-	Not calculated	<0.5-<1	Concentrations were commonly less than the LOR
Potassium	mg/L	NA	-	1.1±0.6	<0.5-2.1	
Sodium	mg/L	NA	-	5.6±4.2	2.8-21	
Chloride	mg/L	NA	-	5±1.2	4-9	
Sulfate	mg/L	NA	-	2±0.8	1-5	
Alkalinity (as $CaCO_3$)	mg/L	NA	-	10±11	<5-52	
Ammonia (as N)	mg/L	0.32	0	0.023±0.026	<0.005-0.096	
Nitrogen (Total Oxidised) (as N)	mg/L	1.0(6)	13	0.300±0.544	<0.005-1.8	Given the aquifer conditions likely to be present as nitrate
Nitrogen (Total)	mg/L	0.250(2)	33	1.0±3.0	<0.1-15	
Phosphate total (P)	mg/L	0.015(2)	0	Not calculated	<0.005	Concentrations were consistently less than the LOR
Phosphorus (Total)	mg/L	0.015(2)	29	Not calculated	<0.05-1.1	Concentrations were commonly less than the LOR
Dissolved aluminium	mg/L	0.027	25	Not calculated	0.005-0.031	EC only measured at MB02 and MB03 during the first two monitoring events
Dissolved arsenic	mg/L	0.0008(4)	85	Not calculated	<0.0002-<0.001	LORs were commonly greater than the nominated DGV
Dissolved cadmium	mg/L	0.00006	88	Not calculated	0.00006-<0.0001	LORs were commonly greater than the nominated DGV

Analyte	Units	DGV(1)(7)	%Values That Exceed the DGV	Mean ± Std (8)(9)	Min-Max	Comments
Dissolved chromium	mg/L	0.00001(5)	100	Not calculated	<0.0002-<0.001	Concentrations were consistently less than the LOR. LORs were greater than the nominated DGV
Dissolved copper	mg/L	0.001	54	0.012±0.038	<0.0005-0.19	
Dissolved iron	mg/L	NA	NA	Not calculated	0.004-0.042	Iron only measured at MB02 and MB03 during the first two monitoring events
Dissolved lead	mg/L	0.001	0	Not calculated	<0.0001-<0.001	
Dissolved manganese	mg/L	1.2	50	Not calculated	0.101-2.85	Manganese only measured at MB02 and MB03 during the first two monitoring events
Dissolved mercury	mg/L	0.00006	85	Not calculated	<0.00005-<0.0001	The high LOR is greater than the nominated DGV
Dissolved nickel	mg/L	0.008	92	Not calculated	<0.001-0.085	
Dissolved zinc	mg/L	0.0024	46	0.045±0.158	<0.001-0.8	
TRH	µg/L	NA	NA	Not calculated	<0.01 – 0.460 (all fractions)	Detections of TRH were present in upgradient well MW201 only.
BTEX and PAHs	µg/L	see Appendix A	0	<LOR		All BTEX and PAH concentrations were below the LOR. It is noted that the LOR for anthracene, benzo(a)pyrene and phenanthrene was above the nominated DGVs.

Notes:
ANZG (2018) 99% protection level default guideline value (DGV) for fresh water.
ANZECC/ARMCANZ (2000) Trigger Values for Chemical Stressors for Southeast Australia Upland River ecosystem
Baseline groundwater data from #MW201 5/10/2021, where values <LOR the LOR was adopted
DGV used for As(V)
DGV used for Cr(VI)
Nitrate DGV taken from "Updating nitrate toxicity effects on freshwater aquatic species "
NA – not available
Mean±stdev not calculated if there was less than five results or if a large number of results were <LOR
In calculating mean±stdev values <LOR were given a value equal to the LOR.

Summary statistics presented in Table 3.1 and the piper plot indicate that water quality within the sandstone aquifer can be uniformly described as having:

- Na-Cl-HCO_3 to Na-HCO_3-Cl type waters.
- Slightly acid to neutral pH (ranging pH 5 to 7.5).
- Freshwater quality (TDS < 216 mg/L).
- Generally low concentrations of metals with detections likely attributed to the host sandstone rock.

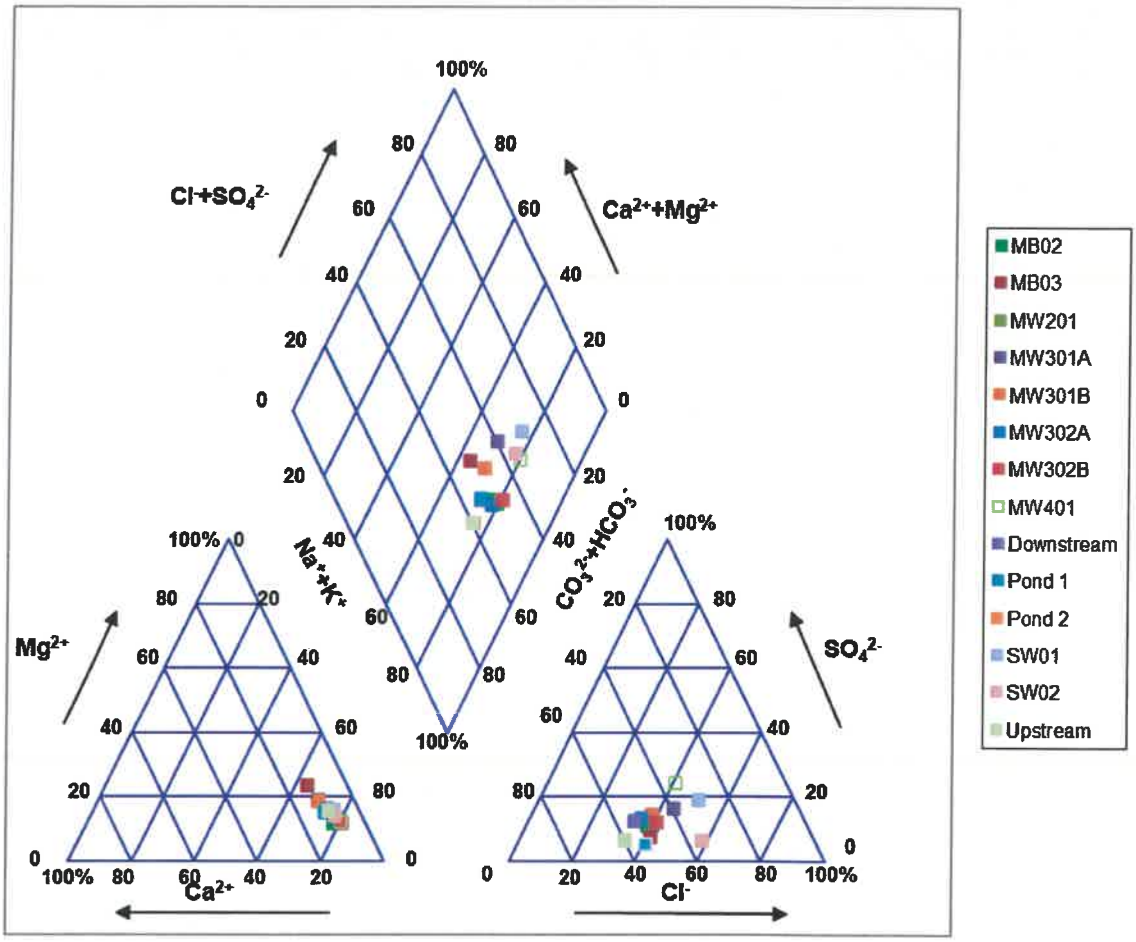

Figure 3.2 *Piper plot for groundwater and surface water - 19 October 2021*

Whilst many analytes exceeded the nominated default guideline value (DGV), observed concentrations are likely to be representative of natural background conditions given the mean, standard deviations, range of concentrations reported, and the similarity in ion composition to surface water sampled both on and downstream of the site. The variability in analyte concentrations observed between monitoring events and locations is likely attributed to inherent natural variability within the aquifer. Many of the noted exceedances were also attributable to elevated LORs that exceeded the nominated DGVs.

3.3.2 Groundwater levels

Groundwater elevation behaviour associated with the groundwater monitoring locations presented in Figure 3.1 are discussed below. MB01 is not present in the figure but is located in the approximate vicinity of MW201 and is up-gradient of the quarry voids.

Previously reported groundwater elevations (GHD, 2018) were based on data collected at the time of well installation on 15 and 31 August 2017. This data is presented in Table 3.2 and indicated that groundwater flow was to the north-east, in the direction of surface water drainage.

Table 3.2 *Groundwater elevations, 15 and 31 August 2017*

Site	Surface elevation (m AHD)	Total depth (m BGL)	Standing Water Level (m BGL)	Groundwater elevation (m AHD)
MB01	1067.62	21.52	19.32	1048.30
MB02	1043.75	28.0	17.45	1026.30
MB03	1038.13	23.25	12.82	1025.31

The water level observed in MB01 was higher than the surface water level in the western and eastern voids indicating that the site voids intercept groundwater from upgradient areas.

Recent groundwater elevation data has been collected using data loggers installed in the site wells between April and October 2021 as well as surface water monitoring sites. The average Standing Water Level (SWL) for the datalogger time period is tabulated in Table 3.3 and data for the surface water monitoring sites is presented in Table 3.4.

Table 3.3 Groundwater elevation data summary

Site	Surface Elevation (m AHD)	Total depth (m BGL)	Standing Water Level (m BGL)	Groundwater elevation (m AHD)	Observation Period
MW201	1067.17	43.86	24.04	1043.13	20/4/21 to 13/10/2021
MB02	1043.75	28.17	13.95	1029.85	20/4/21 to 13/10/2021
MB03	1038.13	23.83	10.95	1027.24	20/4/21 to 13/10/2021
MW301A	1014.58	4.95	1.42	1013.16	20/4/21 to 13/10/2021
MW301B	1014.19	1.22	0.02	1014.17	29/4/21 to 13/10/2021
MW302A	1008.16	2.13	0.23	1007.93	29/4/21 to 13/10/2021
MW302B	1007.57	0.91	0.00	1007.58	29/4/21 to 13/10/2021
MW401	1022.02	11.86	2.14	1019.88	8/7/21 to 13/10/2021

Table 3.4. ***Monitoring data for surface water monitoring sites***

Site	Surface Elevation (m AHD)	Depth above logger (m)	Water Level (m AHD)	Logger level (m AHD)	Observation Period
First pond	1037.82	0.71	1037.85	1037.07	20/4/21 to 13/10/2021
Second pond	1029.88	1.16	1029.78	1028.72	20/4/21 to 13/10/2021
Upstream channel	1024.45	N/A		1023.55	29/4/21 to 13/10/2021
Downstream channel	998.57	N/A		997.80	20/4/21 to 13/10/2021

Figure 3.3 provides the interpolated groundwater elevation contours and flow field using the average groundwater SWLs from the dataloggers. The spatial contouring was performed using kriging interpolation within ArcGIS Map.

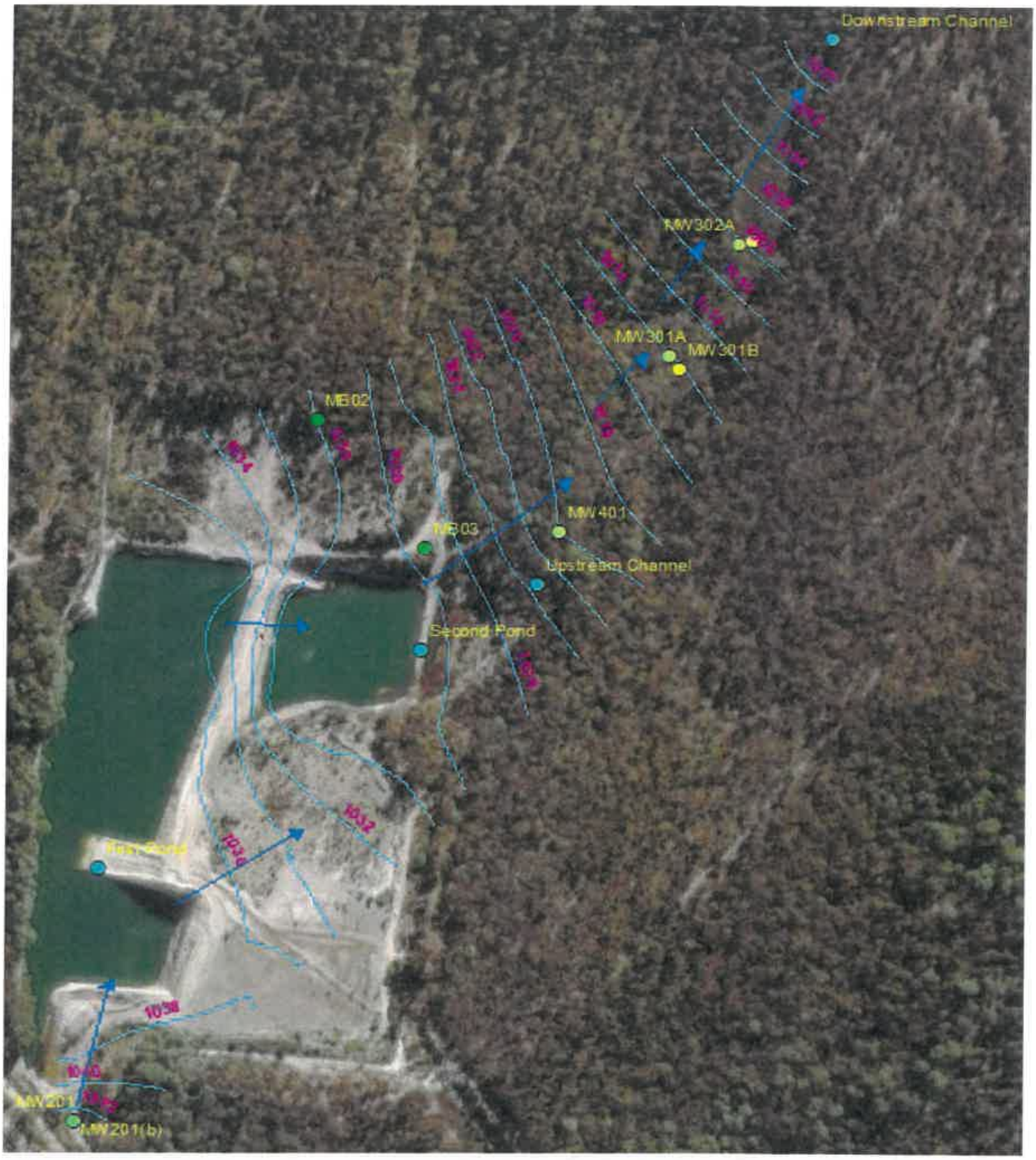

Figure 3.3 *Current groundwater flow field showing groundwater contours (in mAHD)*

Figure 3.4 presents the groundwater levels from monitoring wells at the swamp (in locations at the upstream end of the swamp [MW301A (deep) and MW301B (shallow)] and middle areas of the swamp [MW302A (deep) and MW302B (shallow)]). The purpose of shallow and deep wells adjacent to each other is to characterise the vertical hydraulic gradient. MW301A and MW301B are effective at measuring vertical hydraulic gradient because of the difference in the well depth from 1.94 metres (shallow, in sand) to 5.84 metres (deep, in sandstone). MW302A and MW302B are less effective in measuring vertical hydraulic gradient due to both being screened in the same shallow sandy aquifer where vertical head differences cannot be established.

MW301A and MW301B demonstrate a downward vertical hydraulic gradient as seen by the shallower MW301B hydraulic head being higher than the deeper MW301A hydraulic head by approximately 1 metre. The shallower well is screened in the sand aquifer above the sandstone, while the deeper well is screened in the sandstone unit. This downward vertical gradient indicates that the groundwater is being recharged from the swamp with an approximate vertical hydraulic gradient calculated as 0.26.

The horizontal hydraulic gradient can be measured from the difference in hydraulic head (SWLs) between the same sandy aquifer of MW301 and MW302 compared to the distance between them. The calculated horizontal hydraulic gradient between MW301 and MW302 is 0.009 and reflects groundwater flow direction within the shallow aquifer between the two wells.

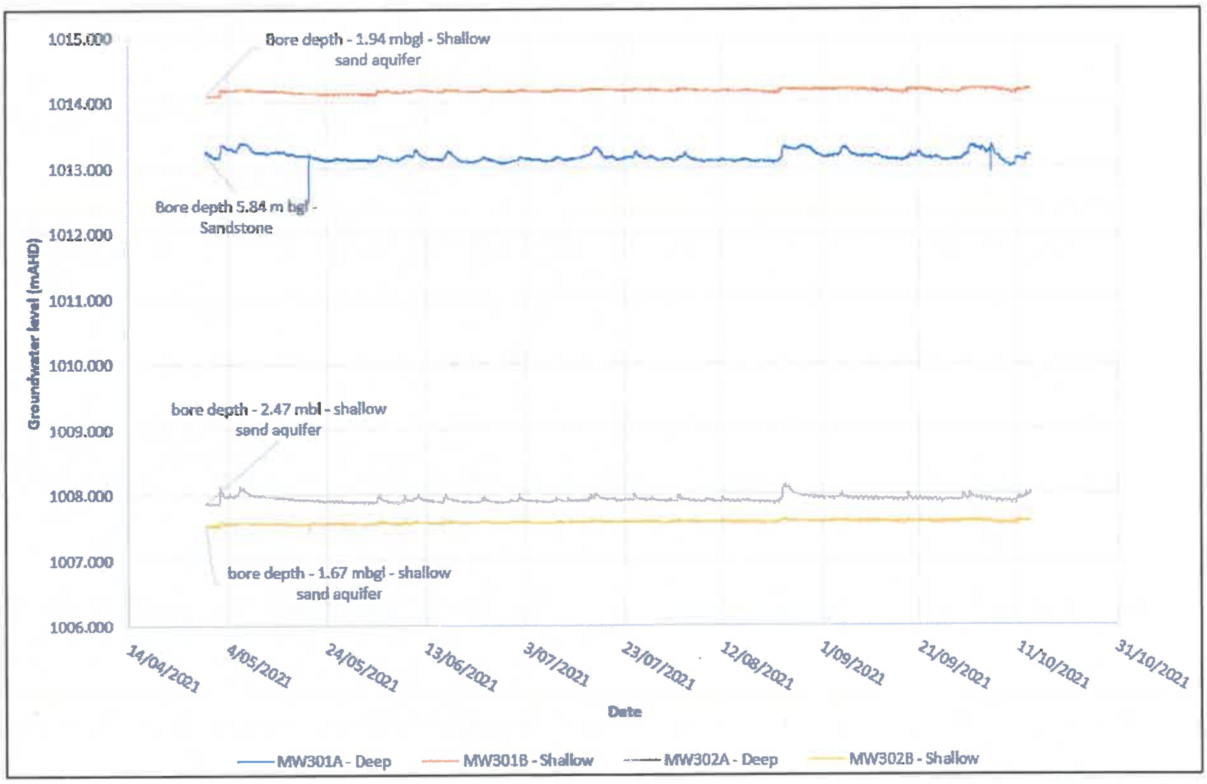

Figure 3.4 **_Groundwater levels at swamp between 4 May 2021 and 11 October 2021_**

3.3.3 Aquifer properties

Aquifer properties were previously described in GHD (2018). Hydraulic conductivities (k) were estimated from analysis of slug testing completed in onsite wells MB02 and MB03. The slug test data was analysed using the "initial response" and "Horslev's basic time lag" methods. The results of the analysis are summarised in Table 3.5. When the results were considered with literature values for the Banks Walls Sandstone aquifer intersecting the site, a range in horizontal hydraulic conductivity of 3 x 10^{-8} m/s to 6 x 10^{-7} m/s was used to establish low and high groundwater flow scenarios for the aquifer intersecting the site.

Table 3.5 **_Hydraulic conductivity_**

Site	K (m/s) Initial response	K (m/s) Horvlev's basic time lag
MB02	2.0 x 10^{-6}	6.9 x 10^{-7}
MB03	3.4 x 10^{-7}	2.6 x 10^{-7}

These two derivations for horizontal hydraulic conductivity have been applied to the seepage analysis calculations.

4. Adopted assessment criteria

4.1 Surface water

A revised surface water management system has been developed involving management of surface water within the site in three separate streams. As outlined in Section 2.1 a key change to the WRA is with relation to the management of water is water that has come into contact with material as it is being placed (contact water). This allows for the separation of different water types and management according to their risks as described below:

- Water from upstream (off-site) areas: This water will be conveyed through/around the site without interaction with site waters wherever practicable, with direct discharge to the downstream receiving system. Where mixing of upstream and site waters is unavoidable, (for example, a cascade of upstream waters currently enters the western void of the site) the upstream waters shall mix only with sediment-laden water (not contact water). Where this mixing occurs the sediment laden water management approach shall include the volumetric contribution of the upstream waters.
- Sediment laden water: This is runoff from areas where disturbed, non-vegetated soil is present but does not consist of foreign imported fill material. In these areas runoff is to be managed in accordance with *Managing Urban Stormwater: Soils and Construction Volume 1, Landcom 2004 and Volume 2, DECC 2008*. The requirements within the documents that apply to a "sensitive" receiving environment would be adopted.
- Contact water: No discharges of surface contact waters would occur other than when treated to background water quality conditions. Background water quality conditions were adopted from the derived 80th percentile water quality data (Newnes Plateau headwater streams) prepared by the Office of Environment and Heritage in 2015[10]. This reflects the methods recommended in ANZECC (2000).

The assessment criteria for the project has been developed based on the State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011 as well as the corresponding WaterNSW guideline *Neutral or Beneficial Effect (NorBE) on Water Quality Assessment Guideline*.

The site is not located within Sydney's drinking water catchment, however the NorBE approach has been applied to the proposed development to achieve the highest level of protection given the sensitivities of receiving waters in the Wollongambe River catchment and the Greater Blue Mountains World Heritage area.

The assessment criteria is derived based on the following definition from the guideline:

A neutral or beneficial effect on water quality is satisfied if the development:

a. has no identifiable potential impact on water quality, or
b. will contain any water quality impact on the development site and prevent it from reaching any watercourse, waterbody, or drainage depression on the site

The assessment criteria has been applied to each category of water as follows:

- Where upstream water does not come into contact with site waters it is anticipated to *have no identifiable potential impact on water quality* and as such satisfy the Neutral or Beneficial requirement of the SEPP (refer Section 3.1a of the guideline).
- Sediment laden water would be managed in accordance with *Managing Urban Stormwater: Soils and Construction Volume 1 and Volume 2* which are current recommended practices (CRPs) in accordance with the SEPP. The SEPP states that new developments or activities should incorporate CRPs and standards endorsed by Water NSW or adopt approaches that achieve the same or better water quality outcomes. Inferring that the outcomes achieved through implementation of the CRPs constitute the appropriate environmental outcomes under the SEPP.
- It is noted that the risk posed through leaching of substances from foreign imported materials is not fully covered under the abovementioned CRPs. As such, for contact runoff areas surface waters will either be contained or treated to achieve background conditions before discharge.

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[10] Clarence Colliery Discharge Investigation (nsw.gov.au)

4.2 Groundwater

The assessment criteria have been developed based on the primary receptor being terrestrial or aquatic ecosystems located immediately downgradient of the swamp. The swamp was identified to be the primary receptor in the EIS water resources assessment (GHD, 2018). Preliminary results from additional site investigations completed by Martens now indicate that the swamp is not hydraulically connected to groundwater emanating from the site and, as such, it has been conservatively assumed that: groundwater discharges to the creek line directly down gradient of the swamp and that the nearest ecological receptor is located at this point.

To maintain the nature of the ecological system of the National park and receiving environment area the groundwater assessment criteria have been designed to maintain the groundwater quality within the boundaries of the beneficial use potential of the receiving ecosystem and within the boundaries of having no identifiable adverse impact on water quality, which is consistent with a neutral or beneficial impact (NorBe) approach (Water NSW, 2021).

The specific values adopted for the groundwater assessment to achieve a neutral or beneficial affect at the nearest receptor are listed below:

- Where background groundwater quality data allows, a change of 10% of the median in background groundwater quality is considered to be acceptable.
- The ANZG (2018) criteria for the protection of 99% of freshwater ecosystems is adopted where the background groundwater quality data is scarcely detectable, non-detectable or absent and the limit of laboratory reporting (LOR) is above the criteria. A change in water quality that prevents a material change in the quantitative value of the ANZG (2018) criteria is considered to be acceptable (e.g., a change less than 0.5 times the criteria).
- The LOR is adopted where the background groundwater quality data is scarcely detectable, non-detectable or absent and the LOR is below the criteria for the protection of 99% of freshwater ecosystems. A change in water quality that prevents a material change in the LOR is considered to be acceptable (e.g., a change less than 0.99 times the LOR).

The development and implementation of these criteria rely on the characterisation of baseline/background groundwater quality. For this assessment the baseline groundwater monitoring data for all wells screened within the sandstone (the primary groundwater pathway), and presented in Appendix A, has been adopted and is discussed further in Section 6.2.2. To monitor for the emergence of unforeseen impacts during operation baseline groundwater monitoring program has been proposed and is detailed in Section 6.5.7.

The criteria have been applied to groundwater immediately prior to discharge into the creek to allow a separate assessment of impacts to the creek from surface water and groundwater, which:

- Allows the individual impacts of surface water and groundwater at the creek to be identified and managed.
- Prevents double counting of the attenuation capacity of the surface water environment.
- Is conservative, in that any additional attenuation capacity in surface water has not been considered as part of the groundwater assessment. It also means the surface water assessment can assume that groundwater does not result in additional impacts that need to be considered in the surface water attenuation assessment.
- It allows the adoption of baseline groundwater quality as target criteria rather than surface water criteria (which is representative of surface water and groundwater inputs).

5. Surface waters assessment

5.1 Overview

A key change to the EIS Water Resources Assessment (GHD 2018) is with relation to the management of water that has come into contact with fill material as it is being placed (contact water). Previously, this runoff was proposed to mix with other types of water and subsequently to discharge from the site.The impact assessment of the former Water Resources Assessment was conducted having regard to the predicted high quality of this discharge water. However, to lower the perceived risk of the site impacting downstream water quality and sensitive receptors, the management approach to the contact water has been revised. That is, contact water would now be either contained on-site with no surface water discharges or captured and treated to achieve background water quality before discharge.

According with the previous approach, a water balance was undertaken for the original EIS Water Resources Assessment (GHD 2018) that focussed on quantifying the mixing of different water types, to inform the predicted quality of discharges. The water balance also provided predictions of the range of volumetric flow rates downstream of the site.

With the change in approach a change in focus of the water balance was required. In particular, a revised representation of the contact water system with relation to containment or treatment (rather than mixing) was required.

Section 4.1 presents the adopted surface water criteria for the revised assessment based on the State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011. It can be noted that the criteria are based on separating the different types of water and managing accordingly. Therefore, the assessment was undertaken with respect to the different water types as outlined in the following sections.

5.2 Upstream surface water

The filling plans have been revised to achieve separation of upstream surface water from contact water. This is achieved by alteration of the staging such that upstream inflows (that currently cascade into the western void at a defined flow point) can be diverted around active fill areas. This is implemented by temporarily (Stages 2 – 3C) diverting the location where upstream flows enter the void and not returning back to the original location until the void has been filled sufficiently to allow clean flows to flow over non-contact areas (Stages 3D onwards). Once this has occurred the route of the previous temporary flow diversion can be filled over to reach the rehabilitated landform and reinstate the approximate location of the original creek line pre-quarrying.

During the initial stages of the project, prior to any diversions occurring the upstream inflows would mix with site runoff in the main western void. However, this would occur in the same manner as the existing scenario, with no altered or filled areas being conveyed to the void. As such, it is not anticipated to materially alter the generally high-water quality of waters already in the pit.

Therefore, based on the revised staging the proposed works allow for conveyance of upstream surface flows around the proposed site activities and associated higher risk site surface waters.

5.3 Site sediment-laden water

Sediment laden water is runoff from site areas where disturbed, non-vegetated soil is present but does not consist of foreign imported fill material. As noted in Section 4.1, sediment laden water is proposed to be managed in accordance with the Water NSW Current Recommended Practice Document *Managing Urban Stormwater: Soils and Construction Volume 1 and Volume 2* for receiving environments recognised as "sensitive". The Current Recommended Practice documents are management practices that have been endorsed by WaterNSW, which is referenced in the 2011 SEPP and the 2021 NorBE Guidelines.

This is consistent with the approach adopted in the original Water Resources Assessment where a sediment settling zone requirement of 800 cubic metres per hectare of catchment was specified based on the procedures of the above document for a 95th Percentile 5-day rainfall event of 99.6 millimetres. Although any sediment basins would be cleaned out after every significant runoff event, an additional volume of 200 cubic metres per hectare would be provided, resulting in a total volumetric requirement of 1 ML per hectare of catchment.

Filling plans presented in Appendix A have been developed. It can be noted that sediment generating intermediate cover areas are conveyed to proposed sediment basins with the sediment basins sized based on the above requirement. Where sediment laden areas need to be pumped to the sediment basins, the pumping capacity will be sized to convey the design 5-day rainfall event for the basin. It should be noted that for sediment generating areas that are below grade (e.g., excavations) significantly more storage will be provided by virtue of being below grade (in a pit) than would be required under *Managing Urban Stormwater: Soils and Construction*.

5.4 Contact water

The methodology and results of the revised assessment of contact water, based on containment or treatment, are presented in the following sections.

5.4.1 Contact water methodology

As noted in Section 4.1 the criteria adopted for contact water is that no discharges should occur other than when treated to background water quality conditions. As such, an assessment methodology was developed to determine:

- Ensure contact waters can be contained on-site.
- Irrespective of the above, development of a contingency plan involving treatment and discharge, if needed during site operations to further limit the contact water catchment.

The methodology adopted is outlined in the following sections.

It should be noted that the intermediate cap or rehabilitated areas are not managed as contact water on the basis that intermediate or final capping material will be sourced from on-site. As such, it does not pose the same risk as imported fill with relation to importation of material with different properties to that of the in-situ geology.

Staging review

A conservative approach was adopted where the most critical stage was identified, and the revised water balance simulated over a long meteorological period occurring over a static most critical site configuration. The critical phase was adopted as the one where containment of waters would be the most difficult to achieve, and is based broadly on the following two key parameters:

- Whether the exposed filling area is above-grade where it could drain via gravity to a discharge point. For example, filling the bottom of the large void would not be the critical stage as large rainfall events would fill up the lined void storage rather than discharge.
- The exposed fill area.

Based on this the selected critical stage is considered to be during Stage 3. During this period a maximum active fill area of 1.3 hectares would be maintained (using interim cover if required). An allowance of 0.1 hectares was also provided to consider the contact water flow paths, forming a total catchment of 1.4 hectares.

It was also identified that in order to implement a containment/treatment approach the eastern void would need to remain as a water storage. This void would be lined to the same standard as the areas containing the emplaced material.

System identification

Based on the critical stage identified as discussed above the contact water system includes a contact water catchment draining to the eastern void which would be operated as a lined contact water storage. Contact water is proposed to be managed via either/both irrigation over the emplaced material (only within the contact catchment) or treatment and discharge at background water quality concentrations. Therefore, the operation of the contact water system was identified as follows:

- Rainfall on the contact catchment would either:
  - Runoff (or be pumped) and enter the eastern void.

  - Be taken up into the imported material as it is placed.
  - Remain at or near the material surface and evaporate.
  - Infiltrate where it could either:
    - Be taken up in lower, previously placed material.
    - Migrate to the subsurface system, from where it could potentially be extracted to the eastern void and/or be retained by the proposed liner.
- Rainfall that falls directly on the lined eastern void would contribute directly to the void water storage.
- The eastern void is to be lined to mitigate against leakage.
- Evaporation would occur from the eastern void water surface.
- Treated water (if applicable) would be withdrawn from the eastern void and discharged downstream at background water quality concentrations. Return brine would be recirculated and buried back within the active emplacement area or possibly taken off site for beneficial reuse (draft Environmental Management Plan, GHD,2021).
- Water would be irrigated from the eastern void over the contact water catchment, where it would undergo the same physical processes described above for rainfall on the contact catchment.

It is noted that quantifying all elements of the above system is complex. In particular, representing the potential downwards migration of rainfall or irrigation and subsequent wetting-up of previously placed material, whilst at the same time receiving new incoming material (note: further information on these features is described in the Environmental Management Plan GHD 2021). Therefore, a system approach to the water balance modelling was developed where not all flows of water within the system are quantified but rather:

- The system inputs could be determined with relative accuracy being:
  - 100 percent of rainfall that falls either on the contact catchment or the eastern void.
  - Minor groundwater ingress as the system is lined.
  - Incoming moisture content of the imported material.
- Only system outputs that could be quantified with more confidence were included being:
  - Treatment and disposal (if required).
  - Evaporation of the void water surface.
  - Minor seepage based on the system being lined.
  - Evaporation off the contact catchment surface where rainfall or irrigation over the catchment occurs.
  - Wetting up of the material as it is placed from the incoming moisture content to the field capacity.
- Conservatively, the downwards migration and subsequent wetting of material previously placed was not represented. That is, material is only wetted via irrigation as it comes in. During wet periods wetting up of material placed previously during dry periods cannot be relied upon. This is a conservative assumption in the conceptualisation of the system as being confined to the current emplacement area. In reality, applied irrigation would to some extent in time migrate downwards to the subsurface into previous stages of filling. In particular, since the critical stage is where filling occurs at relatively higher levels.
- Assuming excess catchment water immediately enters the eastern void without the time lag that would actually occur

Therefore, the adopted system configuration for the water balance modelling is shown in Figure 5.1. This system was modelled, not with the aim of quantifying all water elements, rather to confirm the feasibility of containment and to inform the required treatment rate (if any).

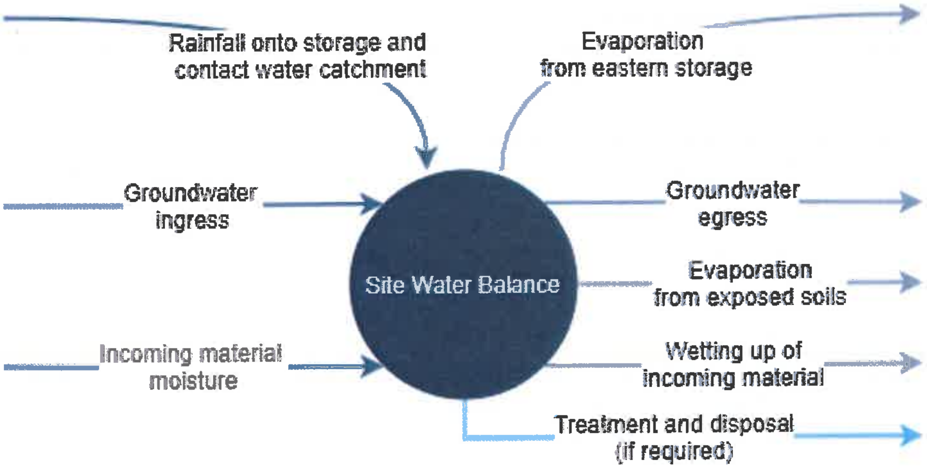


Figure 5.1 ***Water balance model configuration***

Furthermore, as discussed in the "Adopted Approach" section below, an additional 'contingency' model was also established to determine the treatment requirements. As a precautionary and conservative approach, in the contingency model not all of the identified disposal mechanisms were represented. This is discussed further in the "Adopted Approach" section.

Assessment tools

As noted above, evaporation of water from the contact catchment surface is an output from the modelled system. Further, as noted in Section 4.1 surface water management criteria have been adopted in accordance with the 2011 SEPP which stipulates the use of WaterNSW Current Recommended Practices. One of these documents is the *NSW EPA Environmental Guidelines – Solid Waste Landfills 2016* which specifies the use of the Hydrologic Evaluation of Landfill Performance (HELP) model. As such, the HELP model was adopted to estimate evaporation off a bare soil surface representing the contact catchment.

However, the water balance model requires the dynamic estimation of parameters based on the current system state. In particular, evaporation from the surface is dependent on whether water has been applied from the eastern void. This is in turn dependent on the water level in the void at that point in time. HELP does not have the ability to include dynamic considerations such as this.

Therefore, an approach was adopted where the water balance was developed using the GoldSIM software package but utilising a time series input from the simulation of a HELP model. GoldSIM is a flexible simulation tool that can be dynamically coded (similar to a spreadsheet) to allow custom representation of the modelled system.

Incoming material

In reviewing the system conceptualisation, it can be identified that the ability to contain contact water is dependent on the nature of the incoming materials. In particular:

- The incoming moisture content.
- The field capacity.
- Flow properties of the material such as particle size or porosity. These would influence the ability of the materials to retain water at the surface for evaporation.
- The compaction of the material when placed and subsequent impacts on hydrogeological properties.

Whilst these properties can be estimated with relative accuracy in terms of long-term trends and properties based on the anticipated nature of material to be imported, the definition of the project does not preclude the importation of materials at a certain point in time that may have less favourable properties with relation to the above parameters and achieving containment.

Therefore, an approach was adopted where a 'best-estimate' of likely incoming materials was adopted to test the likelihood of achieving containment without treatment. However, when stipulating a contingency arrangement involving treatment and disposal at background water quality conditions the following two disposal mechanisms were omitted to remove reliance on the properties of the incoming material:

- Evaporation of the surface of the emplaced material.
- Wetting up of incoming material from the incoming moisture content to the field capacity.

Therefore, the contingency arrangement has been developed to satisfy the assessment criteria irrespective of fluctuations in the properties of imported material.

The following sections outline the adopted approach and results, including both the best-estimate and contingency assessments. It should be noted that whilst the best-estimate model provides a best-estimate of incoming material properties (that is, neither conservative nor non-conservative) it still includes other conservative assumptions in the approach such as not allowing wetting up of previously placed material.

Adopted approach

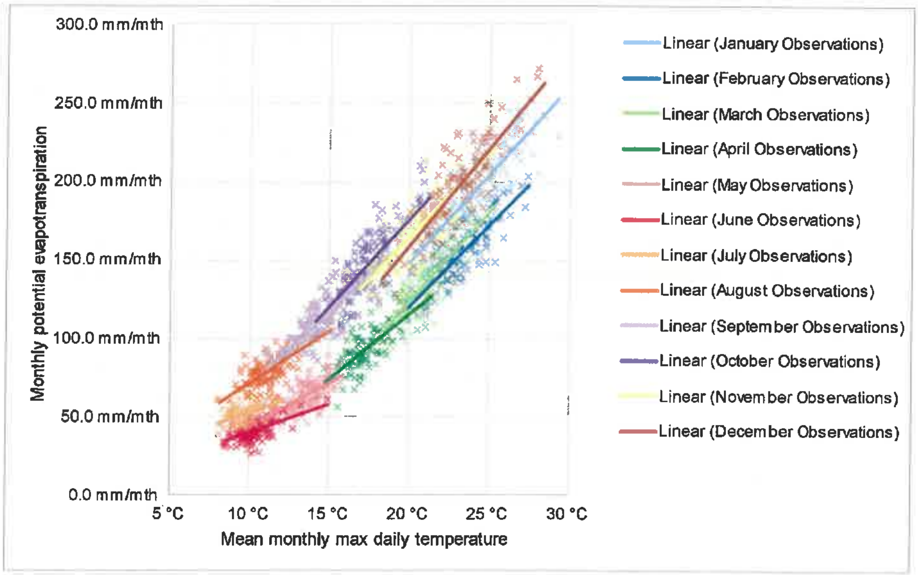
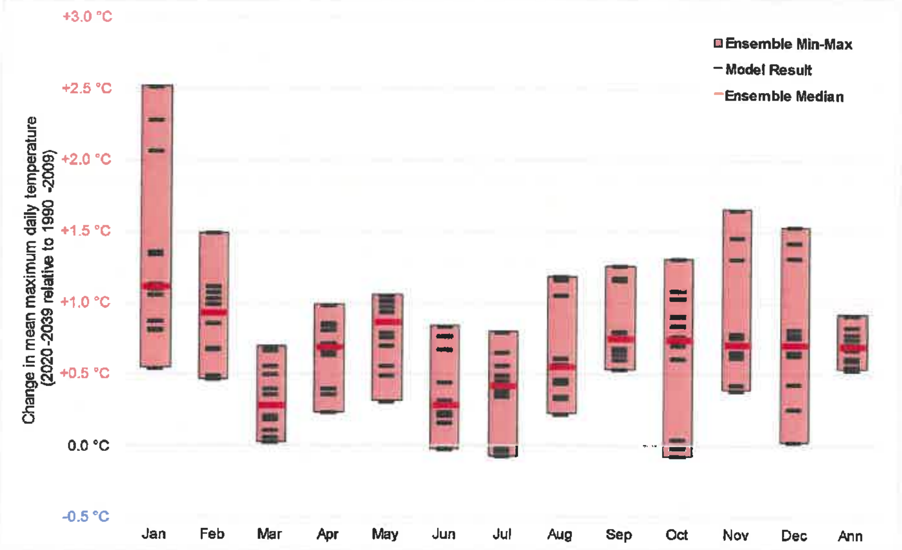
Based on the considerations as outlined the preceding sections the adopted approach for the contact system water balance is outlined as follows, with further details outlined in Table 5.1:

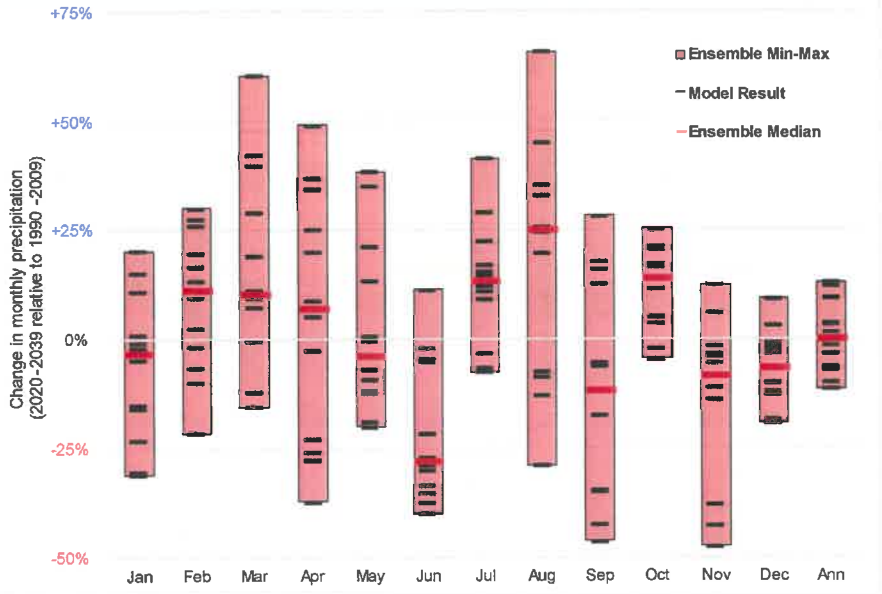
- A catchment area of 1.3 hectares (excluding the eastern void, with a 0.1 hectare allowance for drainage) as per the staging review.
- Meteorological data was revised from the data adopted for the previous WRA. This was based upon further review of available data and rainfall trends. Data was adopted based on interpolated data calculated by the SILO database centred on the site. This adopted data was compared to surrounding stations (Lithgow and Mount Wilson) and was found to represent the increasing West-East rainfall gradient. It was compared to the rainfall adopted for *Hydrology Study, Proposed Rehabilitation of Bell Quarry, Martens and Associates 2021* and found to be appropriately conservative for this assessment of contact water. This was based on the higher rainfall predicted (compared to the Martens data) for the highest 5 percent of rainfall months combined. The time series commenced at 1921 (the commencement of the HELP time series) and extended to 2020
- Evaporation off and direct rainfall on the eastern void as per the previous WRA.
- Groundwater seepage ingress and egress were estimated based on the provision of a liner as outlined as Item 1 in Table 5.1.
- The impacts of climate change with respect to both rainfall and evaporation were considered based on modelling of twelve potential climate change scenarios and confirming the predicted results apply for all scenarios. Details of the derivation of the scenarios is outlined as Item 2 in Table 5.1.
- The best-estimate model was simulated as follows:
  - On a monthly time-step. It was noted that the relatively large size of the void corresponds to months or years worth of rainfall over the catchment (not days). As such, a monthly timestep was appropriate.
  - Included wetting up of material as it comes in from an incoming moisture content to a field capacity moisture content. 10 percent moisture addition by mass was input which is discussed as Item 3 in Table 5.1.
  - Included evaporation off the bare-soil contact water catchment. This is discussed as Item 4 in Table 5.1
  - No treatment and subsequent discharge was included. On the basis that the model was intending to assess whether containment without treatment is likely to be feasible. As such the treatment protocol identified for the contingency model was not modelled.
- The contingency model was simulated as follows:
  - No net wetting of the material to form a disposal mechanism.
  - No evaporation off the contact water catchment (either of rainfall or irrigation water).
  - Various treatment contingency protocols were simulated to develop the proposed treatment contingency system. Protocols were based on commissioning a treatment system when the void reaches a nominated level then a lag time occurs before treatment is installed and operational (refer to Section 5.4.2). The simulation therefore commenced with the void at the water level corresponding to the trigger when treatment is commissioned. It then represents the void filling with no treatment disposal whilst the treatment is coming on-line. Then treatment occurs at the treatment capacity, with model results being iteratively reviewed to determine whether any overflows occur before the void is drawn down sufficiently by the treatment. The feasibility of treating the required volumes to background water quality conditions was reviewed as outlined in Item 5 of Table 5.1.

- The above protocols were represented over a wide range of climatic conditions. This was undertaken by resimulating the model multiple times, each time commencing at a different month in the modelled meteorological time period.
- Results were then extracted and discussed with particular relation to:
  - Prediction through the best-estimate model of whether containment of contact water without treatment is expected.
  - Iterating the treatment protocol and capacities in the contingency model to develop appropriate controls.

Table 5.1 Technical Description

Item #	Item	Description
1	Groundwater	A groundwater inflow into the lined emplacement areas was estimated as a relationship based upon the water level in the pit. Inflows varied but were in the range of 250 litres per day. This was considered a conservative estimate based on the groundwater inflows developed concurrently to the water balance assessment. It was noted that it was a minor contributor to the overall quantum of flows in the water balance.
2	Climate change	Consideration of potential changes to future climate was considered based upon NSW Government Climate Change modelling (NARCliM). Changes to the meteorological data was adopted based upon the following: – Changes to potential evapotranspiration is not an output of climate models. Historical correlation between mean monthly maximum temperature and monthly potential evaporation was determined as shown below. Analysis of 12 NARCliM model simulations was then undertaken to determine the predicted change in mean monthly max daily temperature for 2020-2039 compared to 1990-2009. This identified a spread of changes corresponding to a warmer future climate. – For each model simulation, using the change in mean monthly max daily temperature; the quantum of additional potential evapotranspiration was calculated. This typically resulted in between 0 to 125 mm/month of additional evapotranspiration. This was added on a monthly basis to the observed climatic period, with scaling applied to account for lower evapotranspiration from bare soils.

Item #	Item	Description
		  – Changes to potential precipitation is an output of climate models. However, to ensure that the same base-climatic series (corresponding to the evaporative time-series), the historical climate sequence was modified. Analysis of 12 NARCliM model simulations was undertaken to determine the predicted change in monthly rainfall totals for 2020-2039 compared to 1990-2009. This identified a spread of changes, with models generally suggesting changes in the order of ±10% of annual rainfall, with more significant seasonal shifts. – For each model simulation, the historical climate was scaled by applying a monthly precipitation factor.

Item #	Item	Description
		 – 12 NARCliM models were simulated for comparison to the historical climate, generating an ensemble of outcomes that may correspond to future climates.
3	Incoming material	A review of moisture content testing results as reported by ADE Consulting group (2017) was undertaken and indicated average moisture content between 2.0% and 23.4% vol/vol for the imported material. Typical field capacities from the HELP model were applied for the soil samples based on reported soil classification types. The HELP model provides default soil properties for a range of materials for the purpose of infiltration modelling for the proposed material. These values were used to estimate the likely available storage capacity for a range of soils. This represents the wetting capacity for the incoming material as it is placed from the incoming moisture content to the field capacity. The average available wetting capacity was estimated to be approximately 10.2%. This moisture rate was applied to the maximum incoming material rate. This is on the basis of the critical stage occurring at a later point in time and when filling is occurring at the maximum rate (which was advised by Bell Quarry Rehabilitation Pty Ltd to be expected from the commencement of operations).
4	Evaporation off the catchment	As noted previously, the HELP model was utilised to estimate evaporation of the soil of the contact water catchment. However, the HELP model is not able to receive a dynamic time series of evaporation. Therefore, several simulations of HELP were run each with a different quantum of irrigation (determined as the proportion of daily evaporation deficit being irrigated). Based on review of the HELP results a time series equal to rainfall plus 40 percent of the deficit was selected. This was based upon: – For an application greater than this (40 percent of the deficit) the evaporative loss of the soil was not significantly greater. That is, the evaporative capacity of the atmosphere was governing rather than the applied irrigation rate. – The volumes associated with this amount of irrigation are realistically feasible based on-site infrastructure and meteorological conditions. • Further details of the HELP modelling are outlined in the attached technical memorandum (Appendix C).
5	Treatment feasibility	Refer attached Contact Water and Leachate Treatment Options Report (Appendix D).

5.4.2 Contact water results

The results of the best estimate model are presented in Figure 5.2, which shows the predicted water levels in the eastern void (without the treatment contingency protocol) over the modelled time series for the different climate change realisations as well as historical climate. It can be noted that overflows from the contact water system are not predicted based on the historical climate and are only predicted in four of the twelve climate change models. Average flows of the modelled system elements are shown on Figure 5.3.

The input parameters of the contingency model were iterated until no overflows from the contact water system were predicted for the historical climate even with the conservative assumptions of the contingency model (no wetting up of material, no evaporation from the material surface). Climate change models were also simulated for this model, with the median, 1st Decile and 9th Decile results analysed. The adopted parameters based on iteration were:

- When the eastern void exceeds 45 percent of the total capacity, receival of material would cease. Covering of all exposed fill areas is commenced and completed within 40 days. After this the catchment would be diverted around the eastern void. This was determined as the quantity of time required to minimise the risk of high levels in the eastern void.
- At the same time the arrangement for provision of treatment at 85 kL/day would commence and would be operational within 20 weeks (actual delivery and commissioning of the system based on the two vendor responses would be approximately 10-20 weeks). The treatment rate selected was determined as the rate required to manage levels in the eastern void and dewater to a level that permits the cover to be removed and material to resume being received at the site and emplaced.
- Receival of material would recommence once the eastern void is down to 20 percent full and treatment would be utilised to maintain the void at a regular level of 30 percent from there onwards.

The results of the contingency model demonstrating containment are shown on Figure 5.4. These results suggest that:

- The historical climate is not predicted to reach full capacity of the eastern void in any of the simulations. That is, under historical climate conditions, overflow is not predicted.
- Less than 0.5% of the 13,524 climate simulations are predicted to reach full capacity of the eastern void. That is, including consideration of the estimated range of potential climate change outcomes and the variability of the observed climate to date, there is a 1 in 200 likelihood of the proposed treatment contingency measures being insufficient to prevent overflow. It should be noted that this is the chance of overflow occurring, should treatment be required. However, based on the best-estimate model (including wetting up of the material and evaporation over the catchment) treatment may not necessarily be required. Combining these two considerations, the chance of overflow is considered very low and can essentially be eliminated by covering the emplaced material and diverting rainfall away from the eastern void.

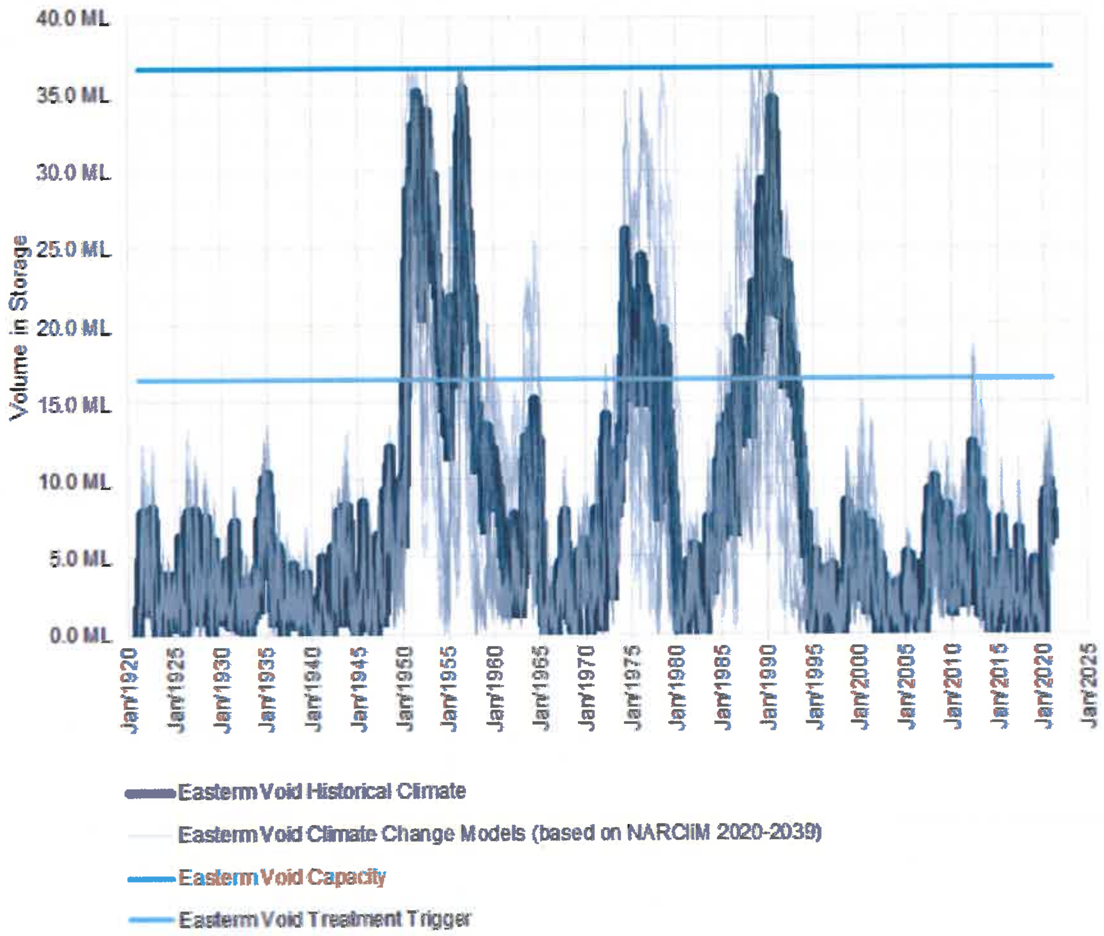
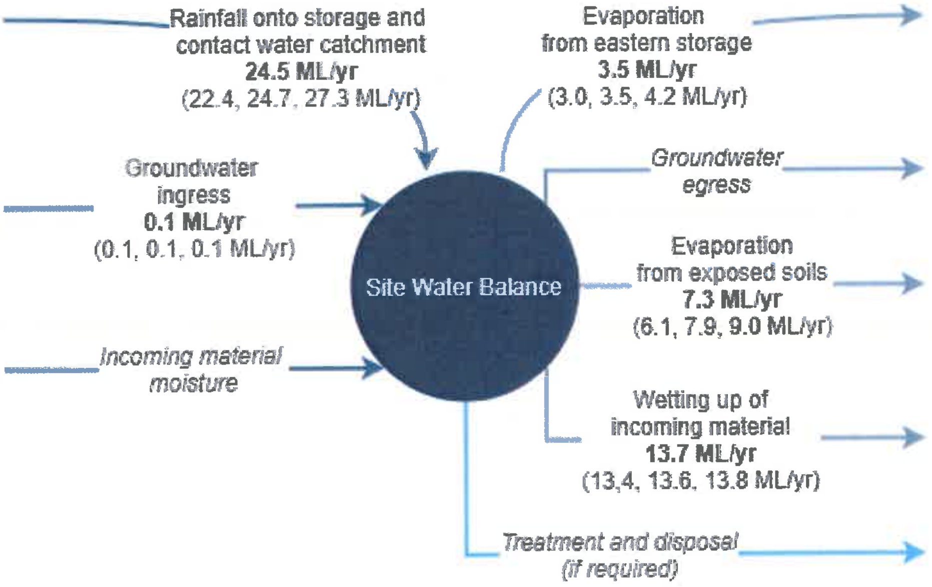


Figure 5.2 *Simulated Eastern Void storage volume for historical and future climate considerations*



Values in bold are based on the historical climate period.
(Values in brackets are shown as the 1st, 5th and 9th Decile of climate change models.)
Components in italics are not directly modelled

Figure 5.3 *Average annual results for historical and future climate considerations*

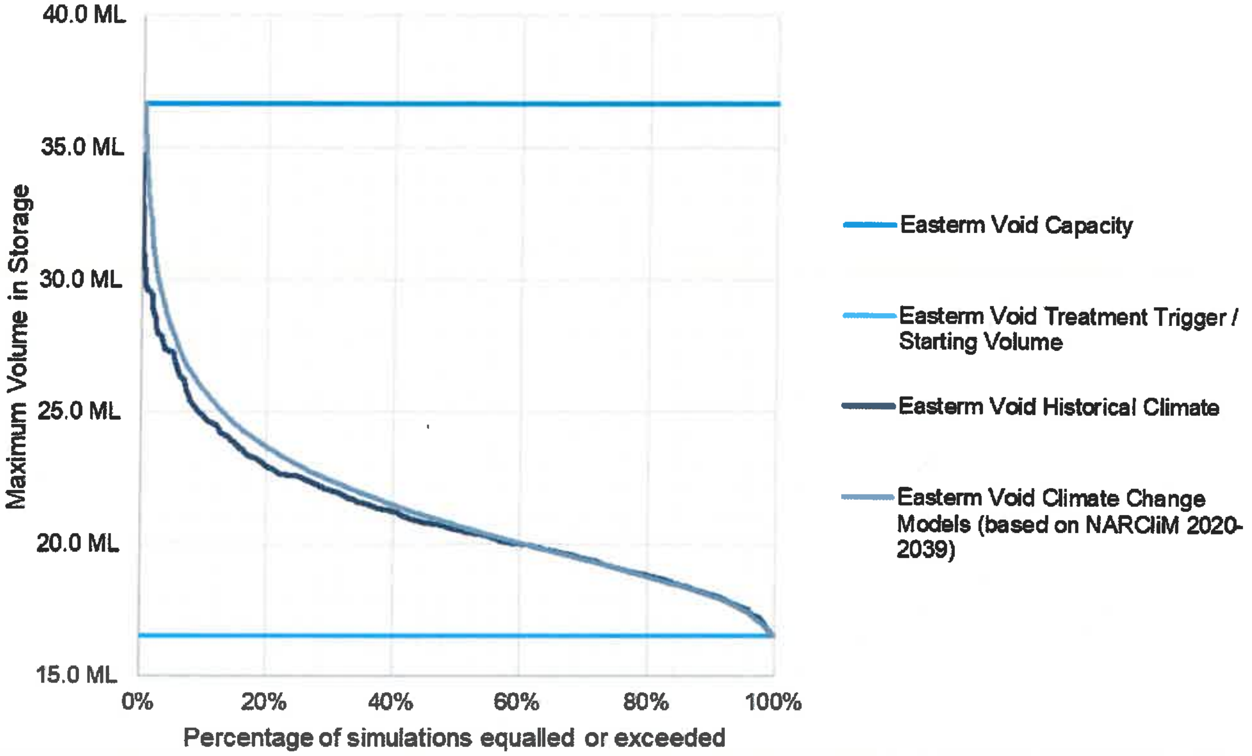


Figure 5.4 Statistics on maximum volume in the eastern void for historical and future climate considerations

With respect to the best estimate model, it is also noted that the likelihood of requiring to commission treatment (exceeding the treatment trigger threshold of 45%) has been analysed, based on historical and climate change models. It was estimated that for the historical climate the trigger is exceeded approximately 15 percent of the time and 11 percent of the time upon consideration of climate change. Noting that the critical phase modelled in the water balance only represents one stage of the project, there is therefore a significant likelihood of treatment not being required throughout the lifetime of the project. This supports the basis of adopting a trigger approach to commissioning treatment only if required.

5.5 Discussion

5.5.1 Criteria review

Reviewing the outcomes of the surface waters assessment described herein with respect to the surface water management criteria identified in Section 4.1 it can be noted:

- The revised staging the proposed works allow for conveyance of upstream surface flows around the proposed site activities and associated higher risk site surface waters.
- Site sediment laden water would be managed via separation from upstream water and contact water followed by collection and management in accordance with the WaterNSW Current Recommended Practice *Managing Urban Stormwater: Soils and Construction*.
- A best-estimate water balance model identified that the contact water catchment can be separated from other waters and could be fully contained without treatment, for the historical climate. However, to provide further contingency and consider climate change a contingency (treatment) model was developed specifying a treatment protocol. Under this contingency model overflows were not predicted for the historical climate. Including consideration of the estimated range of potential climate change outcomes and the variability of the observed climate to date, there is a rarer than 1 in 200 likelihood of the proposed treatment contingency measures being insufficient to prevent overflow. This is even with a set of conservative assumptions whereby disposal from wetting up of material or evaporation from the catchment surface is excluded. This very low risk

can essentially be eliminated by covering the emplaced material and diverting rainfall away from the eastern void.

On the basis of the above the surface water system is to operate in accordance with the 2011 SEPP and the NorBE criterion.

5.5.2 Downstream flow volumes

Further consideration was also undertaken subsequently to the previous WRA with relation to two items raised after its preparation:

- The potential for increasing stress on the downstream environments during dry periods by reducing the current reliability of surface flows. In particular, a swamp identified downstream of the site.
- Alteration of downstream volumetric flow patterns, resulting in issues with relation to downstream geomorphic stability.

These are discussed in the following sections.

Downstream flows during dry periods

It is noted that the revised staging presented in this revised WRA results in all periods of the project consisting of one of the following configurations:

- Existing conditions, where upstream flows cascade into the western site void and the site voids overflow to the downstream system, subject to rainfall conditions at the time.
- Dewatering of the western voids, where the upstream inflows enter the voids and are subsequently pumped out for discharge (along with water already in the pits).
- Diversion of upstream flows via gravity flow through the site, with separation from site waters, then discharging to the downstream environment.
- Final rehabilitated conditions, where upstream flows flow over the final landform, representative of natural catchment topography.

It can be noted from the above that at all times flows from upstream are volumetrically translated through the site. For the revised staging there is no point in time where upstream flows are captured within the site and reused over long periods within the site, which could potentially subsequently stress downstream environments. Rather, during any point where the upstream flow path is entering the void dewatering to downstream would occur regularly. Dewatering and staging would be timed such that dewatering would not be completed until the upstream gravity flow diversion is in place. Therefore, allowing a continual connection between the upstream catchment and downstream environment.

It is further noted:

- The revised staging minimises the contact water area, which is the area that needs to be captured and potentially contained (if treatment and discharge is not occurring). This area is approximately 1.4 hectares which is approximately 5-10 % of the upstream plus site catchment area draining to the site discharge point.
- Sediment laden areas of the site are anticipated to have similar runoff properties to the current site configuration and would be discharged after appropriate treatment in accordance with WaterNSW recommended practices.
- Runoff from rehabilitated areas within the site would be conveyed for discharge to represent pre-quarrying conditions.

On this basis, the proposed operational stages of the works are not anticipated to pose a significant risk to downstream flow rates during dry periods compared to existing or natural conditions.

Alteration to volumetric flow patterns

Based on the review of the staging discussed above, it can be noted that there is a period during the initial stages of the project where upstream flows would continue as is currently occurring to enter the western void as it is being dewatered, and then pumped out. Whilst the overall volumes of upstream inflows would be represented in the pumped discharges, the nature of the discharges would be altered. This is because pumped discharges would not fully replicate the temporal pattern of rainfall derived discharges. The following considerations are relevant to this:

- Martens and Associates have prepared a MUSIC model to estimate existing flow volumes in consideration of calibration to observed flow volumes undertaken since the previous WRA. This has predicted site discharges in the order of 2.9 ML/day are exceeded approximately 2 per cent of the time. Whilst 2 per cent is a small percent of the overall time series, at 7 days per year it represents a major proportion of days where significant flow is occurring. That is, it is a flow event that occurs regularly under existing conditions.
- The previous WRA predicted pumping-derived discharges during the maximum periods of the most critical stages (1 and 3) in the order of 1 to 2 ML/day.
- For the revised staging the maximum pumped discharges are anticipated to be less on the basis that upstream flows are diverted around the main north-western void before it is fully dewatered.
- As a general indication, 2 ML/day could dispose of the initial volume of water in the void in approximately 3 months, significantly less than the actual dewatering period.
- Therefore, the rate of flow during the dewatering stage would not be outside the range of flows typically experienced under existing conditions.
- In addition, Martens and Associates has undertaken additional geomorphological assessment which identified that low flows generally enter and infiltrate into the swamp, whereas larger flows in the swamp are broad flat, with some concentration in a central sag area in places as there is no defined channel occurs within the main swamp area, with a channel appearing at the downstream extent of the swamp as local gradient steepen.

5.6 Surface water monitoring

Surface water monitoring would be undertaken as outlined below:

Table 5.2 Surface Water Monitoring

Location	Frequency	Analytes
– Within all site sediment-laden water storages	– Quarterly, and – Prior to any managed discharge from the sediment laden system.	– Twice yearly sampling: TSS and Turbidity – Prior to discharge: TSS, or turbidity if a TSS: Turbidity relationship has been developed based on a minimum of 10 observations
– At all site sediment-laden water overflows	– If overflowing during operational hours, up to 4 times per year. – Daily during any discharges occurring from rainfall below the design storm event (99.6 mm).	– TSS and Turbidity.
– Eastern void contact water storage	– Quarterly, or – Monthly if eastern void above 30 percent of capacity.	– Table 5.3 for the first four samples then rationalised by removing analytes demonstrably removed by the potential future. In situ field parameters (pH, DO, redox, EC, temp). – The analytical suite, taking into account Table 6.7 would be reviewed should leachate be added to the contact water storage.
– Existing pit dewatering discharges during initial stages	– Monthly, during dewatering.	– In situ field parameters (pH, DO, redox, EC, temp) – Cation and anions – Chemical constituents (see Table 6.7– as per Groundwater Management Plan)
– Above upstream cascade inflow to site – Immediately downstream of site outflows	– When flowing, up to 4 times per year.	

Table 5.3 Eastern Void Monitoring

Analytes		
pH	Cadmium (Total and Dissolved)	Ammonia as N
Electrical Conductivity	Chromium (Total and Dissolved)	Nitrite as N
Total Dissolved Solids 25°C	Cobalt (Total and Dissolved)	Nitrate as N
Total Dissolved Solids (sum ions)	Copper (Total and Dissolved)	Nitrite + Nitrate as N
Total Suspended Solids	Lead (Total and Dissolved)	Total Kjeldahl Nitrogen as N
Turbidity	Manganese (Total and Dissolved)	Total Nitrogen as N
Hydroxide Alkalinity as CaCO3	Molybdenum (Total and Dissolved)	Total Phosphorus as P
Carbonate Alkalinity as CaCO3	Nickel (Total and Dissolved)	Reactive Phosphorus as P
Bicarbonate Alkalinity as CaCO3	Vanadium (Total and Dissolved)	Total Organic Carbon
Total Alkalinity as CaCO3	Zinc (Total and Dissolved)	COD
Carbon Dioxide	Iron (Total and Dissolved)	Meta- & para-Xylene
Bicarbonate	Strontium (Total and Dissolved)	Naphthalene
Carbonate	Aluminium (Total and Dissolved)	Ortho-Xylene
Calcium Hardness as CaCO3	Antimony (Total and Dissolved)	Benzene
Magnesium Hardness as CaCO3	Lithium (Total and Dissolved)	Cyanide
Total Hardness CaCO3	Selenium (Total and Dissolved)	Total Anions
Sulfate as SO4	Thallium (Total and Dissolved)	Total Cations
Hydrogen Sulfide	Uranium (Total and Dissolved)	Oil & Grease
Chloride	Tin (Total and Dissolved)	Bacterial Analyses (total plate count)
Fluoride	Titanium (Total and Dissolved)	Silica (reactive)
Bromide	Silver (Total and Dissolved)	Silica (total)
Calcium	Mercury (Total and Dissolved)	Arsenic (Total and Dissolved)
Magnesium	Boron (Total and Dissolved)	Beryllium (Total and Dissolved)
Sodium	Free Chlorine	Barium (Total and Dissolved)
Potassium		

5.7 Surface water TARP

Table 5.4 shows the proposed surface water Trigger Action Response Plan with relation to surface water. This has been developed to support implementation of the surface water management strategy described previously. Key definitions with relation to this plan are as follows:

- Sediment laden water discharge criteria: A detailed study was undertaken by the NSW Office and Environment and Heritage (OEH 2015) and provides a detailed data set of background surface water quality in the area. This suggested a background concentration of Total Suspended Solids of 5 mg/L. Either this would be adopted for the design containment or a site specific value based on a reference site downstream monitoring (which would be undertaken in addition to monitoring specified in this revised WRA and recent side tributary monitoring by Martens). A relationship between turbidity and total suspended solids maybe be developed to aid in more rapid assessment of sediment concentrations in the site storages. This would be based on a minimum of 10 observations.
- Sediment laden water design event: consistent with the WaterNSW CRPs and the approach of the previous WRA this would be the 95th Percentile 5-day event of 99.6 millimetres.

Table 5.4 Surface Water TARP

Trigger	Implication	Action
Overflows from the sediment laden system occur when less than the design rainfall event has been experienced.	The sediment laden system is not operating as intended.	All subsequent rainfall events - dewater sediment basins after rainfall to provide design storm event capacity for subsequent storm.
Sediment laden water discharge criteria is exceeded for any managed discharge from the sediment laden system	The sediment laden system is not operating as intended.	All subsequent rainfall events - do not undertake a managed discharge without meeting discharge criteria. If criteria not met refer below trigger.
At the conclusion of the sediment basin management period following rainfall (5-days): – Flocculation has not been able to achieve the sediment laden water discharge criteria, and – Less than the required sediment management capacity is available for subsequent storms.	Due to the low discharge criteria required a higher than standard level of treatment is required to manage sediment laden water.	Other than the final stages of filling, below grade storage (e.g., Northern excavation area) is available for water to be temporarily transferred to until sediment laden water discharge criteria can be satisfied and further investigation/management measures developed if required.. Therefore, transfer to below grade storage, where available, for this purpose. This trigger is unlikely to occur during the later stages. This is because if the in-situ sediments did result in an inability to treat with flocculant to the discharge standard then this would arise during the earlier stages.
The current water volume in the eastern void has exceeded 45 percent of capacity for the first time since being commissioned as the contact water storage.	The requirement for treatment has been triggered.	Cover all exposed material within 40 days and divert the catchment around the eastern void. Arrange treatment within 20 weeks.

6. Groundwater Assessment

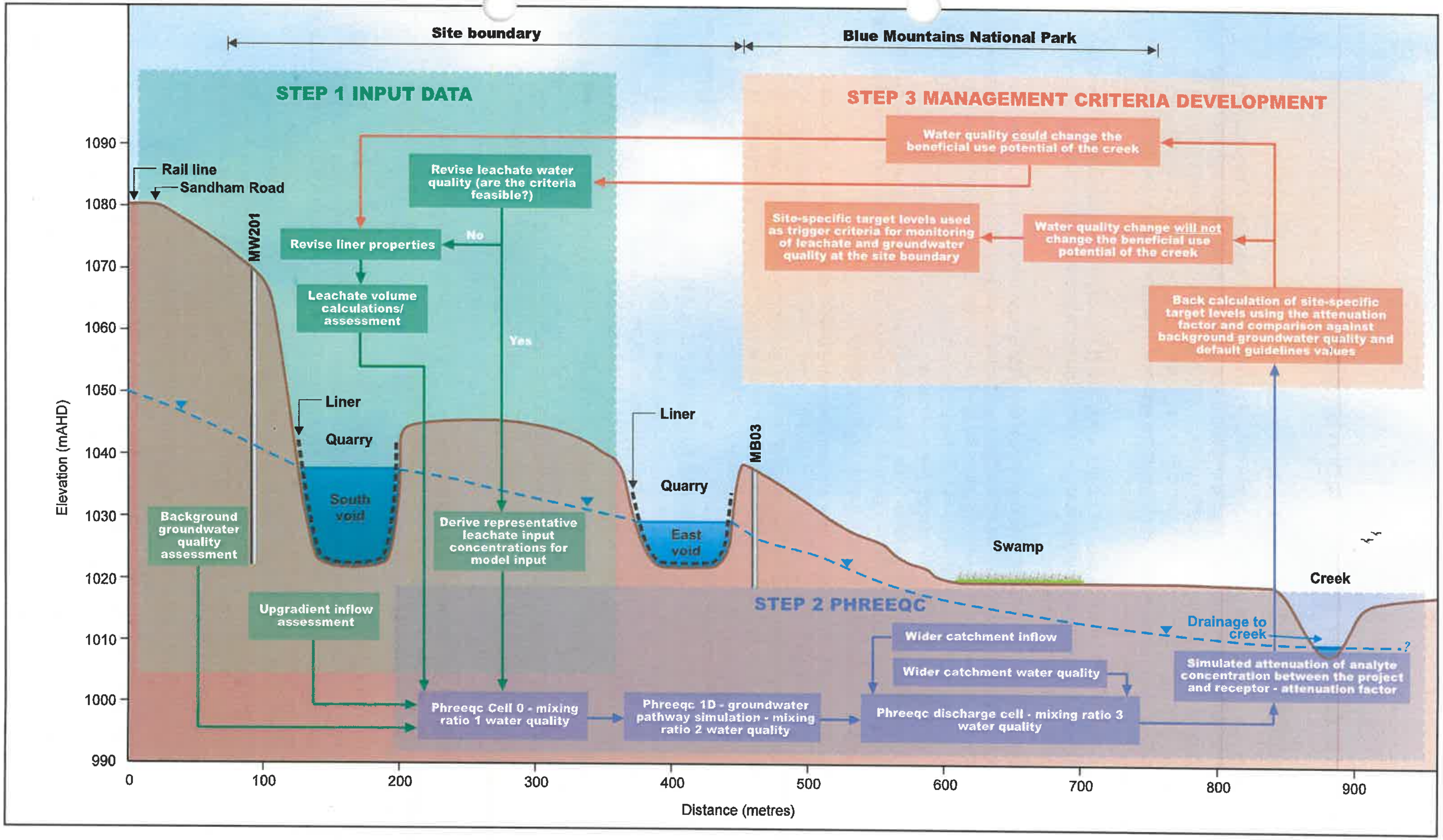
6.1 Assessment approach

Whilst it is proposed to fully line the base and walls of the proposed emplacements area and contact water dam, the modelling approach takes into account that liners do seep small volumes and as such the impacts of predicted seepage migrating in groundwater to downgradient receptors has been assessed. Figure 6.1 presents on overview of the adopted modelling methodology.

The approach broadly includes three stages:

- Step 1 – Assessment of baseline conditions to derive input parameters for groundwater modelling. This has focused on establishing the relative volumes and quality of leachate to background groundwater to facilitate groundwater modelling of groundwater impacts.
- Step 2 – Groundwater modelling using derived input parameters to the assess attenuation along the groundwater pathway by water mixing and flow dispersion processes. This modelling is conservative when compared to the attenuation processes other fate and transport models used for landfill management planning adopt, such as, the Industrial Waste Management Evaluation Model (IWMEM) developed by the United States Environmental Protection Agency (USEPA). The model has been used to derive an attenuatior factor, which represents how much the leachate attenuates between the site and the nearest downgradient receptor.
- Step 3 – The derived attenuation factor has been used to back calculate "acceptable leachate" concentrations in the fill material using the water quality assessment criteria outlined in Section 4.2 and the current baseline water quality. These values have been compared against "potential leachate" quality in the fill material (defined as ASLP results for a typical range of soil types, as presented in the water resources report (GHD, 2018) and ENM soils criteria leachate partitioning values (GHD, 2018)) to assess the potential for an impact to emerge.
- Acceptable leachate concentrations that were below estimated leachate concentrations from the fill material have instigated further assessment of the liner properties to improve modelled attenuation factors until such time that realistic leachate water quality data was achieved or that there was enough confidence in the outcomes to implement a monitoring-based approach (see Section 4.2).

Further detail on the input parameters derived and the modelling results are provided in the remainder of this section.



LEGEND

- Groundwater

Bell Quarry Rehabilitation Project
Newnes Junction, NSW

Groundwater modelling approach

Job Number	12541317
Revision	0
Date	9 Nov 2021

Figure 6.1

AU\Launceston\Projects\Admin\Graphics\12\541317\12541317_LST_01.cdr

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6.2 Groundwater modelling method

6.2.1 Methodology

A geochemical model was developed to gain an understanding of the attenuation capacity of the underlying sandstone aquifer. The NSW guidelines for the assessment and management of groundwater contamination (NSW EPA, 2007) adopted the UK environment agency (UK EA, 2000) definition of natural attenuation as the "effect of naturally occurring physical, chemical and biological processes to reduce the load, concentration, flux or toxicity of polluting substances in groundwater". A conservative approach was maintained in the development of the model by:

- Limiting the transport model to the migration of solutes solely due to flow processes: advection, dispersion and diffusion, and excluding other natural attenuation mechanisms such as secondary mineral formation, sorption, ion exchange or biodegradation.

Geochemical modelling software PHREEQC (Parkhurst and Appelo, 1999) was used to create a one- dimensional (1D) transport model to predict the potential metal and nutrient concentrations over the 450 m pathway between the lined areas and the discharge point at the downgradient edge of the swamp. Other parameters such as hydrocarbons, PCBs, and pesticides were not modelled as these parameters are not included in the database files used by PHREEQC, however, the design of the model, being primarily associated with mixing ratios and mechanical dispersion, enabled the modelling results to be conservatively applied to these analytes. The model used simulated solutions representative of ENM leachate and local groundwater and was limited to the mixing and transport of these solutions as depicted in Figure 6.1 and described below:

- Derivation of the water quality to represent leachate leakage from the lined area (Solution 0 in the PHREEQC transport model) was undertaken using a PHREEQC mixing model. Derivation of this water quality was required to account for the presence of the low permeability liner (geomembrane on the base (K =10^{-14} m/s) and clay on the pit sides (K = 10^{-9} m/s), which acts to significantly reduce leakage from the voids. As part of the model inputs to derive Solution 0 (see cell 0 in Step 2 of Figure 6.1), a ratio of mixing between leachate water and background groundwater migrating beneath the liner was calculated. This was based on estimated flow volumes as described in Section 6.2.2. The ratio adopted for this model was 2.08%: 97.92%.
- The derived Solution 0 (see cell 0 in Step 2 of Figure 6.1) was then used to create a 1D PHREEQC transport model to simulate the migration of leachate impacted groundwater from just outside the lined voids to the discharge point 450 m downgradient (at the outflow point of the swamp) over a period of 500 years.
- To account for groundwater inputs from the surrounding catchment at the discharge point a final PHREEQC mixing model was completed. The ratio of groundwater migrating from the site to catchment groundwater at the discharge point was predicted by using the flow volumes described in Section 6.2.2 (this was estimated to be 17.7%: 82.3%). Modelled discharge concentrations were compared to background groundwater quality, ANZG (2018) DGVs and the LOR.

6.2.2 Derivation of model inputs

6.2.2.1 Distance to the point of discharge

A swamp located approximately 200 metres downstream of the project was previously identified to be the primary receptor in the EIS water resources assessment (GHD, 2018). Additional site investigations (see Section 3.3.2) now indicate that the swamp is not hydraulically connected to groundwater emanating from the site and, as such, it has been conservatively assumed that groundwater discharges to the creek line directly down gradient of the swamp and that the nearest ecological receptor is located at this point. In reality, groundwater discharge is expected to be further downgradient than this location, where the opportunity for attenuation of substances in groundwater emanating from the project is greater. On this basis the adopted distance to the point of discharge (the receptor) is considered to be conservative.

The distance to the down-gradient edge of the swamp was estimated to be 450 metres.

6.2.2.2 Leachate water quality

The leachate water quality adopted for this assessment was adapted from the previous water resources assessment (GHD, 2018). This broadly included:

- Nine Australian Standard Leaching Procedure (ASLP) testing results for leachate from samples expected to be typical of material that would be accepted at the site.
- The use of the ENM order soils criteria in a theoretical soil water partitioning equation to estimate leachate concentrations as well incorporation of bio-availability parameters where suitable. The partitioning equation adopted mid-range partitioning co-efficients for the assessment which had broad correlation with the ASLP testing results.

These values have been used as input values to the model to assess if the concentrations are attenuated to acceptable levels (as defined in Section 4.2) at the downgradient receptor. As discussed in Section 6.2.1, hydrocarbons, PCBs and pesticides were not modelled as these parameters are not included in the database files used by PHREEQC. However, concentrations of these parameters at the discharge point were calculated from the mixing and dispersion ratios determined by the groundwater modelling.

The leachate results are presented in Table 6.1 relative to the DGVs for the protection of 99 per cent of freshwater ecosystems (ANZG, 2018) and background groundwater quality.

The substances listed in the table represent those analysed as part of the ASLP testing and those presented in the ENM Order (2014).

Table 6.1 Estimated leachate concentrations

Parameter	Units	DGV (ANZG, 2018)	Background groundwater quality	Maximum ASLP result from representative soil testing	ENM partitioning (GHD, 2018)
pH	pH units	6.5 – 8.0	5.05	5.28	8
Arsenic	mg/L	0.0008 (AsV)	<0.001	**0.001**	0.0008
Copper	mg/L	0.001	0.04	**0.013**	**0.002**
Nickel	mg/L	0.008	0.005	0.006	0.002
Zinc	mg/L	0.0024	0.065	**0.484**	**0.0048**
Cadmium	mg/L	0.00006	<0.0001	**0.0004**	**0.000063**
Lead	mg/L	0.001	<0.001	0.01	0.00032
Chromium	mg/L	0.00001 (CrVI)	<0.001	**0.007**	**0.588**
Mercury	mg/L	0.00006	<0.00005	0.00005	0.00001
Nitrate	mg/L	1	0.53	**2.35**	
Ammonia	mg/L	0.32	0.013	0.11	
Reactive P	mg/L		<0.005	0.01	
Electrical conductivity	dS/m	0.35	0.065	**0.712**	**1.436**
Benzene	mg/L	0.6	<0.001		0.103
Toluene	mg/L	0.11	<0.001		**10.057**
Ethylbenzene	mg/L	0.05	<0.001		**2.294**
Total xylene	mg/L				
Ortho-xylene	mg/L	0.2	<0.001		**0.319**
Meta-xylene	mg/L	0.14	<0.002		**0.95**
Para-xylene	mg/L	0.14	<0.002		**0.317**
TPH C10-C36	mg/L		<0.050	<0.05	14.12

TRH					
TRH >C10 - C16	mg/L		<0.100	<0.100	
TRH >C16 - C34	mg/L		<0.100	<0.100	
TRH >C34 - C40	mg/L		<0.100	<0.100	
OPP					
Chlorpyrifos	mg/L	0.00000004		**<0.0005**	
OCP					
Heptachlor	mg/L	0.000001		**<0.0005**	
Endosulfan	mg/L	0.000003		**<0.0005**	
Endrin	mg/L	0.000001		**<0.0005**	
4.4`-DDT	mg/L	0.000006		**<0.002**	
PAH					
Naphthalene	mg/L	0.0025	<0.001	<0.001	**0.0032**
Anthracene	mg/L	0.00001	<0.001	**<0.001**	
Benzo(a)pyrene	mg/L	0.00001	<0.001	**<0.0005**	**0.00004**
PCB	mg/L			<0.001	

Notes:

Bolded values constitute exceedances of the DGV's

Background groundwater quality data represent the data from MW201 for 5 October 2021 supplemented with data from MB02 for electrical conductivity and the adjacent site (GSS Environmental, 2011) for pH. Concentrations of petroleum/recoverable hydrocarbons (TPH and TRH) values were identified in MW201 but have been removed as it is expected that background concentrations of TPH and TRH should be below detection. Red text in the table highlights exceedances of the background water quality.

6.2.2.3 Leachate volumes

The project design includes a geomembrane liner with a hydraulic conductivity of 10^{-14} m/s on the base of filled areas and a clay liner with hydraulic conductivity of 10^{-9} m/s on the sides of the filled pit voids. The contact water dam will be lined with a geomembrane. With these liners in place, groundwater from upgradient of the voids will flow beneath the project site with a volume represented by the volume of groundwater recharge over the area upgradient of the project site. To facilitate this flow regime a more permeable layer will be installed under the basal liner (Environmental Management Plan, GHD 2021). A small quantity will leak through the clay liner on the upgradient side of the voids to mix with the leachate (after operation) and seep out the eastern side of the voids. A small component will also leak through the liner from areas above groundwater located to the north and southeast of the voids. The leakage from these areas was estimated to be 1 L/ha/day or a total 2.7 L/day given that these areas are estimated to have a footprint of 2.7 hectares.

Martens and Associates (Martens 2021) have completed numerical groundwater modelling to assess the post closure groundwater conditions and the relationship of the site with the downgradient swamp. The preliminary results from the calibrated post closure groundwater model indicate that leachate seepage rates through the liner, after closure and capping of the emplaced fill, approximate 140 L/day. This includes approximately 100 L/day of groundwater through flow and 50 L/day of rainfall inputs.

6.2.2.4 Groundwater flow beneath the quarry and from the wider catchment

Upgradient groundwater interpreted to be seeping into or beneath the site is expected to originate from rainfall recharge in the blue shaded area in Figure 6.2, which has an area of 11.1 Ha as presented in Table 6.2. This represents groundwater that can mix with leachate emanating from the site at the start (Cell 0) in the PHREEQC model (see Figure 6.1).

Recharge to this area occurs as the resultant flux after surface runoff, soil water storage in the unsaturated zone, and evapotranspiration has been accounted for. The site is located in the Water Sharing Plan (WSP) for the *Greater Metropolitan Region Groundwater Sources 2011*, which adopts 6 per cent of average annual rainfall as a groundwater recharge value for this area. This is equivalent to 51 mm/yr. However, this is not based on any scientific recharge investigations. A review of groundwater recharge rates for sandstones in the Sydney basin completed for the M4-M5 link groundwater modelling (HydroSimulations, 2017) indicated a range of between 2 per cent and 10 per cent of annual rainfall. The calibrated groundwater recharge rates adopted for the M4-M5 link modelling were between 2 per cent and 3 per cent of annual rainfall. For consistency with Marten's interim groundwater model, the calibrated recharge value of 2.6 per cent of average annual rainfall from the model was applied to the upgradient groundwater catchment (blue area in Figure 6.2) to estimate volumes flowing beneath the emplaced fill. Using the upgradient area and a recharge rate of 22.1 mm/yr the estimated groundwater flow beneath the site is 6.721 m^3/day. This volume has been used to mix with leachate at the start (Cell 0) of the PHREEQC model.

The downstream receptor receives rainfall recharge from the geochemical modelled area (yellow) and the wider catchment area (green), which is approximately 82.3 per cent of the total catchment area (Figure 6.2). This water is mixed with the upgradient rainfall recharge (blue) and void leachate to provide a potential mixing ratio at the point of discharge to the downgradient receptor.

Table 6.2 Groundwater contributing areas

Area	Recharge area (up-slope from western pit – blue area)	Geochemical modelling area - yellow area	Wider groundwater contributing area discharging to "downstream channel monitoring point - green area	Total catchment groundwater contributing area (sum of all contributing areas)
Metres squared (m^2)	111,000	144,871	371,517	627,388
Hectares (Ha)	11.1	14.5	37.15	62.74
Proportion of total %	17.7%	23.1%	59.2%	100%

Figure 6.2 ***The total catchment area for Bell Quarry indicating the recharge area upgradient from pit 1 (blue area) and the geochemical modelling area downgradient from the voids to the downstream channel (yellow area). Total catchment area is indicated by the sum of the green area, yellow area and blue area***

Based on the relative proportions of leachate to groundwater recharge the following mixing ratios have been used in the modelling:

- 2.08:97.92 of leachate with upgradient groundwater
- 17.7:82.3 of the simulated leachate plume at the receptor with groundwater from the wider catchment.

6.2.2.5 Background groundwater concentrations and variability

The water quality data for MW201 from 5 October 2021, located upgradient of the site, was used as the background water quality input to the model. In the absence of electrical conductivity (EC) data for MW201 the EC from MB02 was adopted. Concentrations of petroleum/recoverable hydrocarbons (TPH and TRH) values were identified in MW201 but have been removed as it is expected that background concentrations of TPH and TRH should be below detection (as is the case with all other wells monitored at the site). The water quality data are presented in Table 3.1, Table 6.3 and Appendix A.

To maintain the pristine nature of the ecological system an acceptable variability in background water quality was required to be established, from which the modelled concentrations could vary from the input concentrations (MW201 data), without having an adverse impact at the receptor. The process adopted for establishing an acceptable variability is summarised below with the adopted variation and associated rationale provided in Table 6.3.

- Where background groundwater quality data is sufficient, a change of 10% of the median in background groundwater quality was adopted.
- The ANZG (2018) criteria for the protection of 99% of freshwater ecosystems was adopted where the background groundwater quality data was scarcely detectable, non-detectable or absent and the LOR is above the criteria. A change in water quality that prevented a material change in the quantitative value of the criteria was considered to be acceptable (e.g., a change less than 0.5 times the criteria).
- The limit of laboratory reporting was adopted where the background groundwater quality data was data was scarcely detectable, non-detectable or absent and the LOR was below the criteria for the protection of 99% of freshwater ecosystems. A change in water quality that prevented a material change in the quantitative value of the criteria was adopted (e.g., a change less than 0.99 times the LOR).

It is noted that there is variability in the background concentrations to those used as model input concentrations (e.g., the concentrations from MW201 for 5 October 2021). This is not considered likely to materially affect the modelling outcomes because with the model design a lower or higher background concentration results in a proportionately lower or higher concentration to achieve at the down gradient receptor.

Table 6.3 Background water quality

Parameter	Units	Laboratory Limit or Reporting (LOR)	DGV (ANZG, 2018)	Background water quality (MW210 5 October 2021)	Modelled background water quality	Estimated background variability in groundwater quality
pH	pH units		6.5-7.5	5.05	5.05	pH within range - just need to be within the 5 to 9 range
Arsenic	mg/L	0.0002	0.0008	<0.001	0.001	Only one detect to date for dissolved concentrations. LOR based value of 0.000099 adopted.
Copper	mg/L	0.0004	0.001	0.04	0.04	Based on review of data a change of 0.00035 mg/L was considered to be acceptable (unlikely to be perceptible) this is 10% of the median.
Nickel	mg/L	0.0005	0.008	0.005	0.005	Based on review of data a change of 0.00011 mg/L was considered to be acceptable (unlikely to be perceptible) this is 10% of the median.
Zinc	mg/L	0.001	0.0024	0.065	0.065	Based on review of data a change of 0.0021 mg/L was considered to be acceptable (unlikely to be perceptible) this is 10% of the median.
Cadmium	mg/L	0.00005	0.00006	<0.0001	0.0001	Only two detects to date for dissolved concentrations. LOR based value of 0.000099 adopted
Lead	mg/L	0.0001	0.001	<0.001	0.001	Only one detect to date for dissolved concentrations. LOR based value of 0.000099 adopted
Chromium	mg/L	0.0003	0.00001	<0.001	0.001	No detectable concentrations to date for dissolved concentrations. LOR based value of 0.000099 adopted
Mercury	mg/L	0.00004	0.00006	<0.00005	0.00005	Only two detects to date for dissolved concentrations. LOR

Parameter	Units	Laboratory Limit or Reporting (LOR)	DGV (ANZG, 2018)	Background water quality (MW210 5 October 2021)	Modelled background water quality	Estimated background variability in groundwater quality
						based value of 0.000099 adopted
Nitrate	mg/L	0.01	1	0.53	0.53	Only two samples analysed, and one inferred at MW201) to date - data ranged from 0.09 to 0.89 - a change of 0.01 mg/L has been conservatively considered to be acceptable.
Ammonia	mg/L	0.005	0.32	0.013	0.013	Based on review of data a change of 0.0013 mg/L was considered to be acceptable (unlikely to be perceptible) this is 10% of the median.
Reactive P	mg/L	0.01	0.015	<0.005	0.005	Only two samples analysed to date. LOR based value of 0.000099 adopted
Electrical conductivity	dS/m	0.001		0.065	0.065	Based on 10% of the median change of 0.005 dS/m was considered to be acceptable (GSS environmental, 2011 data was included)
Benzene	mg/L	0.001	0.6	<0.001	0.001	Based on 99% of the LOR
Toluene	mg/L	0.001	0.11	<0.001	0.001	Based on 99% of the LOR
Ethylbenzene	mg/L	0.001	0.05	<0.001	0.001	Based on 99% of the LOR
Total xylene	mg/L	0.001				
Ortho-xylene	mg/L	0.001	0.2	<0.001	0.001	Based on 99% of the LOR
Meta-xylene	mg/L	0.001	0.14	<0.002	0.001	Based on 99% of the LOR
Para-xylene	mg/L	0.001	0.14	<0.002	0.001	Based on 99% of the LOR
TPH C10-C36	mg/L	0.05		<0.050	0.05	Based on 99% of the LOR
TRH						
TRH >C10 - C16	mg/L	0.05		<0.100	0.05	Based on 99% of the LOR
TRH >C16 - C34	mg/L	0.1		<0.100	0.1	Based on 99% of the LOR
TRH >C34 - C40	mg/L	0.1		<0.100	0.1	Based on 99% of the LOR
OPP						
Chlorpyrifos	mg/L	0.000005	0.00000004		0.000005	Based on 99% of the LOR
OCP						
Heptachlor	mg/L	0.000001	0.000001		0.000001	Based on 99% of the LOR
Endosulfan	mg/L	0.000001	0.000003		0.000001	Based on 99% of the LOR
Endrin	mg/L	0.000001	0.000001		0.000001	Based on 99% of the LOR
4.4`-DDT	mg/L	0.000001	0.000006		0.000006	Based on 99% of the LOR
PAH						
Naphthalene	mg/L	0.00002	0.0025	<0.001	0.001	Based on 99% of the LOR
Anthracene	mg/L	0.00001	0.00001	<0.001	0.00001	Based on 99% of the LOR

Parameter	Units	Laboratory Limit or Reporting (LOR)	DGV (ANZG, 2018)	Background water quality (MW210 5 October 2021)	Modelled background water quality	Estimated background variability in groundwater quality
Benzo(a)pyrene	mg/L	0.00001	0.00001	<0.001	0.00001	Based on 99% of the LOR
PCB	mg/L	0.0001			0.0001	Based on 99% of the LOR

Notes:

DGV value adopted for pH was from the upland rivers default trigger value for south east Australia.

DGV value adopted for reactive phosphorus was from the upland rivers default trigger value for south east Australia.

6.2.3 Summary of model input parameters

The inputs adopted for the PHREEQC model prepared for the site are provided in Table 6.4.

Table 6.4 PHREEQC Model Inputs

Parameter	Value	Notes
Background and catchment groundwater quality	See section 3.3.1, section 6.2.2.5, Appendix A and Appendix B	Water quality data from upgradient well MW201 on 5/10/2021 was adopted, except for pH which was not monitored and was therefore derived from the average groundwater pH value from the neighbouring site (GSS Environmental, 2011). EC data from MB02 as adopted in the absence of data for MW210. A default pe of 4 and temperature of 18°C were also selected.
ENM / ASLP leachate water quality	See section 6.2.2.2 and Appendix B	The maximum leachate concentrations estimated from either: – ASLP testing of representative soils (as presented in the water resources report GHD, 2018) or – Application of partitioning equations to the NSW ENM Order (2014) soil concentrations using the process outlined in the water resources report (GHD, 2018), were used as input concentrations. It is noted that these initial values have little bearing on the outcomes of the modelling as the model is limited to mixing and dispersion processes, and the development of site specific target levels was based on a back calculation approach using mixing and dispersion ratios determined from the model outputs.
Database	minteq.v4.dat	Minteq V4 is a more comprehensive database than the PHREEQC default.
Solution 0 Derivation Mixing Model		
Mixing ratio	Local groundwater = 0.9792 ENM leachate = 0.0208	See section for description on how ratios were calculated.
1D Transport		
Flow direction	forward	-
Boundary condition	constant /constant	Groundwater inflow was represented as up-gradient groundwater through-flow. Outflow was represented by discharge to the downgradient edge of the swamp. Both inflow and outflow were simulated as constants (perennial flow). Constant and complete outflow to the discharge location is considered a conservative approach.
Flowpath length	450 m	From the voids to the discharge point at the edge of the swamp (see section 6.2.2.1)
Flow Velocity (u_L)	32.2 m/yr	Based on the following: K = 0.0098 m/day dh/dl = 27 m / 300 m between the outflow point at the northern void and MW301A Effective porosity = 0.01

Dispersivity (α)	10 m	Dispersion was conceptualised as comparably high compared to advection, given the fractured rock environment (1:1).
Diffusion Coefficient (*D*)	0.3×10^{-9}	Diffusion was considered negligible (PHREEQC default value adopted).
Number of Cells	45	Cell lengths and numbers were optimised to minimise numerical dispersion. Optimisation results are presented in Appendix B.
Cell length	10 m	
Discharge Point Mixing Model		
Mixing ratio	Site groundwater = 0.177 Catchment = 0.823	See Sections 6.2.1 and 6.2.2.4 for a description on how ratios were calculated.

6.2.4 Modelling assumptions and limitations

The PHREEQC model developed by GHD for this site utilises available data and assumptions that GHD considers to be relevant to site characteristics as outlined in this report. Notwithstanding the above, GHD has adopted a modelling approach that conservatively manages uncertainty in the modelling input parameters and conceptual understanding of the site conditions.

The following assumptions/limitations apply to the PHREEQC modelling:

- That the data provided to and used by GHD is accurate and reliable.
- Constant material leachate, baseline groundwater and catchment groundwater composition, and hydraulic gradient for both low inflow and high inflow conditions.
- Catchment and baseline groundwater composition is similar to groundwater composition at upgradient MW201.
- All solutions are at equilibrium.
- Does not include mineral precipitation/dissolution, kinetic reactions, sorption/desorption, or ion exchange reactions.
- The system is closed with respect to CO_2 and O_2.
- Other specific assumptions related to parameter input selection can be found in Table 6.4.

6.3 Groundwater modelling results

Results from the PHREEQC modelling are summarised in Table 6.5.

Table 6.5 ***PHREEQC modelling results***

Analyte (mg/L unless otherwise specified)	LOR	DGV(1) (8)	Input Water Quality Leachate (4)	Input Water Quality Groundwater (3)	Solution 0 (below the lined void)	Last modelled cell at 450 m after 500 yrs	Discharge after 500 yrs
pH (pH units)	-	6-5-7.5(2)	5	5.05	5.05	5.05	5.05
Arsenic	0.0002	0.0008(5)	0.001	0.0010	0.001	0.001	0.001
Copper	0.0004	0.001	0.013	0.04	0.0394	0.0397	0.0399
Nickel	0.0005	0.008	0.006	0.005	0.0050	0.0050	0.0050
Zinc	0.001	0.0024	0.484	0.065	0.0737	0.0694	0.0658
Cadmium	0.00005	0.00006	0.0004	0.0001	0.0001	0.0001	0.0001
Lead	0.0001	0.001	0.01	0.001	0.0012	0.0011	0.0010
Chromium	0.0003	0.00001(6)	0.588	0.001	0.0132	0.0073	0.0021
Mercury	0.00004	0.00006	0.00005	0.00005	0.00005	0.00005	0.00005
Nitrate (as N)	0.01	1.0(7)	2.35	0.53	0.5306	0.5145	0.5006
Ammonia (as N)	0.005	0.32	0.11	0.013	0.000	0.000	0.000
Reactive phosphorus (as P)	0.01	0.015(2)	0.01	0.005	0.0051	0.0051	0.0050
Electrical conductivity (dS/m)	0.001		1.436	0.065	0.0935(9)	0.0795(10)	0.0676(11)
Benzene	0.001	0.6	0.103	0.001	0.0031(9)	0.0021(10)	0.0012(11)
Toluene	0.001	0.11	10.057	0.001	0.2102(9)	0.1077(10)	0.0199(11)
Ethylbenzene	0.001	0.05	2.294	0.001	0.0487(9)	0.0253(10)	0.0053(11)
Total xylene	0.001						
Ortho-xylene	0.001	0.2	0.319	0.001	0.0076(9)	0.0044(10)	0.0016(11)
Meta-xylene	0.001	0.14	0.95	0.001	0.0207(9)	0.0111(10)	0.0028(11)
Para-xylene	0.001	0.14	0.317	0.001	0.0076(9)	0.0044(10)	0.0016(11)
TPH C10-C36	0.05		14.12	0.05	0.3427(9)	0.1993(10)	0.0764(11)
TRH							

Analyte (mg/L unless otherwise specified)	LOR	DGV(1) (8)	Input Water Quality Leachate (4)	Input Water Quality Groundwater (3)	Solution 0 (below the lined void)	Last modelled cell at 450 m after 500 yrs	Discharge after 500 yrs
TRH >C10 - C16	0.05		0.100	0.05	0.051(9)	0.051(10)	0.050(11)
TRH >C16 - C34	0.1		0.100	0.1	0.100(9)	0.100(10)	0.100(11)
TRH >C34 - C40	0.1		0.100	0.1	0.100(9)	0.100(10)	0.100(11)
OPP							
Chlorpyrifos	0.000005	0.00000004	0.0005	0.000005	0.000015(9)	0.00001(10)	0.000006(11)
OCP							
Heptachlor	0.000001	0.000001	0.0005	0.000001	0.00001(9)	0.00001(10)	0.000002(11)
Endosulfan	0.000001	0.000003	0.0005	0.000001	0.00001(9)	0.00001(10)	0.000002(11)
Endrin	0.000001	0.000001	0.0005	0.000001	0.00001(9)	0.00001(10)	0.000002(11)
4.4`-DDT	0.000001	0.000006	0.002	0.000001	0.00004(9)	0.00002(10)	0.000005(11)
PAH							
Naphthalene	0.00002	0.0025	0.0032	0.00002	0.00009(9)	0.00005(10)	0.00003(11)
Anthracene	0.00001	0.00001	0.001	0.00001	0.00003(9)	0.00002(10)	0.00001(11)
Benzo(a)pyrene	0.00001	0.00001	0.0005	0.00001	0.00002(9)	0.00002(10)	0.00001(11)
PCB	0.0001		0.001	0.0001	0.0001(9)	0.0001(10)	0.0001(11)

Notes:

1 ANZG (2018) 99% protection level DGVs for fresh water

2 ANZECC/ARMCANZ (2000) Trigger Values for Chemical Stressors for Southeast Australia Upland River ecosystem

3 Baseline groundwater data from #MW201 5/10/2021, where values <LOR the LOR was adopted

4 Worst case values from ADE (2017) - leachate testing or estimated concentrations by applying partitioning equations to the NSW ENM Order 2014 soil concentrations (GHD, 2018)

5 DGV used for As(V)

6 DGV used for Cr(VI)

7 Nitrate DGV taken from "Updating nitrate toxicity effects on freshwater aquatic species "

8 If no value presented there is no criterion.

9. Calculated from (leachate concentration * 0.0208) + (groundwater concentration * 0.9792) = Solution 0 concentration

10 Calculated from (solution 0 concentration * 0.51) + (groundwater concentration * 0.49) = Last cell at 450 m after 500 yrs concentration, determined from the PHREEQC transport output

11 Calculated from (last cell after 500 yrs concentration * 0.177) + (groundwater concentration * 0.823) = Discharge after 500 yrs concentration

The modelling indicates that pH, reactive phosphorus, arsenic, copper, nickel, zinc, cadmium, lead, mercury, nitrate, ammonia, benzene, TRH, OPP, OCP, PAH (excluding naphthalene) and PCB concentrations at the discharge point were similar to the background groundwater concentrations (MW201 5/10/2021) or below the nominated DGVs after 500 years of modelling. Some variation was noted for nitrate and ammonia, with discharge concentrations being lower than background, but this can be attributed to nitrogen speciation undertaken by the model due to the redox conditions set for the model (i.e. pe =4). All other analytes had notably higher concentrations than those used in the model to represent background water quality. The modelling therefore suggests that, when using the material leachate concentrations adopted for this model, mixing and dispersion processes alone are not sufficient to attenuate all potential ENM analytes seeping from the lined area to background concentrations after a period of 500 years. The results have been considered relative to acceptable background variations in water quality in 6.4.

Back calculations on the modelled results indicate that, as a result of mixing and dispersion attenuation processes along the flow path at the discharge point, 0.19 per cent of the discharging groundwater is comprised of leachate from the lined area, with the remaining 99.81 per cent comprised of background/catchment groundwater. These mixing percentages can be applied to other analytes that have not been included in the model to predict their concentrations at discharge, such has been done for hydrocarbons, PCBs, and pesticides. These mixing percentages can also be used to set suitable site-specific target levels for leachate from the fill material based on the conservatively calculated attenuation capacity associated with mixing and dispersion processes within the aquifer. The background variability will, however, need to be considered when site specific target values are derived. The derivation of these target levels will help prevent future impacts at the discharge point associated with the potential seepage of leachate from the lined area.

6.4 Discussion

The back-calculated acceptable site leachate concentrations using the groundwater model have been compared against to the ASLP and estimated ENM partitioning values (see Section 6.2.2.2) to further contextualise the likelihood of an impact occurring. This comparison is provided in Table 6.6 and is summarised below:

- Noting that calculated acceptable site leachate concentrations that are above all leachate concentrations estimated from ASLP testing and ENM partitioning means that there is no potential risk, the acceptable site leachate concentrations are colour coded as follows:
  - Orange indicates the acceptable site leachate concentration is below the estimated leachate partitioning value only.
  - Red indicates the acceptable site leachate concentration is below the ASLP leachate result.
  - Clear indicates the acceptable site leachate concentration is above all material leachate estimates
- The ASLP results are all below the acceptable site leachate concentrations (except for DDT) suggesting that soils originating from those areas are unlikely to pose a potential adverse impact to the downgradient receptor. The reason for DDT being above the ASLP result is expected be because of the LOR being orders of magnitude above the adopted assessment criteria and is expected to be resolved with sampling analysis using lower LORs.
- The estimated ENM leachate concentrations for chromium, toluene, ethylbenzene, m-xylene and TPH C10-C36 are above the acceptable site leachate concentrations. Noting that the concentrations in the ASLP results are acceptable, there is a greater risk these analytes result in leachate concentrations being generated above the acceptable site concentrations.

  The estimated ENM leachate concentrations established for TPH, ethylbenzene, toluene and m-xylene by applying partitioning equations to the ENM criteria are generally representative of a contaminated site, which indicates that the partitioning equation inputs/results are overly conservative and not representative of \VENM and ENM material that will be accepted at the site. Further to this, the acceptable site leachate concentrations are also representative of groundwater concentrations that would be present within the vicinity of petroleum impacted soils, which is also not representative of VENM and ENM material that will be accepted at the site. As such, it is considered unlikely that leachable concentrations from ENM and VENM of these analytes would be above the acceptance site leachate concentrations and that the ASLP results are more representative of concentrations that would leach.

  With regard to chromium the estimated ENM partitioning results are approximately 80 times the ASLP result suggesting the partitioning equations are likely to be conservative. Further the ASLP chromium values represent total concentrations as opposed to hexavalent chromium which is expected to drive chromium toxicity in freshwater. Speciated chromium analysis will be completed as part of monitoring at the site to provide further clarity on this.

Noting the risk identified for chromium, a monitoring program has been developed to monitor for and respond to the emergence of impacts, which is detailed in Section 6.5. The monitoring system provides an early warning system that will allow a response to be implemented during operation of the site many years before any adverse impact would potentially eventuate at downgradient receptors.

- All other analytes are not predicted to represent an impact when compared against the acceptable site leachate concentrations.

Table 6.6 Comparison of acceptable leachate concentrations with estimated source material leachate

Parameter	Units	Maximum ASLP result	Estimated ENM partitioning values (GHD, 2018)	Acceptable site leachate concentrations
pH	pH units	5.28	8	5.3
Arsenic	mg/L	0.001	0.0008	0.053
Copper	mg/L	0.013	0.002	0.225
Nickel	mg/L	0.006	0.002	0.06
Zinc	mg/L	0.484	0.0048	1.18
Cadmium	mg/L	0.0004	0.000063	0.025
Lead	mg/L	0.01	0.00032	0.052
Chromium	mg/L	0.007	0.588	0.105
Mercury	mg/L	0.00005	0.000008	0.0052
Nitrate	mg/L	2.35		5.5
Ammonia	mg/L	0.11		0.7
Reactive P	mg/L	0.01		0.5
Electrical conductivity	dS/m		1.436	2.7
Benzene	mg/L	<0.001	0.103	0.5
Toluene	mg/L	<0.002	10.057	0.5
Ethylbenzene	mg/L	<0.002	2.294	0.5
Total xylene	mg/L			
Ortho-xylene	mg/L	<0.002	0.319	0.5
Meta-xylene	mg/L	<0.002	0.95	0.5
Para-xylene	mg/L	<0.002	0.317	0.5
TPH C10-C36	mg/L	<0.05	14.12	0.55
TRH				
TRH >C10 - C16	mg/L	<0.100		0.55
TRH >C16 - C34	mg/L	<0.100		0.6
TRH >C34 - C40	mg/L	<0.100		0.6
OPP				
Chlorpyrifos	mg/L	<0.0005		0.0005
OCP				
Heptachlor	mg/L	<0.0005		0.005
Endosulfan	mg/L	<0.0005		0.0037
Endrin	mg/L	<0.0005		0.0053

Parameter	Units	Maximum ASLP result	Estimated ENM partitioning values (GHD, 2018)	Acceptable site leachate concentrations
4.4`-DDT	mg/L	<0.002		0.00025
PAH				0
Naphthalene	mg/L	<0.001	0.0032	0.006
Anthracene	mg/L	<0.001		0.005
Benzo(a)pyrene	mg/L	<0.0005	0.00004	0.0046
PCB	mg/L	<0.001		0.1

6.5 Groundwater management plan

6.5.1 Introduction and objectives

The primary aim of the groundwater management plan (GMP) is to:

- Prevent adverse water quality impacts to down gradient sensitive ecosystems byeveloping a monitoring program that:
  - Characterises baseline groundwater conditions from which groundwater changes associated with the project.
  - Monitors for any changes in groundwater conditions outside those assessed to be acceptable.
  - Characterises emergence of unforeseen impacts early to facilitate changes to operational procedures while the plant is operating.
  - Developing trigger action response procedures to appropriately manage any unforeseen impacts that emerge as part of the monitoring program.

The management measures proposed to meet these objectives are provided in the remainder of this GMP.

For this GMP the primary receptor is considered to be groundwater adjacent to the potential terrestrial and aquatic ecosystems located within the creek directly downgradient of the swamp (450 metres downgradient of the site). It is noted that the swamp is not considered to be hydraulically connected to groundwater emanating from the project (see Section 3.3.2) and that groundwater emanating from the project may actually discharge further down gradient.

6.5.2 Summary of management approach

The overarching management approach to preventing the development of adverse groundwater quality impacts from leachate includes:

- Emplacement of a low permeability liner as detailed in Section 6.2.2 to limit migration to underlying groundwater.
- Controlling the type of material that can be accepted at the site and limiting it to VENM, ENM or material subject to a specific resource recovery order and exemption.
- Monitoring the effectiveness of the management system, detecting unforeseen changes in groundwater conditions early and implementing additional protection measures that prevent adverse impacts and limit long term monitoring obligations.

To facilitate early detection of potential impacts and subsequently an early response to unforeseen potential impacts, site specific monitoring criteria will be developed using the attenuation factors established by the conservative groundwater modelling (see Section 6.3).

The monitoring criteria will be applied to leachate water quality in the emplaced fill and to groundwater immediately down gradient of the filled areas. This will allow management measures to be implemented many years before the potential risk could be realised at the nearest downgradient receptor.

If groundwater conditions are deemed to represent a potential adverse impact additional trigger action response measures will be implemented to investigate (act) and adequately respond (mitigate) potential impacts identified.

An adaptive monitoring and management approach will be adopted at the site whereby:

- Site specific monitoring criteria will be readily updated as additional baseline data is collated.
- The revision of the method for assessing potential impacts based on trends in the expanding baseline, leachate and downgradient monitoring well data set.

6.5.3 Site specific assessment criteria

Using the groundwater model attenuation factors established from the groundwater modelling presented in Section 6.3 the site-specific trigger levels (SSTLs) presented in Table 6.7, for leachate and groundwater immediately downgradient of the site, have been developed. The SSTL's have been developed for dissolved phase concentrations only.

Table 6.7 Site specific trigger levels

Parameter	Units	Site specific leachate criteria	Site specific criteria for groundwater at the site boundary
pH	pH units	5 to 9	5 to 9
Arsenic	mg/L	0.053	0.0021
Copper	mg/L	0.225	0.0438
Nickel	mg/L	0.06	0.0061
Zinc	mg/L	1.18	0.0882
Cadmium	mg/L	0.052	0.0012
Lead	mg/L	0.052	0.0021
Chromium	mg/L	0.053	0.0021
Mercury	mg/L	0.026	0.00059
Nitrate	mg/L	5.5	0.6334
Ammonia	mg/L	0.7	0.0273
Reactive P	mg/L	0.5	0.0153
Electrical conductivity	dS/m	2.7	0.1198
Benzene	mg/L	0.5	0.0114
Toluene	mg/L	0.5	0.0114
Ethylbenzene	mg/L	0.5	0.0114
Total xylene	mg/L	0	
Ortho-xylene	mg/L	0.5	0.0114
Meta-xylene	mg/L	0.5	0.0114
Para-xylene	mg/L	0.5	0.0114
TPH C10-C36	mg/L	0.55	0.0604
TRH			
TRH >C10 - C16	mg/L	0.55	0.0604
TRH >C16 - C34	mg/L	0.6	0.1104
TRH >C34 - C40	mg/L	0.6	0.1104
OPP			
Chlorpyrifos	mg/L	0.005	0.0001
OCP			

Parameter	Units	Site specific leachate criteria	Site specific criteria for groundwater at the site boundary
Heptachlor	mg/L	0.005	0.0001
Endosulfan	mg/L	0.005	0.0001
Endrin	mg/L	0.005	0.0001
4.4`-DDT	mg/L	0.005	0.0001
PAH			
Naphthalene	mg/L	0.006	0.0011
Anthracene	mg/L	0.005	0.0001
Benzo(a)pyrene	mg/L	0.0046	0.0001
PCB	mg/L	0.048	0.0011

Notes: chromium analysis should be speciated into hexavalent and trivalent results with comparison of hexavalent chromium against the site specific criteria.

Based on the conservatism built into the modelling the SSTLs are conservative and are expected to maintain the groundwater quality within the boundaries of the beneficial use potential and result in no identifiable adverse impact on water quality, at the downgradient receptor.

As these criteria rely on background water quality values and statistics, they will be updated each time new groundwater monitoring data becomes available using the methods described in Sections 6.1 and 6.2.

Subject to an appropriate number of baseline data points consideration will be given to revising this approach to compare the baseline/background groundwater quality 80th percentile value (reference site) with the median value in leachate and groundwater multiplied by the relevant attenuation factors established by the modelling (Section 6.3). This reflects the methods recommended in ANZECC (2000).

6.5.4 Managing the quality of material coming on to site

Only material defined as VENM, ENM or material that meets an order and exemption pursuant to clauses 91 and 92 of the Protection of the Environmental Operations (Waste) Regulation 2014 (which would require the approval of the EPA) would be accepted at the site.

A mapping system will be developed to document the location of material deposited on site from each off-site location it originated from. This will facilitate the development of management measures should SSTLs be exceeded.

6.5.5 Monitoring program

The following monitoring will be undertaken to establish baseline conditions and assess the emergence of unforeseen impacts during construction and operation:

1. Leachate monitoring to check that leachate concentrations in the emplaced fill are less than the leachate SSTLs.
2. Groundwater monitoring immediately downgradient of the emplaced fill to check that concentrations in groundwater are less than the groundwater SSTLs.
3. Upgradient groundwater quality monitoring to characterise baseline groundwater conditions on which changes in groundwater quality associated with the project can be assessed and which the SSTLs can be modified.

A summary of the monitoring program is presented in Table 6.8. The monitoring locations are presented in Figure 6.3.

Baseline monthly monitoring has been proposed to facilitate the collection of an extensive data set prior to the commencement of operations, which will consolidate the development of SSTLs and provide flexibility for using alternative methods to revise the SSTLs.

The LORs adopted for monitoring would be equivalent to those presented in Table 6.3.

Paper Size ISO A4

0 25 50 75 100

Meters

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

Bell Quarry Rehabilitation Project Pty Ltd
Bell Quarry Appeal

Proposed Groundwater Monitoring Program

Project No.	12541317
Revision No.	A
Date	2/11/2021

FIGURE 6.3

\\ghdnet\ghd\AU\Sydney\Projects\21\12541317\GIS\Maps\Deliverables\21_12541317_011_ProposedGWlocations_.mxd

Data source: Groundwater monitoring locations: Martens; © Department of Customer Service 2020. Created by: mfredie

Table 6.8 *Groundwater monitoring program*

Location ID	Location description	Project Stage	Monitoring media	Monitoring frequency	Monitoring parameters	Purpose
Leachate well ^{A}	New well to be located within the lined imported material ^{A}	Operation (all stages) and post closure (2 years).	Leachate	Quarterly during operation biannually (2^{B} years post closure).	Leachate elevation. Insitu field parameters (pH, DO, redox, EC, temp) Cation and anions Chemical constituents (see Table 6.6)	To assess leachate levels are not excessively elevated. To assess leachate water quality against SSTLs.
MW201	Existing up gradient well	Baseline, operation (all stages) and post closure	Groundwater	Monthly (baseline), quarterly (operation), biannually (2^{B} years post closure).	Groundwater elevation. Insitu field parameters (pH, DO, redox, EC, temp) Cation and anions Chemical constituents (see Table 6.7)	To characterise baseline/background groundwater conditions and consolidate groundwater pathways
MW202	New well up-gradient of the site (surveyed to m AHD)	Baseline, operation (all stages) and post closure	Groundwater	Monthly (baseline), quarterly (operation), biannually (2 years post closure).	Groundwater elevation. Insitu field parameters (pH, DO, redox, EC, temp) Cation and anions Chemical constituents (see Table 6.7)	To characterise baseline/background groundwater conditions and consolidate groundwater pathways.
MB02	Existing well immediately downgradient of filling areas	Baseline, operation (all stages) and post closure	Groundwater	Monthly (baseline), quarterly (operation), biannually (2 years post closure).	Groundwater elevation. Insitu field parameters (pH, DO, redox, EC, temp) Cation and anions Chemical constituents (see Table 6.7)	To monitor for unforeseen impacts downgradient of the emplaced fill and verify the design.
MB03	Existing well immediately downgradient of filling areas	Baseline, operation (all stages) and post closure	Groundwater	Monthly (baseline), quarterly (operation), yearly (2 years post closure).	Groundwater elevation. Insitu field parameters (pH, DO, redox, EC, temp) Cation and anions Chemical constituents (see Table 6.7)	To monitor for unforeseen impacts downgradient of the emplaced fill and verify the design.

Location ID	Location description	Project Stage	Monitoring media	Monitoring frequency	Monitoring parameters	Purpose
MW401	Existing well downgradient of filling areas		Groundwater	Monthly (baseline), quarterly (operation), biannually (2 years post closure).	Groundwater elevation. In situ field parameters (pH, DO, redox, EC, temp) Cation and anions Chemical constituents (see Table 6.7)	To monitor for unforeseen impacts downgradient of the emplaced fill and verify the design.
MW402/MB04	New well immediately down gradient of the south void filling area (surveyed to m AHD)	Baseline, operation (all stages) and post closure.	Groundwater	Monthly (baseline), quarterly (operation), biannually (2 years post closure).	Groundwater elevation. In situ field parameters (pH, DO, redox, EC, temp) Cation and anions Chemical constituents (see Table 6.7)	To monitor for unforeseen impacts downgradient of the emplaced fill and verify the design.
MW301A	Existing well within the downgradient swamp	Baseline, operation (all stages) and post closure.	Groundwater	Daily using data loggers	Groundwater elevation	To monitor for changes in the groundwater pathway (discharge to the swamp)
MW301B	Existing well within the downgradient swamp	Baseline, operation (all stages) and post closure.	Groundwater	Daily using data loggers	Groundwater elevation	To monitor for changes in the groundwater pathway (discharge to the swamp)

Notes:

[A] This well will be relocated to the deepest part of filled areas as the filling operation progresses. At the early stages of infilling the well may be replaced by a sump in a low-lying area that captures fill seepage to facilities samples being collected.

[B] Two years post closure monitoring has bene proposed as it represents a reasonable time frame for leachate quality to stabilise after capping. Subject to monitoring results and trend analysis indicating stabilisation, monitoring would cease.

6.5.6 Data Analysis

At the times of monitoring and reporting (see Section 6.5.7.3) data analysis will include the following tasks:

- Updating the SSTL's using the methods described in Sections 6.1 to 6.3.
- Comparison of leachate and groundwater quality against the SSTLs.
- Establishment of trends in the data using a recognised statistical analysis.

Exceedance of an SSTL does not constitute an actual impact rather an early warning alarm system, providing time for actions to be taken to rectify the emergence of a potential impact. The emergence of actual impacts if it were to occur at the nearest downgradient receptor (immediately downstream of the swamp) are expected to be greater than 10 years. As such an exceedance of an SSTL will provide sufficient time to investigate and implement additional management measures if required.

In addition to the SSTL alarm system, the trend analysis will be used to identify any migration toward the SSTLs to provide an additional tool in responding to the emergence of unforeseen impacts before the SSTLs are exceeded.

6.5.7 Groundwater response plan

The identification process and response protocols to respond to a change in site groundwater elevations or quality conditions outside of those considered to be acceptable are provided in the TARP outlined in Table 6.9. The responses proposed incorporate a staged assessment and development of management measures considered to be appropriate for each individual event should it occur.

The model predictions and an expanding baseline monitoring dataset will provide the basis for trigger levels and take into account predicted responses to filling. Preliminary site-specific triggers have been designed to alert observed parameter responses that are outside of modelled effects or where observed parameter values do not follow anticipated trends.

6.5.7.1 Trigger action response plan

The TARP (Table 6.9) provides appropriate triggers and corresponding response actions for prevention or mitigation of potential impacts to the downgradient receptors as a result of filling the quarry.

The TARP is based on there being a sufficient baseline dataset as outlined in section 6.5.5 and the revision of SSTLs as outlined in Section 6.5.3 and Section 6.5.6.

The TARP has been designed to detect changes to groundwater quality created by the filling operation, outside of those expected, using an early detection system that compares leachate water quality and groundwater quality immediately downgradient of the project against site specific target levels. This system will provide many years to manage any unexpected changes prior to groundwater coming into contact with sensitive ecological communities (the nearest down-gradient receptor).

Maintenance of downward head gradients between wells MW301A and MW301A are included in the TARP to ensure that an alternative and more sensitive groundwater conditions (discharge to the swamp) does not eventuate. It is noted that this more sensitive condition has been simulated by the preliminary Martens and Associated numerical groundwater model not to occur.

Maintenance of leachate levels 4 m below the overtopping point of the main void are included in the TARP to ensure that leachate does not discharge to surface water at the site. It is noted that overtopping of leachate has been simulated by the preliminary Martens and Associated numerical groundwater model not to occur.

Table 6.9 *Trigger Action Response Plan*

Parameter	Frequency	Purpose	Trigger	Action	Person responsible	Timing	Purpose
Leachate quality	Quarterly during operation and for two years after operation	Early detection of leachate water quality that represents a potential risk to downgradient receptors.	Exceedance of the site-specific target levels for leachate.	Engage an appropriately qualified consultant to investigate exceedances and develop a management / remedial strategy	Site owner (or delegate)	Consultant engaged within one month. Inform relevant agencies within one month	Identify, investigate and report on leachate concentrations potentially impacting the receptor.
Leachate levels	Quarterly during operation and for two years after operation	Early detection of the potential for overtopping of the voids by leachate levels	Leachate levels exceeding of 1037.5 m AHD in the main void	Engage an appropriately qualified consultant to investigate exceedances and develop a management / remedial strategy	Site owner (or delegate)	Consultant engaged within one month. Inform relevant agencies within one month	Identify, investigate and report on leachate levels potentially seeping to surface water at the site.
Groundwater quality	Quarterly during operation and for two years after operation	Early detection of groundwater quality that represents a potential risk to downgradient receptors.	Exceedance of the site-specific target levels for groundwater quality.	Engage an appropriately qualified consultant to investigate exceedances and develop a management / remedial strategy	Site owner (or delegate)	Consultant engaged within one month. Inform relevant agencies within one month	Identify, investigate and report on leachate concentrations potentially impacting the receptor.
Groundwater elevations	Elevations during operation and for two years after operation	Early detection of an alternative conceptual hydrogeological condition whereby groundwater discharges to the swamp.	The development of an upward head gradient between MW301A and MW301B. (i.e., groundwater flow into the swamp)	Engage an appropriately qualified consultant to investigate exceedances and develop a management / remedial strategy	Site owner (or delegate)	Consultant engaged within one month. Inform relevant agencies within one month	Identify, investigate and report on changes to the groundwater discharge point.

6.5.7.2 Response action

In the event of an exceedance of the triggers outlined in Table 6.9 the actions outlined in Table 6.9 would be instigated. This includes:

- Engaging an appropriately qualified consultant to investigate the exceedances and develop a management strategy / response program. This is considered to be an appropriate initial action as the TARP is designed to detect impacts early, such that there is time to investigate and respond to exceedances many years before an actual adverse impact could emerge.

In developing an appropriate management strategy for site exceedances the consultant engaged for investigating and developing a management / remedial strategy will consider:

- Additional site conceptualisation investigations to characterise downstream risks long the groundwater pathway (E.g. an expanded monitoring program)
- Additional fate and transport/groundwater modelling using new site data to further characterise the emergence of actual downstream impacts.
- Limiting the material accepted at the site by the implementation of revised (site specific) acceptance criteria.
- Manipulating the chemical conditions in the fill material to reduce leachate quality to acceptable levels.
- Transfer of leachate within the fill mass to improve water quality or lower the leachate elevation.
- Investigating the integrity of the already capped rehabilitated areas for possibly excessing rainfall infiltration and rectify capping system, if needed.
- Transfer leachate to the contact water storage pond, with potential treatment if contact water trigger is reached. If this management measure is adopted the analytical schedule outlined in Table 5.4 should be adopted for monitoring of leachate as outlined in Section 6.5.5.
- Cessation of filling works.
- (If appropriate) no change to operations.

6.5.7.3 Data recording and reporting

6.5.7.3.1 Data management

All water quality data collected by the monitoring program will be checked for quality assurance and representativeness and stored within a dedicated database.

6.5.7.3.2 Annual reporting

It is proposed that reporting on the groundwater conditions monitored would be completed annually with the result provided to the relevant authorities as required and placed on a publicly accessible database (ie web site). The report would include:

- Results and analysis of all surface water and groundwater monitoring relative to adopted assessment criteria.
- Details of the measures undertaken/proposed to address any identified issues.
- Updating of the Water Management Plan to align with site conditions which could include tightening or relaxing/removing the site SSTLS.

6.5.7.3.3 Trigger action response reporting

An exceedance of the SSTLs will trigger an investigation into the cause of the exceedance and preparation of a corrective action plan to re-establish or introduce appropriate management measures as necessary.

The corrective action plan will be approved by the relevant authority who administers the site's development consent, with the mitigation actions determined at that time, as relevant to the exceedance.

7. Licensing requirements

7.1.1 Surface water

Part 1 of Schedule 4 of the Water Management (general) Regulation 2018 includes a list of activities that are exempt from the requirement to obtain a water access license.

The list includes activities considered to be excluded works making reference to Schedule 1 of the regulation.

Schedule 1 – Excluded Works of the regulation identifies dams used solely for the capture, containment and recirculation of drainage and/or effluent, consistent with best management practice to prevent the contamination of a water source, that are located on a minor stream as an excluded work.

The project surface water management system is considered to fall within this definition and is therefore not required to have a water access licence.

7.1.2 Groundwater

Section 5.2.3 of the previous EIS WRA (GHD, 2018) indicated a take of up to 80 ML/yr would be required during operation of the project. The report indicated that there was enough resource available and that trading in the water market to get that volume of water was likely (based on historic trading activity).

In terms of changes to groundwater inflows relative to the previous investigation the following differences are noted:

- During installation of the voids, dewatering consistent with the volumes identified within the previous EIS WRA (GHD, 2108) will be required. For clarity, and using new site data where applicable, the amount of groundwater dewatering is estimated to range between 11 m^3/day (4 ML/yr) and 215 m^3/day (78 ML/yr). This is based on adopting the analytical flow model described by R Marinelli & W Niccoli (2000), a recharge rate of 2.6% from Martens preliminary groundwater flow model, and a range in hydraulic conductivity of between $3x10^{-8}$ m/s and $6x10^{-7}$ m/s (as per the previous WRA report).
- There will be progressive lining of the voids and other areas below the groundwater table to reduce inflow. This means there will be a progressive reduction in the groundwater inflows identified above. Once fully lined, seepage from the surrounding groundwater system into the voids will be in the order of 0.1 m^3/day (based on preliminary results of the Martens model), this seepage will migrate through the lined area and back into the groundwater system on the down gradient side of the lined voids. As such, once lining is complete there will be no net take from the groundwater system.
- Once the emplacement area is lined there will be a reduction in rainfall recharge to groundwater in this area. This is expected to be a difference of approximately 21.2 mm/yr[11]. When considering the liner footprint this approximates a reduction in recharge of 1,378 m^3/year (1.4 ML/yr). This reduction in recharge, will be due to increased run-off to surface water, which is expected to be where groundwater discharges further downstream.

Noting the above an 80 ML/yr licenced groundwater take for construction and operation of the project is required and is consistent with the previous EIS WRA report (GHD 2018).

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[11] This is based on a groundwater recharge rate of 2.6% of annual rainfall (22.1 mm/yr) being reduced to 1 mm/yr by the fill capping.

8. Conclusions

A revised water management system has been developed for the site to ensure the proposed development achieves a neutral of beneficial effect for receiving waters within the catchment.

The management system involves separation of surface water flows to ensure that all surface water released from the site drains only from naturally occurring soils within the catchment or is treated to standard to meet background water quality concentrations.

Upstream catchment flows will be transferred directly through or around the site which will minimise potential for water to be captured and stored within the existing voids during extended dry periods. This will reduce potential stress the downstream receiving water environment and sensitive ecological receptors.

The management system will ensure that all contact water draining from operational areas will be captured in a contact water pond for reuse via on-site irrigation in the active emplacement cell. A water balance has been prepared and indicates all contact water can be retained on site for the lfe of the project under best estimate assumptions emplacement operations when assessed against historical and potential future climate scenarios.

Contingency for the provision of a water treatment plant has also been included as part of the proposed development in the event that the contact water pond approaches approximately 50% capacity to ensure that any releases from the site are treated to meet background water quality standards.

Surface and groundwater monitoring has been undertaken and demonstrated that there is no direct connection between groundwater flows from the quarry site and a hanging swamp located approximately 200 metres downslope.

The adoption of lining system within the emplacement cell will also limit the potential for leachate within emplacement cell to impact upon local or regional groundwater systems. The limited potential for seepage through the lined emplacement cell will result in less than a 0.2% contribution to groundwater volume at the assessed closest discharge point to surface waters downslope of the hanging swamp.

Conservative assumptions have been adopted in relation to the potential concentrations for leachate generation within the emplacement cell and indicates that it is unlikely that leachate generated in the emplacement cell would result in any deterioration of water quality in the aquifer. Site specific leachate target levels have been developed to provide an early warning system of any emerging groundwater impacts arising from the site operations and stipulated in the trigger action response plan.

A detailed surface and ground water monitoring programs have been developed to confirm the conservative predictions in this assessment.

9. References

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WaterNSW (2021), Neutral or Beneficial Effect on Water Quality Assessment Guideline, WaterNSW.

Appendices

Appendix A

Groundwater and surface water monitoring results

Appendix A
Table 1
Water quality results

				Inorganics					Acidity & Alkalinity					Major Ions											Nutrients						
				pH (Lab)	Electrical conductivity (lab)	Total Dissolved Solids (est.)	Total Suspended Solids	Sodium Adsorption Ratio (Filtered)	Alkalinity (Carbonate as CaCO3)	Alkalinity (Bicarbonate as CaCO3)	Alkalinity (Hydroxide as CaCO3)	Alkalinity (total as CaCO3)	Hardness as CaCO3 (Filtered)	Calcium (Filtered)	Magnesium (Filtered)	Potassium (Filtered)	Sodium (Filtered)	Chloride	Sulfate	Sulfate (Filtered)	Fluoride	Cations Total	Anions Total	Ionic Balance	Ammonia as N	Nitrate (as N)	Nitrite (as N)	Nitrogen (Total Oxidised) (as N)	Nitrogen (Total)	Kjeldahl Nitrogen Total	Reactive Phosphorus as P
				pH units	µS/cm	mg/L	mg/L	-	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	meq/L	meq/L	%	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EQL				0.01	1	1	5	0.01	1	1	1	1	1	0.5	0.5	0.5	0.5	1	1	1	0.1	0.01	0.01		0.005	0.01	0.01	0.005	0.1	0.1	0.01
ANZG (2018) - FW - 99% (updated 26 July 2021)																									$0.32^{\#1}$	$1^{\#2}$					
Field_ID	**SampleCode**	**Location_Code**	**Sampled_Date**																												
7822/Downstream	279832-4	Downstream	5/10/2021	-	-	-	-	-	<5	<5	<5	<5	-	<0.5	<0.5	<0.5	4	5	1	-	-	-	-	-1	0.007	-	-	<0.005	<0.1	-	-
7822/Downstream	280787-4	Downstream	19/10/2021	-	-	-	-	-	<5	9	<5	9	-	<0.5	<0.5	0.5	4	4	22	-	-	-	-	-60	<0.005	-	-	<0.005	<0.1	-	-
MB01	ES1721890001	MB01	31/08/2017	7.56	218	-	-	-	<1	67	<1	67	-	18	1	12	13	18	-	7	-	1.85	1.99	-	-	-	-	-	-	-	-
MB02	ES1721890002	MB02	1/09/2017	7.09	72	-	-	-	<1	21	<1	21	-	7	<1	2	4	6	-	4	-	0.57	0.67	-	-	-	-	-	-	-	-
MB02	ES1809234001	MB02	28/03/2018	6.74	65	42	46	1.15	<1	21	<1	21	5	2	<1	1	7	5	-	3	<0.1	0.43	0.62	-	<0.01	0.09	<0.01	0.09	<0.1	<0.1	0.06
7822/MB02	269664-5	MB02	20/05/2021	-	-	-	-	-	<5	<5	<5	<5	-	<0.5	0.5	1.2	4.4	6	3	-	-	-	-	9	0.033	-	-	0.01	<0.1	-	-
7822/MB02	279832-12	MB02	5/10/2021	-	-	-	-	-	<5	<5	<5	<5	-	0.7	<0.5	1	5	6	2	-	-	-	-	14	0.025	-	-	0.009	<0.1	-	-
7822/MB02	280787-11	MB02	19/10/2021	-	-	-	-	-	<5	9	<5	9	-	0.6	<0.5	1	5.3	5	2	-	-	-	-	-13	0.02	-	-	0.01	<0.1	-	-
MB03	ES1720506001	MB03	15/08/2017	7.2	164	-	-	-	<1	52	<1	52	-	13	<1	2	21	9	-	24	-	1.61	1.79	-	-	-	-	-	-	-	-
MB03	ES1809234002	MB03	28/03/2018	5.92	52	34	30	0.72	<1	8	<1	8	<1	<1	<1	2	3	5	-	3	<0.1	0.18	0.36	-	0.1	0.89	<0.01	0.89	1.1	0.2	0.02
7822/MB03	269664-6	MB03	20/05/2021	-	-	-	-	-	<5	7	<5	7	-	1.1	0.9	2.1	2.8	4	3	-	-	-	-	0	0.029	-	-	1.8	1.8	-	-
7822/MB03	279832-13	MB03	5/10/2021	-	-	-	-	-	<5	8	<5	8	-	1	0.8	2	4	5	2	-	-	-	-	-3	0.029	-	-	1.2	1.2	-	-
7822/MB03	280787-12	MB03	19/10/2021	-	-	-	-	-	<5	7	<5	7	-	0.7	0.8	2	3	4	1	-	-	-	-	3	0.021	-	-	1.6	15	-	-
7822/MW201	269664-7	MW201	20/05/2021	-	-	-	-	-	<5	11	<5	11	-	2.5	<0.5	<0.5	5.6	4	2	-	-	-	-	-1	0.009	-	-	0.4	0.7	-	-
7822/MW201	279832-14	MW201	5/10/2021	-	-	-	-	-	<5	9	<5	9	-	0.6	<0.5	<0.5	6.1	5	2	-	-	-	-	-11	0.013	-	-	0.53	1	-	-
7822/MW201	280787-13	MW201	19/10/2021	-	-	-	-	-	<5	7	<5	7	-	<0.5	<0.5	<0.5	5.9	4	2	-	-	-	-	-8	<0.005	-	-	0.53	0.6	-	-
7822/MW301A	269664-3	MW301A	20/05/2021	-	-	-	-	-	<5	<5	<5	<5	-	<0.5	<0.5	1.2	3.2	5	2	-	-	-	-	-2	0.008	-	-	0.02	<0.1	-	-
7822/MW301A	279832-10	MW301A	5/10/2021	-	-	-	-	-	<5	<5	<5	<5	-	<0.5	<0.5	0.8	3	4	3	-	-	-	-	-2	0.005	-	-	0.02	<0.1	-	-
7822/MW301A	280787-9	MW301A	19/10/2021	-	-	-	-	-	<5	5	<5	5	-	<0.5	<0.5	0.9	3	4	2	-	-	-	-	-21	0.013	-	-	0.007	0.1	-	-
7822/MW301B	269664-4	MW301B	20/05/2021	-	-	-	-	-	<5	<5	<5	<5	-	<0.5	<0.5	1.2	2.9	4	2	-	-	-	-	1	0.015	-	-	<0.005	0.1	-	-
7822/MW301B	279832-11	MW301B	5/10/2021	-	-	-	-	-	<5	<5	<5	<5	-	<0.5	<0.5	0.9	3	4	2	-	-	-	-	3	0.008	-	-	<0.005	<0.1	-	-
7822/MW301B	280787-10	MW301B	19/10/2021	-	-	-	-	-	<5	7	<5	7	-	<0.5	<0.5	1	3	4	2	-	-	-	-	-23	0.006	-	-	0.01	0.1	-	-
7822/MW302A	269664-1	MW302A	20/05/2021	-	-	-	-	-	<5	32	<5	32	-	<0.5	<0.5	0.8	16	6	3	-	-	-	-	-12	0.096	-	-	0.009	0.7	-	-
7822/MW302A	279832-8	MW302A	5/10/2021	-	-	-	-	-	<5	<5	<5	<5	-	<0.5	<0.5	0.8	5	6	2	-	-	-	-	7	0.011	-	-	<0.005	<0.1	-	-
7822/MW302A	280787-8	MW302A	19/10/2021	-	-	-	-	-	<5	8	<5	8	-	<0.5	<0.5	0.8	5	4	2	-	-	-	-	-18	<0.005	-	-	<0.005	0.2	-	-
7822/MW302B	269664-2	MW302B	20/05/2021	-	-	-	-	-	<5	6	<5	6	-	2.6	<0.5	<0.5	5.7	5	2	-	-	-	-	11	0.051	-	-	0.009	0.1	-	-
7822/MW302B	279832-9	MW302B	5/10/2021	-	-	-	-	-	<5	8	<5	8	-	<0.5	<0.5	<0.5	6.2	5	2	-	-	-	-	-14	0.022	-	-	0.01	0.2	-	-
7822/MW401	279832-7	MW401	5/10/2021	-	-	-	-	-	<5	<5	<5	<5	-	<0.5	<0.5	0.8	6.1	6	5	-	-	-	-	3	<0.005	-	-	0.02	<0.1	-	-
7822/MW401	280787-7	MW401	19/10/2021	-	-	-	-	-	<5	6	<5	6	-	<0.5	<0.5	0.9	5.7	5	4	-	-	-	-	-13	0.011	-	-	0.02	<0.1	-	-
7822/Pond 1	279832-1	Pond 1	5/10/2021	-	-	-	-	-	<5	5	<5	5	-	0.9	0.6	0.9	4	5	2	-	-	-	-	-1	0.007	-	-	<0.005	0.3	-	-
7822/Pond 1	280787-1	Pond 1	19/10/2021	-	-	-	-	-	<5	11	<5	11	-	0.6	<0.5	1	4	6	1	-	-	-	-	-29	<0.005	-	-	<0.005	0.2	-	-
7822/Pond 2	279832-2	Pond 2	5/10/2021	-	-	-	-	-	<5	5	<5	5	-	0.8	0.5	1	4	5	1	-	-	-	-	1	0.007	-	-	<0.005	0.3	-	-
7822/Pond 2	280787-2	Pond 2	19/10/2021	-	-	-	-	-	<5	10	<5	10	-	0.5	<0.5	1	4	4	1	-	-	-	-	-25	<0.005	-	-	<0.005	0.3	-	-
7822/SW01	279832-5	SW01	5/10/2021	-	-	-	-	-	<5	<5	<5	<5	-	<0.5	0.7	<0.5	5	7	3	-	-	-	-	4	<0.005	-	-	0.03	<0.1	-	-

Appendix A
Table 1
Water quality results

				Inorganics					Acidity & Alkalinity					Major Ions											Nutrients						
				pH (Lab)	Electrical conductivity (lab)	Total Dissolved Solids (est.)	Total Suspended Solids	Sodium Adsorption Ratio (Filtered)	Alkalinity (Carbonate as CaCO3)	Alkalinity (Bicarbonate as CaCO3)	Alkalinity (Hydroxide as CaCO3)	Alkalinity (total as CaCO3)	Hardness as CaCO3 (Filtered)	Calcium (Filtered)	Magnesium (Filtered)	Potassium (Filtered)	Sodium (Filtered)	Chloride	Sulfate	Sulfate (Filtered)	Fluoride	Cations Total	Anions Total	Ionic Balance	Ammonia as N	Nitrate (as N)	Nitrite (as N)	Nitrogen (Total Oxidised) (as N)	Nitrogen (Total)	Kjeldahl Nitrogen Total	Reactive Phosphorus as P
				pH units	µS/cm	mg/L	mg/L	-	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	meq/L	meq/L	%	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EQL				0.01	1	1	5	0.01	1	1	1	1	1	0.5	0.5	0.5	0.5	1	1	1	0.1	0.01	0.01		0.005	0.01	0.01	0.005	0.1	0.1	0.01
ANZG (2018) - FW - 99% (updated 26 July 2021)																									0.32[#1]	1[#2]					
Field_ID	**SampleCode**	**Location_Code**	**Sampled_Date**																												
7822/SW01	280787-5	SW01	19/10/2021	-	-	-	-	-	<5	5	<5	5	-	<0.5	0.6	<0.5	5.2	6	3	-	-	-	-	-12	0.006	-	-	<0.005	<0.1	-	-
7822/SW02	279832-6	SW02	5/10/2021	-	-	-	-	-	<5	<5	<5	<5	-	<0.5	<0.5	<0.5	5	7	<1	-	-	-	-	3	<0.005	-	-	<0.005	<0.1	-	-
7822/SW02	280787-6	SW02	19/10/2021	-	-	-	-	-	<5	6	<5	6	-	<0.5	<0.5	<0.5	5	7	<1	-	-	-	-	-19	<0.005	-	-	0.02	<0.1	-	-
7822/Upstream	279832-3	Upstream	5/10/2021	-	-	-	-	-	<5	6	<5	6	-	0.9	0.5	0.9	4	5	1	-	-	-	-	1	0.008	-	-	<0.005	0.4	-	-
7822/Upstream	280787-3	Upstream	19/10/2021	-	-	-	-	-	<5	10	<5	10	-	0.5	<0.5	0.9	4	4	1	-	-	-	-	-23	<0.005	-	-	<0.005	<0.1	-	-
Statistical Summary																															
Number of Results				5	5	2	2	2	39	39	39	39	2	39	39	39	39	39	34	5	2	5	5	34	36	2	2	36	36	2	2
Number of Detects				5	5	2	2	2	0	28	0	28	1	18	10	29	39	39	32	5	0	5	5	34	25	2	0	22	19	1	2
Minimum Concentration				5.92	52	34	30	0.72	<1	<5	<1	<5	<1	<0.5	<0.5	<0.5	2.8	4	<1	3	<0.1	0.18	0.36	-60	<0.005	0.09	<0.01	<0.005	<0.1	<0.1	0.02
Minimum Detect				5.92	52	34	30	0.72	ND	5	ND	5	5	0.5	0.5	0.5	2.8	4	1	3	ND	0.18	0.36	ND	0.005	0.09	ND	0.007	0.1	0.2	0.02
Maximum Concentration				7.56	218	42	46	1.15	<5	67	<5	67	5	18	1	12	21	18	22	24	<0.1	1.85	1.99	14	0.1	0.89	<0.01	1.8	15	0.2	0.06
Maximum Detect				7.56	218	42	46	1.15	ND	67	ND	67	5	18	1	12	21	18	22	24	ND	1.85	1.99	14	0.1	0.89	ND	1.8	15	0.2	0.06
Average Concentration				6.9	114				2.2	10	2.2	10		1.5	0.39	1.2	5.4	5.5	2.6	8.2		0.93	1.1	-7.4	0.016			0.2	0.7		
Median Concentration				7.09	72	38	38	0.935	2.5	7	2.5	7	2.75	0.25	0.25	0.9	4.4	5	2	4	0.05	0.57	0.67	-2	0.008	0.49	0.005	0.0095	0.1	0.125	0.04
Standard Deviation				0.62	73				0.68	13	0.68	13		3.5	0.21	1.9	3.6	2.3	3.6	9		0.75	0.75	14	0.023			0.46	2.5		
Number of Guideline Exceedances				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of Guideline Exceedances(Detects Only)				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Env Stds Comments
#1:Measured as NH3-N at pH 8□
#2:Values taken from "Updating nitrate toxicity effects on freshwater aquatic species, 2013"□
#3:(pH >6.5, 0.8 ug/L for pH<6.5)□
#4:In absence of total As guideline, As (V) guideline has been adopted.□
#5:In absence of total Cr guideline, Cr (VI) guideline has been adopted.

Data Comments
#1 NIL (+)VE

Appendix A
Table 1
Water quality results

						Organic Indicators	Metals															
				Phosphate total (P)	Phosphorus (Total)	Dissolved Organic Carbon	Aluminium	Aluminium (Filtered)	Arsenic	Arsenic (Filtered)	Cadmium	Cadmium (Filtered)	Chromium (III+VI)	Chromium (III+VI) (Filtered)	Copper	Copper (Filtered)	Iron	Iron (Filtered)	Lead	Lead (Filtered)	Manganese	Manganese (Filtered)
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EQL				0.005	0.01	1	0.005	0.005	0.0002	0.0002	0.00005	0.00005	0.0002	0.0002	0.0005	0.0005	0.002	0.002	0.0001	0.0001	0.0005	0.0005
ANZG (2018) - FW - 99% (updated 26 July 2021)							0.027#3	0.027#3	0.0008#4	0.0008#4	0.00006	0.00006	0.00001#5	0.00001#5	0.001	0.001			0.001	0.001	1.2	1.2
Field_ID	**SampleCode**	**Location_Code**	**Sampled_Date**																			
7822/Downstream	279832-4	Downstream	5/10/2021	<0.005	<0.05	-	-	-	<0.001	<0.001	<0.0001	<0.0001	<0.001	<0.001	<0.001	<0.001	-	-	<0.001	<0.001	-	-
7822/Downstream	280787-4	Downstream	19/10/2021	<0.005	<0.05	-	-	-	<0.001	<0.001	<0.0001	<0.0001	<0.001	<0.001	0.001	<0.001	-	-	0.002	<0.001	-	-
MB01	ES1721890001	MB01	31/08/2017	-	-	-	277	0.023	0.0681	0.0002	0.223	0.00042	0.825	<0.0002	16.5	0.0047	348	0.079	1.83	<0.0001	14.5	0.396
MB02	ES1721890002	MB02	1/09/2017	-	-	-	24.4	0.005	0.0085	<0.0002	0.0008	<0.00005	0.0484	<0.0002	0.129	<0.0005	22.9	0.004	0.085	<0.0001	0.892	0.101
MB02	ES1809234001	MB02	28/03/2018	-	0.13	<1	-	0.011	-	<0.0002	-	<0.00005	-	<0.0002	-	0.0024	-	0.042	-	<0.0001	-	0.192
7822/MB02	269664-5	MB02	20/05/2021	<0.005	<0.05	-	-	-	-	<0.001	-	<0.0001	-	<0.001	-	0.001	-	-	-	<0.001	-	-
7822/MB02	279832-12	MB02	5/10/2021	<0.005	<0.05	-	-	-	<0.001	<0.001	<0.0001	<0.0001	0.001	<0.001	0.004	0.001	-	-	<0.001	<0.001	-	-
7822/MB02	280787-11	MB02	19/10/2021	<0.005	<0.05	-	-	-	<0.001	<0.001	<0.0001	<0.0001	0.002	<0.001	0.008	0.004	-	-	<0.001	<0.001	-	-
MB03	ES1720506001	MB03	15/08/2017	-	-	-	31.6	0.031	0.0054	0.0002	0.00028	<0.00005	0.0436	<0.0002	0.0348	<0.0005	15	0.016	0.104	<0.0001	7.81	2.85
MB03	ES1809234002	MB03	28/03/2018	-	0.05	2	-	0.019	-	<0.0002	-	0.00006	-	<0.0002	-	0.0089	-	0.018	-	0.0002	-	1.66
7822/MB03	269664-6	MB03	20/05/2021	<0.005	<0.05	-	-	-	-	<0.001	-	<0.0001	-	<0.001	-	0.002	-	-	-	<0.001	-	-
7822/MB03	279832-13	MB03	5/10/2021	<0.005	<0.05	-	-	-	<0.001	<0.001	<0.0001	<0.0001	<0.001	<0.001	0.006	0.005	-	-	0.001	<0.001	-	-
7822/MB03	280787-12	MB03	19/10/2021	<0.005	<0.05	-	-	-	<0.001	<0.001	<0.0001	<0.0001	0.001	<0.001	0.005	0.004	-	-	<0.001	<0.001	-	-
7822/MW201	269664-7	MW201	20/05/2021	<0.005	<0.05	-	-	-	-	<0.001	-	<0.0001	-	<0.001	-	0.19	-	-	-	<0.001	-	-
7822/MW201	279832-14	MW201	5/10/2021	<0.005	<0.05	-	-	-	<0.001	<0.001	<0.0001	<0.0001	<0.001	<0.001	0.043	0.04	-	-	<0.001	<0.001	-	-
7822/MW201	280787-13	MW201	19/10/2021	<0.005	<0.05	-	-	-	<0.001	<0.001	<0.0001	<0.0001	0.018	<0.001	0.086	0.011	-	-	0.004	<0.001	-	-
7822/MW301A	269664-3	MW301A	20/05/2021	<0.005	<0.05	-	-	-	-	<0.001	-	<0.0001	-	<0.001	-	0.017	-	-	-	<0.001	-	-
7822/MW301A	279832-10	MW301A	5/10/2021	<0.005	<0.05	-	-	-	<0.001	<0.001	<0.0001	<0.0001	0.001	<0.001	0.003	0.001	-	-	<0.001	<0.001	-	-
7822/MW301A	280787-9	MW301A	19/10/2021	<0.005	<0.05	-	-	-	<0.001	<0.001	<0.0001	<0.0001	0.004	<0.001	0.004	0.001	-	-	<0.001	<0.001	-	-
7822/MW301B	269664-4	MW301B	20/05/2021	<0.005	<0.05	-	-	-	-	<0.001	-	<0.0001	-	<0.001	-	<0.001	-	-	-	<0.001	-	-
7822/MW301B	279832-11	MW301B	5/10/2021	<0.005	<0.05	-	-	-	<0.001	<0.001	<0.0001	<0.0001	0.005	<0.001	0.009	<0.001	-	-	0.003	<0.001	-	-
7822/MW301B	280787-10	MW301B	19/10/2021	<0.005	<0.05	-	-	-	<0.001	<0.001	<0.0001	<0.0001	0.008	<0.001	0.008	<0.001	-	-	0.005	<0.001	-	-
7822/MW302A	269664-1	MW302A	20/05/2021	<0.005	0.2	-	-	-	-	<0.001	-	<0.0001	-	<0.001	-	<0.001	-	-	-	<0.001	-	-
7822/MW302A	279832-8	MW302A	5/10/2021	<0.005	1.1	-	-	-	0.024	<0.001	0.0007	<0.0001	0.023	<0.001	0.083	0.001	-	-	0.21	<0.001	-	-
7822/MW302A	280787-8	MW302A	19/10/2021	<0.005	0.2	-	-	-	0.005	<0.001	0.0001	<0.0001	0.014	<0.001	0.026	<0.001	-	-	0.039	<0.001	-	-
7822/MW302B	269664-2	MW302B	20/05/2021	<0.005	0.07	-	-	-	-	<0.001	-	<0.0001	-	<0.001	-	0.002	-	-	-	<0.001	-	-
7822/MW302B	279832-9	MW302B	5/10/2021	<0.005	0.2	-	-	-	0.006	<0.001	<0.0001	<0.0001	0.048	<0.001	0.65	0.015	-	-	0.05	<0.001	-	-
7822/MW401	279832-7	MW401	5/10/2021	<0.005	<0.05	-	-	-	<0.001	<0.001	<0.0001	<0.0001	<0.001	<0.001	0.006	0.004	-	-	<0.001	<0.001	-	-
7822/MW401	280787-7	MW401	19/10/2021	<0.005	<0.05	-	-	-	<0.001	<0.001	<0.0001	<0.0001	<0.001	<0.001	0.005	0.003	-	-	<0.001	<0.001	-	-
7822/Pond 1	279832-1	Pond 1	5/10/2021	<0.005	<0.05	-	-	-	<0.001	<0.001	<0.0001	<0.0001	<0.001	<0.001	<0.001	<0.001	-	-	<0.001	<0.001	-	-
7822/Pond 1	280787-1	Pond 1	19/10/2021	<0.005	<0.05	-	-	-	<0.001	<0.001	<0.0001	<0.0001	<0.001	<0.001	0.001	<0.001	-	-	<0.001	<0.001	-	-
7822/Pond 2	279832-2	Pond 2	5/10/2021	<0.005	<0.05	-	-	-	<0.001	<0.001	<0.0001	<0.0001	<0.001	<0.001	<0.001	<0.001	-	-	<0.001	<0.001	-	-
7822/Pond 2	280787-2	Pond 2	19/10/2021	<0.005	<0.05	-	-	-	<0.001	<0.001	<0.0001	<0.0001	<0.001	<0.001	<0.001	<0.001	-	-	<0.001	<0.001	-	-
7822/SW01	279832-5	SW01	5/10/2021	<0.005	<0.05	-	-	-	<0.001	<0.001	<0.0001	<0.0001	<0.001	<0.001	<0.001	<0.001	-	-	<0.001	<0.001	-	-

Appendix A
Table 1
Water quality results

						Organic Indicators	Metals																
				Phosphate total (P)	Phosphorus (Total)	Dissolved Organic Carbon	Aluminium	Aluminium (Filtered)	Arsenic	Arsenic (Filtered)	Cadmium	Cadmium (Filtered)	Chromium (III+VI)	Chromium (III+VI) (Filtered)	Copper	Copper (Filtered)	Iron	Iron (Filtered)	Lead	Lead (Filtered)	Manganese	Manganese (Filtered)
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EQL				0.005	0.01	1	0.005	0.005	0.0002	0.0002	0.00005	0.00005	0.0002	0.0002	0.0005	0.0005	0.002	0.002	0.0001	0.0001	0.0005	0.0005
ANZG (2018) - FW - 99% (updated 26 July 2021)							0.027#3	0.027#3	0.0008#4	0.0008#4	0.00006	0.00006	0.00001#5	0.00001#5	0.001	0.001			0.001	0.001	1.2	1.2
Field_ID	**SampleCode**	**Location_Code**	**Sampled_Date**																			
7822/SW01	280787-5	SW01	19/10/2021	<0.005	<0.05	-	-	-	<0.001	<0.001	<0.0001	<0.0001	<0.001	<0.001	<0.001	<0.001	-	-	<0.001	<0.001	-	-
7822/SW02	279832-6	SW02	5/10/2021	<0.005	<0.05	-	-	-	<0.001	<0.001	<0.0001	<0.0001	<0.001	<0.001	<0.001	<0.001	-	-	<0.001	<0.001	-	-
7822/SW02	280787-6	SW02	19/10/2021	<0.005	<0.05	-	-	-	<0.001	<0.001	<0.0001	<0.0001	<0.001	<0.001	<0.001	<0.001	-	-	<0.001	<0.001	-	-
7822/Upstream	279832-3	Upstream	5/10/2021	<0.005	<0.05	-	-	-	<0.001	<0.001	<0.0001	<0.0001	<0.001	<0.001	<0.001	<0.001	-	-	<0.001	<0.001	-	-
7822/Upstream	280787-3	Upstream	19/10/2021	<0.005	<0.05	-	-	-	<0.001	<0.001	<0.0001	<0.0001	<0.001	<0.001	<0.001	<0.001	-	-	<0.001	<0.001	-	-

Statistical Summary

Number of Results	34	36	2	3	5	30	39	30	39	30	39	30	39	3	5	30	39	3	5
Number of Detects	0	7	1	3	5	6	2	5	2	14	0	20	20	3	5	11	1	3	5
Minimum Concentration	<0.005	<0.05	<1	24.4	0.005	<0.001	<0.0002	<0.0001	**<0.00005**	<0.001	<0.0002	<0.001	<0.0005	15	0.004	<0.001	<0.0001	0.892	0.101
Minimum Detect	ND	0.05	2	24.4	0.005	0.005	0.0002	0.0001	0.00006	0.001	ND	0.001	0.001	15	0.004	0.001	0.0002	0.892	0.101
Maximum Concentration	<0.005	1.1	2	277	0.031	0.0681	<0.001	0.223	0.00042	0.825	<0.001	16.5	0.19	348	0.079	1.83	<0.001	14.5	2.85
Maximum Detect	ND	1.1	2	277	0.031	0.0681	0.0002	0.223	0.00042	0.825	ND	16.5	0.19	348	0.079	1.83	0.0002	14.5	2.85
Average Concentration	0.0025	0.074		111	0.018	0.0043	0.00045	0.0075	0.000058	0.035	0.00045	0.59	0.0084	129	0.032	0.078	0.00045	7.7	1
Median Concentration	0.0025	0.025	1.25	31.6	0.019	0.0005	0.0005	0.00005	0.00005	0.0005	0.0005	0.0045	0.001	22.9	0.018	0.0005	0.0005	7.81	0.396
Standard Deviation	0	0.18		144	0.01	0.013	0.00012	0.041	0.00006	0.15	0.00014	3	0.031	190	0.03	0.33	0.00014	6.8	1.2
Number of Guideline Exceedances	0	0	0	3	1	30	34	30	**36**	30	39	20	20	0	0	11	0	2	2
Number of Guideline Exceedances(Detects Only)	0	0	0	3	1	6	0	5	2	14	0	20	20	0	0	11	0	2	2

Env Stds Comments
#1:Measured as NH3-N at pH 8□
#2:Values taken from "Updating nitrate toxicity effects on freshwater aquatic :
#3:(pH >6.5, 0.8 ug/L for pH<6.5)□
#4:In absence of total As guideline, As (V) guideline has been adopted.□
#5:In absence of total Cr guideline, Cr (VI) guideline has been adopted.

Data Comments
#1 NIL (+)VE

Appendix A
Table 1
Water quality results

										BTEXN									TRH - NEPM 2013							TRH - NEPM 1999					
				Mercury	Mercury (Filtered)	Nickel	Nickel (Filtered)	Zinc	Zinc (Filtered)	Benzene	Toluene	Ethylbenzene	Xylene (o)	Xylene (m & p)	Xylene Total	BTEX (Sum of Total) - Lab Calc	Naphthalene (BTEXN suite)	Naphthalene	F1 (C6-C10 minus BTEX)	C6-C10 Fraction	F2 (>C10-C16 minus Naphthalene)	>C10-C16 Fraction	F3 (>C16-C34 Fraction)	F4 (>C34-C40 Fraction)	>C10-C40 (Sum of Total)	C6-C9 Fraction	C10-C14 Fraction	C15-C28 Fraction	C29-C36 Fraction	C10-C36 (Sum of Total)	Acenaphthene
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
EQL				0.00005	0.00004	0.0005	0.0005	0.001	0.001	1	1	1	1	2	2	1	5	1	10	10	50	50	100	100	50	10	50	100	50	50	1
ANZG (2018) - FW - 99% (updated 26 July 2021)				0.00005	0.00006	0.008	0.008	0.0024	0.0024	500	110	50	200				2.5	2.5													
Field_ID	SampleCode	Location_Code	Sampled_Date																												
7822/Downstream	279832-4	Downstream	5/10/2021	<0.00005	<0.00005	<0.001	<0.001	0.002	0.003	<1	<1	<1	<1	<2	-	-	-	<1	<10	<10	<50	<50	<100	<100	-	<10	<50	<100	<100	-	<1
7822/Downstream	280787-4	Downstream	19/10/2021	<0.00005	<0.00005	<0.001	<0.001	0.002	0.005	<1	<1	<1	<1	<2	-	-	-	<1	<10	<10	<50	<50	<100	<100	<50	<10	<50	<100	<100	<50	<1
MB01	ES1721890001	MB01	31/08/2017	<0.0001	<0.0001	4.62	0.0194	11.1	0.016	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MB02	ES1721890002	MB02	1/09/2017	<0.0001	<0.0001	0.0241	0.0017	0.142	<0.001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MB02	ES1809234001	MB02	28/03/2018	-	0.00007	-	0.001	-	0.039	<1	<2	<2	<2	<2	<2	<1	<5	<1	<20	<20	<100	<100	<100	<100	<100	<20	<50	<100	<50	<50	<1
7822/MB02	269664-5	MB02	20/05/2021	-	<0.00005	-	<0.001	-	0.007	<1	<1	<1	<1	<2	-	-	-	<1	<10	<10	<50	<50	<100	<100	-	<10	<50	<100	<100	-	<1
7822/MB02	279832-12	MB02	5/10/2021	0.0001	<0.00005	0.002	<0.001	0.023	0.007	<1	<1	<1	<1	<2	-	-	-	<1	<10	<10	<50	<50	<100	<100	-	<10	<50	<100	<100	-	<1
7822/MB02	280787-11	MB02	19/10/2021	0.00008	<0.00005	0.002	<0.001	0.011	0.01	<1	<1	<1	<1	<2	-	-	-	<1	<10	<10	<50	<50	<100	<100	<50	<10	<50	<100	<100	<50	<1
MB03	ES1720506001	MB03	15/08/2017	<0.0001	<0.0001	0.0156	0.0011	0.112	0.001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MB03	ES1809234002	MB03	28/03/2018	-	0.00027	-	0.0025	-	0.043	<1	<2	<2	<2	<2	<2	<1	<5	<1	<20	<20	<100	<100	<100	<100	<100	<20	<50	<100	<50	<50	<1
7822/MB03	269664-6	MB03	20/05/2021	-	<0.00005	-	0.003	-	0.036	<1	<1	<1	<1	<2	-	-	-	<1	<10	<10	<50	<50	<100	<100	-	<10	<50	<100	<100	-	<1
7822/MB03	279832-13	MB03	5/10/2021	<0.00005	<0.00005	0.004	0.005	0.052	0.046	<1	<1	<1	<1	<2	-	-	-	<1	<10	<10	<50	<50	<100	<100	-	<10	<50	<100	<100	-	<1
7822/MB03	280787-12	MB03	19/10/2021	<0.00005	<0.00005	0.003	0.003	0.028	0.035	<1	<1	<1	<1	<2	-	-	-	<1	<10	<10	<50	<50	<100	<100	<50	<10	<50	<100	<100	<50	<1
7822/MW201	269664-7	MW201	20/05/2021	-	<0.00005	-	0.085	-	0.8	<1	<1	<1	<1	<2	-	-	-	<1	<10	<10	72	72	140	<100	-	<10	<50	200	<100	-	<1
7822/MW201	279832-14	MW201	5/10/2021	<0.00005	<0.00005	0.007	0.005	0.059	0.065	<1	<1	<1	<1	<2	-	-	-	<1	<10	<10	230	230	460	<100	-	<10	120	490	120	-	<1
7822/MW201	280787-13	MW201	19/10/2021	<0.00005	<0.00005	0.024	0.001	0.24	0.031	<1	<1	<1	<1	<2	-	-	-	<1	<10	<10	<50	<50	<100	<100	<50	<10	<50	<100	<100	<50	<1
7822/MW301A	269664-3	MW301A	20/05/2021	-	<0.00005	-	0.009	-	0.035	<1	<1	<1	<1	<2	-	-	-	<1	<10	<10	<50	<50	<100	<100	-	<10	<50	<100	<100	-	<1
7822/MW301A	279832-10	MW301A	5/10/2021	<0.00005	<0.00005	<0.001	<0.001	0.004	0.002	<1	<1	<1	<1	<2	-	-	-	<1	<10	<10	<50	<50	<100	<100	-	<10	<50	<100	<100	-	<1
7822/MW301A	280787-9	MW301A	19/10/2021	<0.00005	<0.00005	<0.001	<0.001	0.004	0.005	<1	<1	<1	<1	<2	-	-	-	<1	<10	<10	<50	<50	<100	<100	<50	<10	<50	<100	<100	<50	<1
7822/MW301B	269664-4	MW301B	20/05/2021	-	<0.00005	-	<0.001	-	<0.001	<1	<1	<1	<1	<2	-	-	-	<1	<10	<10	<50	<50	<100	<100	-	<10	<50	<100	<100	-	<1
7822/MW301B	279832-11	MW301B	5/10/2021	<0.00005	<0.00005	<0.001	<0.001	0.001	0.002	<1	<1	<1	<1	<2	-	-	-	<1	<10	<10	<50	<50	<100	<100	-	<10	<50	<100	<100	-	<1
7822/MW301B	280787-10	MW301B	19/10/2021	<0.00005	<0.00005	<0.001	<0.001	0.003	0.002	<1	<1	<1	<1	<2	-	-	-	<1	<10	<10	<50	<50	<100	<100	<50	<10	<50	<100	<100	<50	<1
7822/MW302A	269664-1	MW302A	20/05/2021	-	<0.00005	-	<0.001	-	<0.001	<1	<1	<1	<1	<2	-	-	-	<1	<10	<10	<50	<50	<100	<100	-	<10	<50	<100	<100	-	<1
7822/MW302A	279832-8	MW302A	5/10/2021	0.00008	<0.00005	0.011	<0.001	0.2	<0.001	<1	<1	<1	<1	<2	-	-	-	<1	<10	<10	<50	<50	<100	<100	-	<10	<50	<100	<100	-	<1
7822/MW302A	280787-8	MW302A	19/10/2021	<0.00005	<0.00005	0.005	<0.001	0.033	<0.001	<1	<1	<1	<1	<2	-	-	-	<1	<10	<10	<50	<50	<100	<100	<50	<10	<50	<100	<100	<50	<1
7822/MW302B	269664-2	MW302B	20/05/2021	-	<0.00005	-	<0.001	-	<0.001	<1	<1	<1	<1	<2	-	-	-	<1	<10	<10	<50	<50	<100	<100	-	<10	<50	<100	<100	-	<1
7822/MW302B	279832-9	MW302B	5/10/2021	0.00007	<0.00005	0.01	<0.001	0.035	0.001	<1	<1	<1	<1	<2	-	-	-	<1	<10	<10	<50	<50	<100	<100	-	<10	<50	<100	<100	-	<1
7822/MW401	279832-7	MW401	5/10/2021	<0.00005	<0.00005	<0.001	<0.001	0.004	0.001	<1	<1	<1	<1	<2	-	-	-	<1	<10	<10	<50	<50	<100	<100	-	<10	<50	<100	<100	-	<1
7822/MW401	280787-7	MW401	19/10/2021	<0.00005	<0.00005	<0.001	<0.001	0.003	0.007	<1	<1	<1	<1	<2	-	-	-	<1	<10	<10	<50	<50	<100	<100	<50	<10	<50	<100	<100	<50	<1
7822/Pond 1	279832-1	Pond 1	5/10/2021	<0.00005	<0.00005	<0.001	<0.001	0.003	0.002	<1	<1	<1	<1	<2	-	-	-	<1	<10	<10	<50	<50	<100	<100	-	<10	<50	<100	<100	-	<1
7822/Pond 1	280787-1	Pond 1	19/10/2021	<0.00005	<0.00005	<0.001	<0.001	0.003	0.003	<1	<1	<1	<1	<2	-	-	-	<1	<10	<10	<50	<50	<100	<100	<50	<10	<50	<100	<100	<50	<1
7822/Pond 2	279832-2	Pond 2	5/10/2021	<0.00005	<0.00005	<0.001	<0.001	0.003	0.005	<1	<1	<1	<1	<2	-	-	-	<1	<10	<10	<50	<50	<100	<100	-	<10	<50	<100	<100	-	<1
7822/Pond 2	280787-2	Pond 2	19/10/2021	<0.00005	<0.00005	<0.001	<0.001	0.001	<0.001	<1	<1	<1	<1	<2	-	-	-	<1	<10	<10	<50	<50	<100	<100	<50	<10	<50	<100	<100	<50	<1
7822/SW01	279832-5	SW01	5/10/2021	<0.00005	<0.00005	<0.001	<0.001	0.002	0.001	<1	<1	<1	<1	<2	-	-	-	<1	<10	<10	<50	<50	<100	<100	-	<10	<50	<100	<100	-	<1

Appendix A
Table 1
Water quality results

										BTEXN								
				Mercury	Mercury (Filtered)	Nickel	Nickel (Filtered)	Zinc	Zinc (Filtered)	Benzene	Toluene	Ethylbenzene	Xylene (o)	Xylene (m & p)	Xylene Total	BTEX (Sum of Total) - Lab Calc	Naphthalene (BTEXN suite)	Naphthalene
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
EQL				0.00005	0.00004	0.0005	0.0005	0.001	0.001	1	1	1	1	2	2	1	5	1
ANZG (2018) - FW - 99% (updated 26 July 2021)				0.00006	0.00006	0.008	0.008	0.0024	0.0024	600	110	50	200				2.5	2.5
Field_ID	**SampleCode**	**Location_Code**	**Sampled_Date**															
7822/SW01	280787-5	SW01	19/10/2021	<0.00005	<0.00005	<0.001	<0.001	0.001	0.002	<1	<1	<1	<1	<2	-	-	-	<1
7822/SW02	279832-6	SW02	5/10/2021	<0.00005	<0.00005	<0.001	<0.001	0.002	0.001	<1	<1	<1	<1	<2	-	-	-	<1
7822/SW02	280787-6	SW02	19/10/2021	<0.00005	<0.00005	<0.001	<0.001	0.002	0.001	<1	<1	<1	<1	<2	-	-	-	<1
7822/Upstream	279832-3	Upstream	5/10/2021	<0.00005	<0.00005	<0.001	<0.001	0.004	0.002	<1	<1	<1	<1	<2	-	-	-	<1
7822/Upstream	280787-3	Upstream	19/10/2021	<0.00005	<0.00005	<0.001	<0.001	0.005	0.002	<1	<1	<1	<1	<2	-	-	-	<1

				TRH - NEPM 2013							TRH - NEPM 1999					
				F1 (C6-C10 minus BTEX)	C6-C10 Fraction	F2 (>C10-C16 minus Naphthalene)	>C10-C16 Fraction	F3 (>C16-C34 Fraction)	F4 (>C34-C40 Fraction)	>C10-C40 (Sum of Total)	C6-C9 Fraction	C10-C14 Fraction	C15-C28 Fraction	C29-C36 Fraction	C10-C36 (Sum of Total)	Acenaphthene
				µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
EQL				10	10	50	50	100	100	50	10	50	100	50	50	1
ANZG (2018) - FW - 99% (updated 26 July 2021)																
Field_ID	**SampleCode**	**Location_Code**	**Sampled_Date**													
7822/SW01	280787-5	SW01	19/10/2021	<10	<10	<50	<50	<100	<100	<50	<10	<50	<100	<100	<50	<1
7822/SW02	279832-6	SW02	5/10/2021	<10	<10	<50	<50	<100	<100	-	<10	<50	<100	<100	-	<1
7822/SW02	280787-6	SW02	19/10/2021	<10	<10	<50	<50	<100	<100	<50	<10	<50	<100	<100	<50	<1
7822/Upstream	279832-3	Upstream	5/10/2021	<10	<10	<50	<50	<100	<100	-	<10	<50	<100	<100	-	<1
7822/Upstream	280787-3	Upstream	19/10/2021	<10	<10	<50	<50	<100	<100	<50	<10	<50	<100	<100	<50	<1

Statistical Summary

Statistical Summary	Mercury	Mercury (Filtered)	Nickel	Nickel (Filtered)	Zinc	Zinc (Filtered)	Benzene	Toluene	Ethylbenzene	Xylene (o)	Xylene (m & p)	Xylene Total	BTEX (Sum of Total) - Lab Calc	Naphthalene (BTEXN suite)	Naphthalene
Number of Results	30	39	30	39	30	39	36	36	36	36	36	2	2	2	36
Number of Detects	4	2	12	12	30	32	0	0	0	0	0	0	0	0	0
Minimum Concentration	<0.00005	<0.00005	<0.001	<0.001	0.001	<0.001	<1	<1	<1	<1	<2	<2	<1	<5	<1
Minimum Detect	0.00007	0.00007	0.002	0.001	0.001	0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND
Maximum Concentration	0.0001	0.00027	4.62	0.085	11.1	0.8	<1	<2	<2	<2	<2	<2	<1	<5	<1
Maximum Detect	0.0001	0.00027	4.62	0.085	11.1	0.8	ND	ND	ND	ND	ND	ND	ND	ND	ND
Average Concentration	0.000035	0.000034	0.16	0.0039	0.4	0.031	0.5	0.53	0.53	0.53	1				0.5
Median Concentration	0.000025	0.000025	0.0005	0.0005	0.004	0.002	0.5	0.5	0.5	0.5	1	1	0.5	2.5	0.5
Standard Deviation	0.000021	0.00004	0.84	0.014	2	0.13	0	0.12	0.12	0.12	0				0
Number of Guideline Exceedances	7	5	6	3	22	19	0	0	0	0	0	0	0	2	0
Number of Guideline Exceedances(Detects Only)	4	2	6	3	22	19	0	0	0	0	0	0	0	0	0

Statistical Summary	F1 (C6-C10 minus BTEX)	C6-C10 Fraction	F2 (>C10-C16 minus Naphthalene)	>C10-C16 Fraction	F3 (>C16-C34 Fraction)	F4 (>C34-C40 Fraction)	>C10-C40 (Sum of Total)	C6-C9 Fraction	C10-C14 Fraction	C15-C28 Fraction	C29-C36 Fraction	C10-C36 (Sum of Total)	Acenaphthene
Number of Results	36	36	36	36	36	36	15	36	36	36	36	15	36
Number of Detects	0	0	2	2	2	0	0	0	1	2	1	0	0
Minimum Concentration	<10	<10	<50	<50	<100	<100	<50	<10	<50	<100	<50	<50	<1
Minimum Detect	ND	ND	72	72	140	ND	ND	ND	120	200	120	ND	ND
Maximum Concentration	<20	<20	230	230	460	<100	<100	<20	120	490	120	<50	<1
Maximum Detect	ND	ND	230	230	460	ND	ND	ND	120	490	120	ND	ND
Average Concentration	5.3	5.3	33	33	64	50	28	5.3	28	66	51	25	0.5
Median Concentration	5	5	25	25	50	50	25	5	25	50	50	25	0.5
Standard Deviation	1.2	1.2	35	35	70	0	8.8	1.2	16	77	13	0	0
Number of Guideline Exceedances	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of Guideline Exceedances(Detects Only)	0	0	0	0	0	0	0	0	0	0	0	0	0

Env Stds Comments
#1:Measured as NH3-N at pH 8□
#2:Values taken from "Updating nitrate toxicity effects on freshwater aquatic :
#3:(pH >6.5, 0.8 ug/L for pH<6.5)□
#4:In absence of total As guideline, As (V) guideline has been adopted.□
#5:In absence of total Cr guideline, Cr (VI) guideline has been adopted.

Data Comments
#1 NIL (+)VE

Appendix A
Table 1
Water quality results

				PAHs - standard 16																		PAHs - extended	
				Acenaphthylene	Anthracene	Benz(a)anthracene	Benzo(a)pyrene	Benzo[b+j]fluoranthene	Benzo(k)fluoranthene	Benzo(g,h,i)perylene	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-c,d)pyrene	Phenanthrene	Pyrene	Sum of standard 16 PAHs	PAHs (Sum of total) - Lab calc	Total 8 PAHs (as BaP TEQ)(zero LOR) - Lab Calc	Benzo(b+j+k)fluoranthene	B(a)P Total Potency Equivalent
				µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
EQL				1	1	1	0.5	1	1	1	1	1	1	1	1	1	1	0.5	1	0.5	2	5
ANZG (2018) - FW - 99% (updated 26 July 2021)					0.01		0.1						1			0.6						
Field_ID	SampleCode	Location_Code	Sampled_Date																			
7822/Downstream	279832-4	Downstream	5/10/2021	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	-	$0^{\#1}$	-	<2	<5
7822/Downstream	280787-4	Downstream	19/10/2021	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	-	$0^{\#1}$	-	<2	<5
MB01	ES1721890001	MB01	31/08/2017	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MB02	ES1721890002	MB02	1/09/2017	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MB02	ES1809234001	MB02	28/03/2018	<1	<1	<1	<0.5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<0.5	-	<0.5	-	-
7822/MB02	269664-5	MB02	20/05/2021	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	-	$0^{\#1}$	-	<2	<5
7822/MB02	279832-12	MB02	5/10/2021	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	-	$0^{\#1}$	-	<2	<5
7822/MB02	280787-11	MB02	19/10/2021	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	-	$0^{\#1}$	-	<2	<5
MB03	ES1720506001	MB03	15/08/2017	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MB03	ES1809234002	MB03	28/03/2018	<1	<1	<1	<0.5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<0.5	-	<0.5	-	-
7822/MB03	269664-6	MB03	20/05/2021	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	-	$0^{\#1}$	-	<2	<5
7822/MB03	279832-13	MB03	5/10/2021	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	-	$0^{\#1}$	-	<2	<5
7822/MB03	280787-12	MB03	19/10/2021	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	-	$0^{\#1}$	-	<2	<5
7822/MW201	269664-7	MW201	20/05/2021	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	-	$0^{\#1}$	-	<2	<5
7822/MW201	279832-14	MW201	5/10/2021	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	-	$0^{\#1}$	-	<2	<5
7822/MW201	280787-13	MW201	19/10/2021	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	-	$0^{\#1}$	-	<2	<5
7822/MW301A	269664-3	MW301A	20/05/2021	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	-	$0^{\#1}$	-	<2	<5
7822/MW301A	279832-10	MW301A	5/10/2021	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	-	$0^{\#1}$	-	<2	<5
7822/MW301A	280787-9	MW301A	19/10/2021	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	-	$0^{\#1}$	-	<2	<5
7822/MW301B	269664-4	MW301B	20/05/2021	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	-	$0^{\#1}$	-	<2	<5
7822/MW301B	279832-11	MW301B	5/10/2021	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	-	$0^{\#1}$	-	<2	<5
7822/MW301B	280787-10	MW301B	19/10/2021	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	-	$0^{\#1}$	-	<2	<5
7822/MW302A	269664-1	MW302A	20/05/2021	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	-	$0^{\#1}$	-	<2	<5
7822/MW302A	279832-8	MW302A	5/10/2021	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	-	$0^{\#1}$	-	<2	<5
7822/MW302A	280787-8	MW302A	19/10/2021	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	-	$0^{\#1}$	-	<2	<5
7822/MW302B	269664-2	MW302B	20/05/2021	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	-	$0^{\#1}$	-	<2	<5
7822/MW302B	279832-9	MW302B	5/10/2021	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	-	$0^{\#1}$	-	<2	<5
7822/MW401	279832-7	MW401	5/10/2021	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	-	$0^{\#1}$	-	<2	<5
7822/MW401	280787-7	MW401	19/10/2021	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	-	$0^{\#1}$	-	<2	<5
7822/Pond 1	279832-1	Pond 1	5/10/2021	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	-	$0^{\#1}$	-	<2	<5
7822/Pond 1	280787-1	Pond 1	19/10/2021	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	-	$0^{\#1}$	-	<2	<5
7822/Pond 2	279832-2	Pond 2	5/10/2021	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	-	$0^{\#1}$	-	<2	<5
7822/Pond 2	280787-2	Pond 2	19/10/2021	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	-	$0^{\#1}$	-	<2	<5
7822/SW01	279832-5	SW01	5/10/2021	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	-	$0^{\#1}$	-	<2	<5

Appendix A
Table 1
Water quality results

				PAHs - standard 16																	PAHs - extended	
				Acenaphthylene	Anthracene	Benz(a)anthracene	Benzo(a)pyrene	Benzo[b+j]fluoranthene	Benzo(k)fluoranthene	Benzo(g,h,i)perylene	Chrysene	Dibenz(a,h)anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-c,d)pyrene	Phenanthrene	Pyrene	Sum of standard 16 PAHs	PAHs (Sum of total) - Lab calc	Total 8 PAHs (as BaP TEQ)(zero LOR) - Lab Calc	Benzo(b+j+k)fluoranthene	B(a)P Total Potency Equivalent
				µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
EQL				1	1	1	0.5	1	1	1	1	1	1	1	1	1	1	0.5	1	0.5	2	5
ANZG (2018) - FW - 99% (updated 26 July 2021)					0.01		0.1						1			0.6						
Field_ID	**SampleCode**	**Location_Code**	**Sampled_Date**																			
7822/SW01	280787-5	SW01	19/10/2021	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	-	$0^{\#1}$	-	<2	<5
7822/SW02	279832-6	SW02	5/10/2021	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	-	$0^{\#1}$	-	<2	<5
7822/SW02	280787-6	SW02	19/10/2021	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	-	$0^{\#1}$	-	<2	<5
7822/Upstream	279832-3	Upstream	5/10/2021	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	-	$0^{\#1}$	-	<2	<5
7822/Upstream	280787-3	Upstream	19/10/2021	<1	<1	<1	<1	-	-	<1	<1	<1	<1	<1	<1	<1	<1	-	$0^{\#1}$	-	<2	<5
Statistical Summary																						
Number of Results				36	36	36	36	2	2	36	36	36	36	36	36	36	36	2	34	2	34	34
Number of Detects				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	34	0	0	0
Minimum Concentration				<1	<1	<1	<0.5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<0.5	<0	<0.5	<2	<5
Minimum Detect				ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Maximum Concentration				<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<0.5	0	<0.5	<2	<5
Maximum Detect				ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Average Concentration				0.5	0.5	0.5	0.49			0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0		1	2.5
Median Concentration				0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.25	0	0.25	1	2.5
Standard Deviation				0	0	0	0.058			0	0	0	0	0	0	0	0		0		0	0
Number of Guideline Exceedances				0	36	0	36	0	0	0	0	0	0	0	0	36	0	0	0	0	0	0
Number of Guideline Exceedances(Detects Only)				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Env Stds Comments
#1:Measured as NH3-N at pH 8□
#2:Values taken from "Updating nitrate toxicity effects on freshwater aquatic :
#3:(pH >6.5, 0.8 ug/L for pH<6.5)□
#4:In absence of total As guideline, As (V) guideline has been adopted.□
#5:In absence of total Cr guideline, Cr (VI) guideline has been adopted.

Data Comments
#1 NIL (+)VE

Appendix B

PHREEQC water quality inputs and cell optimisation

SOLUTION 1 Leachate		#ADE worst case leachate
temp	18	
pH	5	#worst case from low value of max concentration range pH 5-9 from NSW ENM Order 2014
pe	4	
redox	pe	
units	mg/l	
density	1	
Alkalinity	3	as Ca.5(CO3).5
S(6)	21	as SO4
Cl	20	
Ca	0.5	
Mg	0.5	
Na	23	
K	0.5	
Cd	0.0004	
Cu	0.013	
Ni	0.006	
Pb	0.01	
As	0.001	
Zn	0.484	
Hg	0.00005	
Cr	0.588	
N(-3)	0.11	as NH3
N(+5)	2.35	
P	0.01	
SOLUTION 2 Local groundwater		# MW201 5/10/2021 where values were <LOR the LOR was adopted
temp	18	#estimated based on previous temperature values mesaured at other monitoring locations within this aquifer
pH	5.05	# average value from neighbouring Newnes site
pe	4	
redox	pe	
units	mg/l	
density	1	
Alkalinity	9	as Ca.5(CO3).5
S(6)	2	as SO4
Cl	5	
Ca	0.6	
Mg	0.5	
Na	6.1	
K	0.5	
Cd	0.0001	
Cu	0.04	
Ni	0.005	
Pb	0.001	
As	0.001	
Zn	0.065	
Hg	0.00005	
Cr	0.001	
N(-3)	0.013	as NH3
N(+5)	0.53	
P	0.005	

Phreeqc Cell Optimisation

Numerical dispersion in PHREEQC 1D transport models can occur when a model grid is too coarse. As such optimisation of the model grid was undertaken in a stepwise fashion as described in Table A1. An optimal cell length of 10 m was chosen for the transport model.

Table A1 *Phreeqc 1D transport model cell optimisation*

Cell Optimisation - Phreeqc Model effective porosity 0.01															
Flow Scenario	Model	Flow length (m)	Lengths (of cell) (m)	Cells (number of)	Lengths	Years	Ave. linear flow velocity (m/y)	Time step (y)	Time step (s)	Shifts	Boundary conditions	Dispersivity	correct disp	print and punch cells	Output Zn (mg/L)
	Cell Opt. 4	450	5	90	90*5	500	32.2	0.16	4897959	3219	constant/constant	5	true	90	0.1881
	Cell Opt. 3		10	45	45*10			0.31	9795918	1610		10		45	0.1881
	Cell Opt. 2		50	9	9*50			1.55	48979592	322		50		9	0.1881
	Cell Opt. 1		90	5	5*90			2.80	88163265	179		90		5	0.1886

🟩 Optimal

Model outputs

Solution 0 mixing ouput																										
sim	state	soln	dist_x	time	step	pH	temp	mu	As_mg/l	Ca_mg/l	Cd_mg/l	Cr_mg/l	Cu_mg/l	K_mg/l	Mg_mg/l	Na_mg/l	Ni_mg/l	Pb_mg/l	S(6)_mg/l	Zn_mg/l	Cl_mg/l	alkalinity_CaCo3mg/l	Hg_mg/l	NO3_mg/l	NH3_mg/l	P_mg/L
3	react	1	-99	0	1	5.04529	18	0.00046	0.0010	0.5979	0.0001	0.0132	0.0394	0.4998	0.5000	6.4517	0.0050	0.0012	2.3952	0.0737	5.3121	8.7887	0.00005	0.5306	0.0000	0.0051
Transport after 500 yrs last cell output																										
sim	state	soln	dist_x	time	step	pH	temp	mu	As_mg/l	Ca_mg/l	Cd_mg/l	Cr_mg/l	Cu_mg/l	K_mg/l	Mg_mg/l	Na_mg/l	Ni_mg/l	Pb_mg/l	S(6)_mg/l	Zn_mg/l	Cl_mg/l	alkalinity_CaCo3mg/l	Hg_mg/l	NO3_mg/l	NH3_mg/l	P_mg/L
1	transp	45	445	1.58E+10	1610	5.04835	18	0.00045	0.0010	0.5989	0.0001	0.0073	0.0397	0.4997	0.5000	6.2808	0.0050	0.0011	2.2030	0.0695	5.1604	8.8561	0.00005	0.5145	0.0000	0.0051
Discharge upgradient + catchmnet groundwater output																										
s	state	soln	dist_x	time	ste	pH	ten	m	As_mg/l	Ca_mg/l	Cd_mg/l	Cr_mg/l	Cu_mg/l	K_mg/l	Mg_mg/l	Na_mg/l	Ni_mg/l	Pb_mg/l	S(6)_mg/l	Zn_mg/l	Cl_mg/l	alkalinity_CaCo3mg/l	Hg_mg/l	NO3_mg/l	NH3_mg/l	P_mg/L
3	react	1	-99	0	1	5.04718	18	0.00044	0.0010	0.5998	0.0001	0.0021	0.0399	0.4998	0.5000	6.1320	0.0050	0.0010	2.0357	0.0658	5.0284	8.9135	0.00005	0.5006	0.0000	0.0050

Appendix C

HELP Modelling

Memorandum

19 November 2021

1. Introduction

This memorandum outlines the methodology, assumptions and results of the infiltration and evapotranspiration modelling performed using the US EPA's Hydraulic Evaluation of Landfill Performance (HELP) model and in accordance with the NSW EPA Environmental Guidelines: Solid Waste Landfills, 2nd Edition (NSW EPA, April 2016). These include guidance on soil materials and whilst applicable to landfills are also relevant to soil emplacement facilities.

The HELP model was used generally in the Revised Water Resources Assessment for the proposed works at Bell Quarry:

- To estimate evapotranspiration loss off the bare soil of the contact water catchment. This modelling was used to inform the water balance assessment (Section 3).

2. Reliance

GHD relied upon the following information to undertake the infiltration modelling:

- ADE Consulting Group (2017) – Soil and water sampling — Bell Quarry Rehabilitation Project, Blue Mountains NSW, dated 6th December 2017
- Bureau of Meteorology (BOM) (2021), climate data for Lithgow (Birdwood St) (BOM station number 063224
- NSW EPA (2016), Environmental Guidelines: Solid Waste Landfills, 2nd Edition, dated April 2016
- SILO weather data (SILO | LongPaddock | Queensland Government) from point data source located at a latitude of -33.50 and a longitude of 150.25
- US EPA (1994) The Hydrologic Evaluation of Landfill Performance (HELP) Model, dated 1994

3. Contact water catchment evaporation

As outlined in the revised Water Resources Assessment the HELP model was utilised to estimate evaporation off the bare soil of the contact water catchment for the 'best-estimate' water balance assessment.

3.1 General

Two key inputs were required for the infiltration modelling:

1. Climate data (specifically rainfall, temperature, and evaporation data)
2. Cover profile (including material type and depth)

3.2 Climate data

Climate data was obtained as described in Section 2.

The precipitation data obtained was modified to incorporate irrigation into the model. Several simulations of HELP were run each with a different quantum of irrigation (determined as the proportion of daily evaporation deficit being irrigated).

Precipitation data was created and modelled as follows:

- Original precipitation data
- Original precipitation data + 30% of the deficit
- Original precipitation data + 40% of the deficit

As outlined in the Revised Water Resources Assessment for an application greater than 40 percent of the deficit the evaporative loss of the soil was not significantly greater. That is, the evaporative capacity of the atmosphere was governing rather than the applied irrigation rate. As such the 40% scenario was adopted.

3.3 Modelling assumptions

The HELP model considered the following key assumptions:

- The infiltration was considered through the cover arrangements as outlined in Table 1.
- HELP standard values for porosity, field capacity, wilting point and hydraulic conductivity were utilised for the selected material types based on the results of the ADE (2017) soil and water sampling, engineering judgement and previous experience.

Table 1 Capping arrangements

Arrangements	Profile (top to bottom)
0.3 m evaporative zone depth Bare ground conditions Graded for 5% and a 50 m slope length	500 mm thick sandy clay layer (HELP soil profile #13) 5000 mm thick sandy clay fill (HELP soil profile #13)

3.4 Results

The results of HELP modelling resulted in a time series of evapotranspiration in response to various irrigation scenarios. This output formed a time series input into the water balance, documented in the Revised Water Resources Assessment.

The HELP model outputs can be viewed in Appendix A.

4. Summary

The HELP model was used in the Revised Water Resources Assessment for the proposed works at Bell Quarry:

- To estimate evaporation loss off the bare soil of the contact water catchment, to inform the water balance assessment

The contact water catchment evaporation modelling resulted in a time series of evapotranspiration outputs corresponding to various irrigation scenarios. This output formed a time series input into the water balance, documented in the Revised Water Resources Assessment.

Appendix A

HELP modelling outputs

Rainfall scenario with irrigation - 30% rain

Assumptions:
Bare ground
Sandy clay
No initial moisture content set
100% runoff available

Year	Month	Date format	Evapotranspiration
1921	January	1/01/1921	79.87
1921	February	1/02/1921	68.38
1921	March	1/03/1921	65.49
1921	April	1/04/1921	44.56
1921	May	1/05/1921	38.76
1921	June	1/06/1921	32.25
1921	July	1/07/1921	39.74
1921	August	1/08/1921	40.31
1921	Septembe	1/09/1921	49.93
1921	October	1/10/1921	68.18
1921	Novembeı	1/11/1921	79.75
1921	December	1/12/1921	88.14
1922	January	1/01/1922	78.07
1922	February	1/02/1922	68.54
1922	March	1/03/1922	66.39
1922	April	1/04/1922	34.95
1922	May	1/05/1922	37.59
1922	June	1/06/1922	31.63
1922	July	1/07/1922	37.8
1922	August	1/08/1922	41.01
1922	Septembe	1/09/1922	48.23
1922	October	1/10/1922	66.54
1922	Novembeı	1/11/1922	66.39
1922	December	1/12/1922	82.95
1923	January	1/01/1923	71.61
1923	February	1/02/1923	53.5
1923	March	1/03/1923	60.43
1923	April	1/04/1923	45.33
1923	May	1/05/1923	39.13
1923	June	1/06/1923	32.65
1923	July	1/07/1923	38.28
1923	August	1/08/1923	41.46
1923	Septembe	1/09/1923	47.78
1923	October	1/10/1923	67.73
1923	Novembeı	1/11/1923	65.22
1923	December	1/12/1923	65.73
1924	January	1/01/1924	72.43
1924	February	1/02/1924	69.34
1924	March	1/03/1924	66.15
1924	April	1/04/1924	42.01
1924	May	1/05/1924	36.82
1924	June	1/06/1924	31.03
1924	July	1/07/1924	38.4
1924	August	1/08/1924	42.86
1924	Septembe	1/09/1924	49.33
1924	October	1/10/1924	70.8
1924	Novembeı	1/11/1924	75.26
1924	December	1/12/1924	84.17
1925	January	1/01/1925	72.16

1925 February	1/02/1925	68.06
1925 March	1/03/1925	65.34
1925 April	1/04/1925	44.88
1925 May	1/05/1925	38.14
1925 June	1/06/1925	32.56
1925 July	1/07/1925	36.62
1925 August	1/08/1925	40.95
1925 Septembe	1/09/1925	45.5
1925 October	1/10/1925	62.03
1925 November	1/11/1925	76.86
1925 December	1/12/1925	82.61
1926 January	1/01/1926	79.04
1926 February	1/02/1926	61.82
1926 March	1/03/1926	53.02
1926 April	1/04/1926	44.6
1926 May	1/05/1926	36.35
1926 June	1/06/1926	32.19
1926 July	1/07/1926	38.84
1926 August	1/08/1926	42.84
1926 Septembe	1/09/1926	48.47
1926 October	1/10/1926	65.98
1926 November	1/11/1926	53.39
1926 December	1/12/1926	82.31
1927 January	1/01/1927	80.14
1927 February	1/02/1927	67.06
1927 March	1/03/1927	59.28
1927 April	1/04/1927	43.49
1927 May	1/05/1927	35.88
1927 June	1/06/1927	29.74
1927 July	1/07/1927	19.13
1927 August	1/08/1927	23.71
1927 Septembe	1/09/1927	38.55
1927 October	1/10/1927	72.68
1927 November	1/11/1927	78.03
1927 December	1/12/1927	87.02
1928 January	1/01/1928	78
1928 February	1/02/1928	71.31
1928 March	1/03/1928	67.28
1928 April	1/04/1928	45.21
1928 May	1/05/1928	35.83
1928 June	1/06/1928	31.41
1928 July	1/07/1928	38.51
1928 August	1/08/1928	43.96
1928 Septembe	1/09/1928	38.95
1928 October	1/10/1928	67.2
1928 November	1/11/1928	66.51
1928 December	1/12/1928	66.56
1929 January	1/01/1929	61.51
1929 February	1/02/1929	65.36
1929 March	1/03/1929	66.78
1929 April	1/04/1929	43.17
1929 May	1/05/1929	36.62
1929 June	1/06/1929	30.65
1929 July	1/07/1929	35.24
1929 August	1/08/1929	41.45
1929 Septembe	1/09/1929	47.23
1929 October	1/10/1929	70.19
1929 November	1/11/1929	75.49

1929	December	1/12/1929	88.41
1930	January	1/01/1930	79.58
1930	February	1/02/1930	70.19
1930	March	1/03/1930	66.49
1930	April	1/04/1930	43.29
1930	May	1/05/1930	37.44
1930	June	1/06/1930	32.91
1930	July	1/07/1930	39.74
1930	August	1/08/1930	42.46
1930	Septembe	1/09/1930	47.38
1930	October	1/10/1930	69.02
1930	November	1/11/1930	77.53
1930	December	1/12/1930	86.58
1931	January	1/01/1931	79.33
1931	February	1/02/1931	68.31
1931	March	1/03/1931	66.64
1931	April	1/04/1931	43.5
1931	May	1/05/1931	38.18
1931	June	1/06/1931	31.98
1931	July	1/07/1931	38
1931	August	1/08/1931	37.62
1931	Septembe	1/09/1931	44.99
1931	October	1/10/1931	64.01
1931	November	1/11/1931	75.95
1931	December	1/12/1931	86.22
1932	January	1/01/1932	79.6
1932	February	1/02/1932	70
1932	March	1/03/1932	66.96
1932	April	1/04/1932	43.75
1932	May	1/05/1932	37.72
1932	June	1/06/1932	30.6
1932	July	1/07/1932	37.29
1932	August	1/08/1932	42.97
1932	Septembe	1/09/1932	48.6
1932	October	1/10/1932	68.92
1932	November	1/11/1932	78.13
1932	December	1/12/1932	82.27
1933	January	1/01/1933	79.76
1933	February	1/02/1933	63.83
1933	March	1/03/1933	46.95
1933	April	1/04/1933	43.87
1933	May	1/05/1933	37.37
1933	June	1/06/1933	31.84
1933	July	1/07/1933	39.42
1933	August	1/08/1933	39.75
1933	Septembe	1/09/1933	47.81
1933	October	1/10/1933	72.54
1933	November	1/11/1933	75.19
1933	December	1/12/1933	86.99
1934	January	1/01/1934	80.01
1934	February	1/02/1934	66.8
1934	March	1/03/1934	67.91
1934	April	1/04/1934	43.97
1934	May	1/05/1934	37.84
1934	June	1/06/1934	30.66
1934	July	1/07/1934	39.02
1934	August	1/08/1934	42.56
1934	Septembe	1/09/1934	49.31

1934	October	1/10/1934	68.4
1934	November	1/11/1934	75.91
1934	December	1/12/1934	85.54
1935	January	1/01/1935	78.7
1935	February	1/02/1935	66.86
1935	March	1/03/1935	64.99
1935	April	1/04/1935	43.34
1935	May	1/05/1935	36.06
1935	June	1/06/1935	26.09
1935	July	1/07/1935	37.82
1935	August	1/08/1935	42.35
1935	Septembe	1/09/1935	47.35
1935	October	1/10/1935	71.81
1935	November	1/11/1935	72.37
1935	December	1/12/1935	87.81
1936	January	1/01/1936	79.37
1936	February	1/02/1936	69.18
1936	March	1/03/1936	65.3
1936	April	1/04/1936	42.48
1936	May	1/05/1936	37.45
1936	June	1/06/1936	30.03
1936	July	1/07/1936	38.99
1936	August	1/08/1936	43.75
1936	Septembe	1/09/1936	46.95
1936	October	1/10/1936	62.21
1936	November	1/11/1936	45.27
1936	December	1/12/1936	86.59
1937	January	1/01/1937	79.76
1937	February	1/02/1937	67.17
1937	March	1/03/1937	65.66
1937	April	1/04/1937	42.9
1937	May	1/05/1937	36.62
1937	June	1/06/1937	30.88
1937	July	1/07/1937	36.92
1937	August	1/08/1937	43.31
1937	Septembe	1/09/1937	49.35
1937	October	1/10/1937	72.58
1937	November	1/11/1937	77.92
1937	December	1/12/1937	92.49
1938	January	1/01/1938	80.86
1938	February	1/02/1938	67.3
1938	March	1/03/1938	63
1938	April	1/04/1938	40.44
1938	May	1/05/1938	39.16
1938	June	1/06/1938	31.49
1938	July	1/07/1938	37.29
1938	August	1/08/1938	41.62
1938	Septembe	1/09/1938	48.38
1938	October	1/10/1938	69.47
1938	November	1/11/1938	80.76
1938	December	1/12/1938	77.07
1939	January	1/01/1939	79.92
1939	February	1/02/1939	72.37
1939	March	1/03/1939	67.35
1939	April	1/04/1939	45.18
1939	May	1/05/1939	39.04
1939	June	1/06/1939	32.02
1939	July	1/07/1939	36.22

1939	August	1/08/1939	42.16
1939	Septembe	1/09/1939	47.07
1939	October	1/10/1939	68.95
1939	November	1/11/1939	76.11
1939	December	1/12/1939	70.57
1940	January	1/01/1940	78.52
1940	February	1/02/1940	55.32
1940	March	1/03/1940	43.41
1940	April	1/04/1940	42.9
1940	May	1/05/1940	36.03
1940	June	1/06/1940	31.2
1940	July	1/07/1940	30.6
1940	August	1/08/1940	27.91
1940	Septembe	1/09/1940	32.25
1940	October	1/10/1940	67.16
1940	November	1/11/1940	72.59
1940	December	1/12/1940	91.58
1941	January	1/01/1941	77.51
1941	February	1/02/1941	65.87
1941	March	1/03/1941	64.62
1941	April	1/04/1941	44.96
1941	May	1/05/1941	36.81
1941	June	1/06/1941	31
1941	July	1/07/1941	38.23
1941	August	1/08/1941	30.83
1941	Septembe	1/09/1941	48.64
1941	October	1/10/1941	69.24
1941	November	1/11/1941	79.6
1941	December	1/12/1941	59.28
1942	January	1/01/1942	59.58
1942	February	1/02/1942	66.1
1942	March	1/03/1942	67.33
1942	April	1/04/1942	44.89
1942	May	1/05/1942	36.78
1942	June	1/06/1942	32.59
1942	July	1/07/1942	38.14
1942	August	1/08/1942	42.81
1942	Septembe	1/09/1942	48.13
1942	October	1/10/1942	69.19
1942	November	1/11/1942	76.23
1942	December	1/12/1942	88.56
1943	January	1/01/1943	78.57
1943	February	1/02/1943	68.71
1943	March	1/03/1943	58.57
1943	April	1/04/1943	42.94
1943	May	1/05/1943	36.99
1943	June	1/06/1943	29.99
1943	July	1/07/1943	35.98
1943	August	1/08/1943	39.22
1943	Septembe	1/09/1943	46.38
1943	October	1/10/1943	69.43
1943	November	1/11/1943	72.82
1943	December	1/12/1943	85.7
1944	January	1/01/1944	83.07
1944	February	1/02/1944	70.39
1944	March	1/03/1944	59.47
1944	April	1/04/1944	41.65
1944	May	1/05/1944	36.26

1944 June	1/06/1944	30.17
1944 July	1/07/1944	37.82
1944 August	1/08/1944	41.74
1944 Septembe	1/09/1944	48.68
1944 October	1/10/1944	72.02
1944 Novembeı	1/11/1944	53.52
1944 December	1/12/1944	67.16
1945 January	1/01/1945	70.52
1945 February	1/02/1945	66.73
1945 March	1/03/1945	65.04
1945 April	1/04/1945	43.84
1945 May	1/05/1945	36.45
1945 June	1/06/1945	33.16
1945 July	1/07/1945	36.96
1945 August	1/08/1945	42.69
1945 Septembe	1/09/1945	47.19
1945 October	1/10/1945	44.5
1945 Novembeı	1/11/1945	63.89
1945 December	1/12/1945	89.04
1946 January	1/01/1946	79.87
1946 February	1/02/1946	70.41
1946 March	1/03/1946	64.17
1946 April	1/04/1946	42.89
1946 May	1/05/1946	36.74
1946 June	1/06/1946	30.36
1946 July	1/07/1946	39.24
1946 August	1/08/1946	28.47
1946 Septembe	1/09/1946	35.57
1946 October	1/10/1946	58.6
1946 Novembeı	1/11/1946	79.99
1946 December	1/12/1946	90.59
1947 January	1/01/1947	73.98
1947 February	1/02/1947	66.61
1947 March	1/03/1947	67.14
1947 April	1/04/1947	44.04
1947 May	1/05/1947	39.18
1947 June	1/06/1947	31.78
1947 July	1/07/1947	37.72
1947 August	1/08/1947	41.23
1947 Septembe	1/09/1947	48.12
1947 October	1/10/1947	69.34
1947 Novembeı	1/11/1947	72.98
1947 December	1/12/1947	87.04
1948 January	1/01/1948	74.9
1948 February	1/02/1948	71.29
1948 March	1/03/1948	63.31
1948 April	1/04/1948	42.09
1948 May	1/05/1948	35.97
1948 June	1/06/1948	31.87
1948 July	1/07/1948	35.94
1948 August	1/08/1948	23.04
1948 Septembe	1/09/1948	48.3
1948 October	1/10/1948	70.55
1948 Novembeı	1/11/1948	73.16
1948 December	1/12/1948	69.24
1949 January	1/01/1949	76.78
1949 February	1/02/1949	67.22
1949 March	1/03/1949	66.64

1949 April	1/04/1949	42.12
1949 May	1/05/1949	36.75
1949 June	1/06/1949	30.06
1949 July	1/07/1949	37.62
1949 August	1/08/1949	41.64
1949 Septembe	1/09/1949	48.18
1949 October	1/10/1949	74.07
1949 November	1/11/1949	66.53
1949 December	1/12/1949	87.98
1950 January	1/01/1950	79.65
1950 February	1/02/1950	66.55
1950 March	1/03/1950	67.23
1950 April	1/04/1950	44.14
1950 May	1/05/1950	37.46
1950 June	1/06/1950	32.96
1950 July	1/07/1950	40.35
1950 August	1/08/1950	41.71
1950 Septembe	1/09/1950	50.28
1950 October	1/10/1950	70.27
1950 November	1/11/1950	74.31
1950 December	1/12/1950	83.37
1951 January	1/01/1951	77.85
1951 February	1/02/1951	68.45
1951 March	1/03/1951	68.96
1951 April	1/04/1951	41.98
1951 May	1/05/1951	34.74
1951 June	1/06/1951	33.1
1951 July	1/07/1951	37.41
1951 August	1/08/1951	40.18
1951 Septembe	1/09/1951	50.19
1951 October	1/10/1951	69.09
1951 November	1/11/1951	59.37
1951 December	1/12/1951	77.76
1952 January	1/01/1952	77.36
1952 February	1/02/1952	55.1
1952 March	1/03/1952	66.7
1952 April	1/04/1952	43.76
1952 May	1/05/1952	36.37
1952 June	1/06/1952	32.08
1952 July	1/07/1952	37.97
1952 August	1/08/1952	42.81
1952 Septembe	1/09/1952	48.03
1952 October	1/10/1952	70.53
1952 November	1/11/1952	73.67
1952 December	1/12/1952	79.25
1953 January	1/01/1953	77.78
1953 February	1/02/1953	65
1953 March	1/03/1953	66.85
1953 April	1/04/1953	46.01
1953 May	1/05/1953	37.35
1953 June	1/06/1953	30.75
1953 July	1/07/1953	28.25
1953 August	1/08/1953	27.41
1953 Septembe	1/09/1953	45.33
1953 October	1/10/1953	69.06
1953 November	1/11/1953	75.98
1953 December	1/12/1953	86.43
1954 January	1/01/1954	76.86

1954 February	1/02/1954	66.63
1954 March	1/03/1954	64.96
1954 April	1/04/1954	39.7
1954 May	1/05/1954	36.49
1954 June	1/06/1954	31.28
1954 July	1/07/1954	38.08
1954 August	1/08/1954	42.83
1954 Septembe	1/09/1954	46.92
1954 October	1/10/1954	71.11
1954 Novembei	1/11/1954	77.99
1954 December	1/12/1954	85.2
1955 January	1/01/1955	67.22
1955 February	1/02/1955	67.27
1955 March	1/03/1955	68.73
1955 April	1/04/1955	45.63
1955 May	1/05/1955	36.85
1955 June	1/06/1955	31.55
1955 July	1/07/1955	36.71
1955 August	1/08/1955	42.43
1955 Septembe	1/09/1955	48.3
1955 October	1/10/1955	70.92
1955 Novembei	1/11/1955	74.63
1955 December	1/12/1955	84.16
1956 January	1/01/1956	78.16
1956 February	1/02/1956	69.2
1956 March	1/03/1956	67.71
1956 April	1/04/1956	43.93
1956 May	1/05/1956	37.15
1956 June	1/06/1956	31.21
1956 July	1/07/1956	37.22
1956 August	1/08/1956	40.37
1956 Septembe	1/09/1956	45.85
1956 October	1/10/1956	67.56
1956 Novembei	1/11/1956	63.08
1956 December	1/12/1956	85.96
1957 January	1/01/1957	79.42
1957 February	1/02/1957	67.02
1957 March	1/03/1957	66.41
1957 April	1/04/1957	45.12
1957 May	1/05/1957	35.84
1957 June	1/06/1957	26.21
1957 July	1/07/1957	35.99
1957 August	1/08/1957	42.14
1957 Septembe	1/09/1957	48.38
1957 October	1/10/1957	46.22
1957 Novembei	1/11/1957	79.94
1957 December	1/12/1957	77.2
1958 January	1/01/1958	81.5
1958 February	1/02/1958	69.34
1958 March	1/03/1958	68.24
1958 April	1/04/1958	45.59
1958 May	1/05/1958	39.11
1958 June	1/06/1958	32.14
1958 July	1/07/1958	37.74
1958 August	1/08/1958	43.17
1958 Septembe	1/09/1958	46.31
1958 October	1/10/1958	69.73
1958 Novembei	1/11/1958	72.03

1958	December	1/12/1958	86.61
1959	January	1/01/1959	81.25
1959	February	1/02/1959	69.9
1959	March	1/03/1959	67.7
1959	April	1/04/1959	44.75
1959	May	1/05/1959	33.48
1959	June	1/06/1959	27.04
1959	July	1/07/1959	38.33
1959	August	1/08/1959	42.26
1959	Septembe	1/09/1959	43.13
1959	October	1/10/1959	67.42
1959	November	1/11/1959	82.79
1959	December	1/12/1959	87.36
1960	January	1/01/1960	85.42
1960	February	1/02/1960	70.33
1960	March	1/03/1960	66.24
1960	April	1/04/1960	43.6
1960	May	1/05/1960	34.93
1960	June	1/06/1960	30.07
1960	July	1/07/1960	38.52
1960	August	1/08/1960	40.97
1960	Septembe	1/09/1960	47.6
1960	October	1/10/1960	70.43
1960	November	1/11/1960	73.79
1960	December	1/12/1960	86.36
1961	January	1/01/1961	79.93
1961	February	1/02/1961	68.23
1961	March	1/03/1961	66.55
1961	April	1/04/1961	44.42
1961	May	1/05/1961	35.99
1961	June	1/06/1961	31.45
1961	July	1/07/1961	37.3
1961	August	1/08/1961	40.84
1961	Septembe	1/09/1961	47.75
1961	October	1/10/1961	74.51
1961	November	1/11/1961	78.32
1961	December	1/12/1961	88.7
1962	January	1/01/1962	77.84
1962	February	1/02/1962	68.11
1962	March	1/03/1962	66.21
1962	April	1/04/1962	43.35
1962	May	1/05/1962	35.57
1962	June	1/06/1962	32.91
1962	July	1/07/1962	33.43
1962	August	1/08/1962	41.36
1962	Septembe	1/09/1962	47.61
1962	October	1/10/1962	67.62
1962	November	1/11/1962	76.06
1962	December	1/12/1962	79.14
1963	January	1/01/1963	78.93
1963	February	1/02/1963	68.04
1963	March	1/03/1963	65.55
1963	April	1/04/1963	44.09
1963	May	1/05/1963	38.37
1963	June	1/06/1963	31.45
1963	July	1/07/1963	36.74
1963	August	1/08/1963	41.59
1963	Septembe	1/09/1963	47.81

1963 October	1/10/1963	71.13
1963 November	1/11/1963	73.75
1963 December	1/12/1963	88.3
1964 January	1/01/1964	80.66
1964 February	1/02/1964	69.13
1964 March	1/03/1964	66.06
1964 April	1/04/1964	44.05
1964 May	1/05/1964	36.12
1964 June	1/06/1964	31.6
1964 July	1/07/1964	37.64
1964 August	1/08/1964	40.5
1964 Septembe	1/09/1964	48.39
1964 October	1/10/1964	66.03
1964 November	1/11/1964	77.96
1964 December	1/12/1964	81.96
1965 January	1/01/1965	58.55
1965 February	1/02/1965	50.37
1965 March	1/03/1965	53.86
1965 April	1/04/1965	37.52
1965 May	1/05/1965	36.6
1965 June	1/06/1965	25.12
1965 July	1/07/1965	36.26
1965 August	1/08/1965	42.35
1965 Septembe	1/09/1965	50.99
1965 October	1/10/1965	69.53
1965 November	1/11/1965	75.04
1965 December	1/12/1965	88.28
1966 January	1/01/1966	77.01
1966 February	1/02/1966	67.19
1966 March	1/03/1966	65.58
1966 April	1/04/1966	43.82
1966 May	1/05/1966	35.42
1966 June	1/06/1966	31.19
1966 July	1/07/1966	33.6
1966 August	1/08/1966	32.98
1966 Septembe	1/09/1966	46.54
1966 October	1/10/1966	67.81
1966 November	1/11/1966	75.47
1966 December	1/12/1966	85.57
1967 January	1/01/1967	79.82
1967 February	1/02/1967	66.71
1967 March	1/03/1967	62.15
1967 April	1/04/1967	43.7
1967 May	1/05/1967	36.47
1967 June	1/06/1967	33.16
1967 July	1/07/1967	37.07
1967 August	1/08/1967	39.82
1967 Septembe	1/09/1967	46.66
1967 October	1/10/1967	70.92
1967 November	1/11/1967	71.14
1967 December	1/12/1967	65.06
1968 January	1/01/1968	78.44
1968 February	1/02/1968	69.25
1968 March	1/03/1968	63.27
1968 April	1/04/1968	45.06
1968 May	1/05/1968	35.08
1968 June	1/06/1968	29.92
1968 July	1/07/1968	31.05

1968 August	1/08/1968	34.39
1968 Septembe	1/09/1968	46.28
1968 October	1/10/1968	68.76
1968 Novembei	1/11/1968	59.25
1968 December	1/12/1968	79.63
1969 January	1/01/1969	73.61
1969 February	1/02/1969	63.51
1969 March	1/03/1969	66.83
1969 April	1/04/1969	44.02
1969 May	1/05/1969	36.42
1969 June	1/06/1969	31.13
1969 July	1/07/1969	38.49
1969 August	1/08/1969	43.63
1969 Septembe	1/09/1969	44.37
1969 October	1/10/1969	68.59
1969 Novembei	1/11/1969	74.08
1969 December	1/12/1969	87.19
1970 January	1/01/1970	80.79
1970 February	1/02/1970	74.04
1970 March	1/03/1970	66.14
1970 April	1/04/1970	45.12
1970 May	1/05/1970	35.11
1970 June	1/06/1970	31.99
1970 July	1/07/1970	31.09
1970 August	1/08/1970	38.59
1970 Septembe	1/09/1970	44.14
1970 October	1/10/1970	73.43
1970 Novembei	1/11/1970	73.01
1970 December	1/12/1970	88.59
1971 January	1/01/1971	80.53
1971 February	1/02/1971	68.02
1971 March	1/03/1971	70.24
1971 April	1/04/1971	45.46
1971 May	1/05/1971	37.02
1971 June	1/06/1971	31.13
1971 July	1/07/1971	34.4
1971 August	1/08/1971	41.96
1971 Septembe	1/09/1971	49.77
1971 October	1/10/1971	76.48
1971 Novembei	1/11/1971	74.13
1971 December	1/12/1971	84.12
1972 January	1/01/1972	73.94
1972 February	1/02/1972	69.27
1972 March	1/03/1972	66.22
1972 April	1/04/1972	43.83
1972 May	1/05/1972	37.06
1972 June	1/06/1972	31.5
1972 July	1/07/1972	37.78
1972 August	1/08/1972	40.32
1972 Septembe	1/09/1972	53.98
1972 October	1/10/1972	70.33
1972 Novembei	1/11/1972	77.69
1972 December	1/12/1972	100.82
1973 January	1/01/1973	85.81
1973 February	1/02/1973	61.98
1973 March	1/03/1973	68.15
1973 April	1/04/1973	44.92
1973 May	1/05/1973	38.17

1973 June	1/06/1973	30.89
1973 July	1/07/1973	39.74
1973 August	1/08/1973	41.26
1973 Septembe	1/09/1973	48.17
1973 October	1/10/1973	66.96
1973 Novembei	1/11/1973	71.18
1973 December	1/12/1973	82.9
1974 January	1/01/1974	72.15
1974 February	1/02/1974	60.51
1974 March	1/03/1974	63.84
1974 April	1/04/1974	42.47
1974 May	1/05/1974	36.9
1974 June	1/06/1974	31.11
1974 July	1/07/1974	37.41
1974 August	1/08/1974	39.81
1974 Septembe	1/09/1974	43.79
1974 October	1/10/1974	64.91
1974 Novembei	1/11/1974	70.71
1974 December	1/12/1974	79.06
1975 January	1/01/1975	78.97
1975 February	1/02/1975	66.69
1975 March	1/03/1975	62.85
1975 April	1/04/1975	41.01
1975 May	1/05/1975	37.2
1975 June	1/06/1975	30.78
1975 July	1/07/1975	39.16
1975 August	1/08/1975	41.02
1975 Septembe	1/09/1975	46.86
1975 October	1/10/1975	64.43
1975 Novembei	1/11/1975	79.77
1975 December	1/12/1975	73.25
1976 January	1/01/1976	73.1
1976 February	1/02/1976	65.14
1976 March	1/03/1976	63.54
1976 April	1/04/1976	41.93
1976 May	1/05/1976	36.57
1976 June	1/06/1976	23.16
1976 July	1/07/1976	38.46
1976 August	1/08/1976	40.99
1976 Septembe	1/09/1976	44.01
1976 October	1/10/1976	61.03
1976 Novembei	1/11/1976	74.36
1976 December	1/12/1976	99.07
1977 January	1/01/1977	85.94
1977 February	1/02/1977	71.02
1977 March	1/03/1977	66.34
1977 April	1/04/1977	45.38
1977 May	1/05/1977	36.64
1977 June	1/06/1977	30.76
1977 July	1/07/1977	36.47
1977 August	1/08/1977	42
1977 Septembe	1/09/1977	45.27
1977 October	1/10/1977	69.19
1977 Novembei	1/11/1977	57.53
1977 December	1/12/1977	90.13
1978 January	1/01/1978	77.41
1978 February	1/02/1978	73.77
1978 March	1/03/1978	67.99

1978 April	1/04/1978	43.74
1978 May	1/05/1978	37.72
1978 June	1/06/1978	31
1978 July	1/07/1978	36.9
1978 August	1/08/1978	40.14
1978 Septembe	1/09/1978	45.32
1978 October	1/10/1978	67.92
1978 Novembei	1/11/1978	74.23
1978 December	1/12/1978	82.45
1979 January	1/01/1979	93.62
1979 February	1/02/1979	78.23
1979 March	1/03/1979	66.73
1979 April	1/04/1979	44.78
1979 May	1/05/1979	36.27
1979 June	1/06/1979	32.76
1979 July	1/07/1979	37.67
1979 August	1/08/1979	39.21
1979 Septembe	1/09/1979	44.39
1979 October	1/10/1979	71.43
1979 Novembei	1/11/1979	82.47
1979 December	1/12/1979	109.36
1980 January	1/01/1980	82.44
1980 February	1/02/1980	76.2
1980 March	1/03/1980	75.82
1980 April	1/04/1980	47.45
1980 May	1/05/1980	38.39
1980 June	1/06/1980	32.16
1980 July	1/07/1980	38.1
1980 August	1/08/1980	44.85
1980 Septembe	1/09/1980	56.87
1980 October	1/10/1980	67.89
1980 Novembei	1/11/1980	90.3
1980 December	1/12/1980	94.17
1981 January	1/01/1981	90.9
1981 February	1/02/1981	70.1
1981 March	1/03/1981	70.23
1981 April	1/04/1981	48.78
1981 May	1/05/1981	37.88
1981 June	1/06/1981	30.99
1981 July	1/07/1981	37.61
1981 August	1/08/1981	40.76
1981 Septembe	1/09/1981	53.38
1981 October	1/10/1981	73.84
1981 Novembei	1/11/1981	71.51
1981 December	1/12/1981	92.5
1982 January	1/01/1982	84.51
1982 February	1/02/1982	74.58
1982 March	1/03/1982	63.23
1982 April	1/04/1982	45.15
1982 May	1/05/1982	37.39
1982 June	1/06/1982	30.47
1982 July	1/07/1982	27.14
1982 August	1/08/1982	18.47
1982 Septembe	1/09/1982	40.76
1982 October	1/10/1982	73.06
1982 Novembei	1/11/1982	80.79
1982 December	1/12/1982	76.27
1983 January	1/01/1983	90.36

1983 February	1/02/1983	79.5
1983 March	1/03/1983	77.71
1983 April	1/04/1983	42.78
1983 May	1/05/1983	38.58
1983 June	1/06/1983	31.12
1983 July	1/07/1983	37.33
1983 August	1/08/1983	35.96
1983 Septembe	1/09/1983	50.81
1983 October	1/10/1983	69.09
1983 November	1/11/1983	74.07
1983 December	1/12/1983	85.28
1984 January	1/01/1984	74.28
1984 February	1/02/1984	70.87
1984 March	1/03/1984	63.51
1984 April	1/04/1984	42.67
1984 May	1/05/1984	36.45
1984 June	1/06/1984	32.62
1984 July	1/07/1984	37.04
1984 August	1/08/1984	42.5
1984 Septembe	1/09/1984	44.6
1984 October	1/10/1984	68.61
1984 November	1/11/1984	79.18
1984 December	1/12/1984	91.17
1985 January	1/01/1985	91.44
1985 February	1/02/1985	68.16
1985 March	1/03/1985	70.38
1985 April	1/04/1985	43.56
1985 May	1/05/1985	37.77
1985 June	1/06/1985	30.86
1985 July	1/07/1985	37.48
1985 August	1/08/1985	41.28
1985 Septembe	1/09/1985	46.18
1985 October	1/10/1985	67.48
1985 November	1/11/1985	73.34
1985 December	1/12/1985	88.2
1986 January	1/01/1986	80.02
1986 February	1/02/1986	70.51
1986 March	1/03/1986	65.23
1986 April	1/04/1986	48.83
1986 May	1/05/1986	38.12
1986 June	1/06/1986	30.93
1986 July	1/07/1986	38.11
1986 August	1/08/1986	41.64
1986 Septembe	1/09/1986	48.45
1986 October	1/10/1986	65.88
1986 November	1/11/1986	72.07
1986 December	1/12/1986	89.02
1987 January	1/01/1987	86.27
1987 February	1/02/1987	68.91
1987 March	1/03/1987	62.61
1987 April	1/04/1987	44.6
1987 May	1/05/1987	37.18
1987 June	1/06/1987	32.38
1987 July	1/07/1987	37.45
1987 August	1/08/1987	43.19
1987 Septembe	1/09/1987	50.19
1987 October	1/10/1987	66.7
1987 November	1/11/1987	76.91

1987 December	1/12/1987	86.22
1988 January	1/01/1988	83.27
1988 February	1/02/1988	68.06
1988 March	1/03/1988	64.68
1988 April	1/04/1988	41.75
1988 May	1/05/1988	37.94
1988 June	1/06/1988	32.43
1988 July	1/07/1988	40.56
1988 August	1/08/1988	35.9
1988 Septembe	1/09/1988	49.56
1988 October	1/10/1988	78.52
1988 November	1/11/1988	64.56
1988 December	1/12/1988	86.65
1989 January	1/01/1989	72.54
1989 February	1/02/1989	67.44
1989 March	1/03/1989	65.89
1989 April	1/04/1989	43.55
1989 May	1/05/1989	39.07
1989 June	1/06/1989	31.76
1989 July	1/07/1989	36.78
1989 August	1/08/1989	39.08
1989 Septembe	1/09/1989	48.52
1989 October	1/10/1989	72.33
1989 November	1/11/1989	74.77
1989 December	1/12/1989	88.62
1990 January	1/01/1990	80.88
1990 February	1/02/1990	62.89
1990 March	1/03/1990	65.86
1990 April	1/04/1990	42.72
1990 May	1/05/1990	38.58
1990 June	1/06/1990	30.93
1990 July	1/07/1990	38.31
1990 August	1/08/1990	39.67
1990 Septembe	1/09/1990	45.82
1990 October	1/10/1990	69.51
1990 November	1/11/1990	69.65
1990 December	1/12/1990	105.25
1991 January	1/01/1991	89.73
1991 February	1/02/1991	80.79
1991 March	1/03/1991	72.99
1991 April	1/04/1991	42.34
1991 May	1/05/1991	38.22
1991 June	1/06/1991	35.14
1991 July	1/07/1991	38.27
1991 August	1/08/1991	41.85
1991 Septembe	1/09/1991	49.46
1991 October	1/10/1991	69.64
1991 November	1/11/1991	67.76
1991 December	1/12/1991	77.15
1992 January	1/01/1992	78.53
1992 February	1/02/1992	64.36
1992 March	1/03/1992	66.02
1992 April	1/04/1992	42.6
1992 May	1/05/1992	36.69
1992 June	1/06/1992	31.04
1992 July	1/07/1992	39.34
1992 August	1/08/1992	41.53
1992 Septembe	1/09/1992	46.13

1992	October	1/10/1992	68.14
1992	November	1/11/1992	71.11
1992	December	1/12/1992	78.98
1993	January	1/01/1993	81.86
1993	February	1/02/1993	69.47
1993	March	1/03/1993	63.05
1993	April	1/04/1993	45.9
1993	May	1/05/1993	37.06
1993	June	1/06/1993	31.11
1993	July	1/07/1993	39.72
1993	August	1/08/1993	43.58
1993	Septembe	1/09/1993	47.35
1993	October	1/10/1993	69.18
1993	November	1/11/1993	76.47
1993	December	1/12/1993	85.94
1994	January	1/01/1994	90.55
1994	February	1/02/1994	70.87
1994	March	1/03/1994	62.62
1994	April	1/04/1994	44.96
1994	May	1/05/1994	38.05
1994	June	1/06/1994	29.43
1994	July	1/07/1994	38.59
1994	August	1/08/1994	26.64
1994	Septembe	1/09/1994	40.79
1994	October	1/10/1994	61.37
1994	November	1/11/1994	80.53
1994	December	1/12/1994	94.12
1995	January	1/01/1995	73.45
1995	February	1/02/1995	67.12
1995	March	1/03/1995	66.47
1995	April	1/04/1995	42.81
1995	May	1/05/1995	38.31
1995	June	1/06/1995	32.01
1995	July	1/07/1995	37.21
1995	August	1/08/1995	36.9
1995	Septembe	1/09/1995	43.18
1995	October	1/10/1995	67.34
1995	November	1/11/1995	58.21
1995	December	1/12/1995	83.82
1996	January	1/01/1996	76.58
1996	February	1/02/1996	67.56
1996	March	1/03/1996	65.9
1996	April	1/04/1996	42.28
1996	May	1/05/1996	39.14
1996	June	1/06/1996	32.95
1996	July	1/07/1996	38.4
1996	August	1/08/1996	42.52
1996	Septembe	1/09/1996	51.23
1996	October	1/10/1996	70.99
1996	November	1/11/1996	75.29
1996	December	1/12/1996	88.55
1997	January	1/01/1997	74.96
1997	February	1/02/1997	71.19
1997	March	1/03/1997	68.8
1997	April	1/04/1997	33.43
1997	May	1/05/1997	35.52
1997	June	1/06/1997	32.28
1997	July	1/07/1997	38.16

1997 August	1/08/1997	41.94
1997 Septembe	1/09/1997	47.8
1997 October	1/10/1997	72.51
1997 November	1/11/1997	72.01
1997 December	1/12/1997	88.54
1998 January	1/01/1998	82.53
1998 February	1/02/1998	77.33
1998 March	1/03/1998	77.36
1998 April	1/04/1998	40.26
1998 May	1/05/1998	37.81
1998 June	1/06/1998	32.18
1998 July	1/07/1998	38
1998 August	1/08/1998	43.05
1998 Septembe	1/09/1998	49.92
1998 October	1/10/1998	68.39
1998 November	1/11/1998	69.47
1998 December	1/12/1998	89.87
1999 January	1/01/1999	84.05
1999 February	1/02/1999	66.07
1999 March	1/03/1999	67.75
1999 April	1/04/1999	41.82
1999 May	1/05/1999	37.69
1999 June	1/06/1999	28.2
1999 July	1/07/1999	39.38
1999 August	1/08/1999	43.53
1999 Septembe	1/09/1999	50.08
1999 October	1/10/1999	69.78
1999 November	1/11/1999	67.7
1999 December	1/12/1999	80.89
2000 January	1/01/2000	74.19
2000 February	1/02/2000	74.96
2000 March	1/03/2000	65.52
2000 April	1/04/2000	42.2
2000 May	1/05/2000	36.45
2000 June	1/06/2000	31.1
2000 July	1/07/2000	39.21
2000 August	1/08/2000	41.84
2000 Septembe	1/09/2000	53.15
2000 October	1/10/2000	68.11
2000 November	1/11/2000	73.5
2000 December	1/12/2000	94.37
2001 January	1/01/2001	89.51
2001 February	1/02/2001	70.53
2001 March	1/03/2001	64.68
2001 April	1/04/2001	45.79
2001 May	1/05/2001	36.85
2001 June	1/06/2001	29.39
2001 July	1/07/2001	29.9
2001 August	1/08/2001	42.24
2001 Septembe	1/09/2001	51.12
2001 October	1/10/2001	70.42
2001 November	1/11/2001	73.83
2001 December	1/12/2001	90.27
2002 January	1/01/2002	79.47
2002 February	1/02/2002	63.17
2002 March	1/03/2002	68.52
2002 April	1/04/2002	47.2
2002 May	1/05/2002	37.54

2002 June	1/06/2002	32.42
2002 July	1/07/2002	38.54
2002 August	1/08/2002	24.25
2002 Septembe	1/09/2002	45.88
2002 October	1/10/2002	54.36
2002 November	1/11/2002	67.41
2002 December	1/12/2002	93.22
2003 January	1/01/2003	85.78
2003 February	1/02/2003	67.29
2003 March	1/03/2003	64.67
2003 April	1/04/2003	42.8
2003 May	1/05/2003	38.45
2003 June	1/06/2003	33.78
2003 July	1/07/2003	38.73
2003 August	1/08/2003	42.73
2003 Septembe	1/09/2003	51.63
2003 October	1/10/2003	65.89
2003 November	1/11/2003	75.75
2003 December	1/12/2003	90.82
2004 January	1/01/2004	80.3
2004 February	1/02/2004	82.05
2004 March	1/03/2004	68.57
2004 April	1/04/2004	47.87
2004 May	1/05/2004	25.6
2004 June	1/06/2004	32
2004 July	1/07/2004	30.49
2004 August	1/08/2004	41.28
2004 Septembe	1/09/2004	49.84
2004 October	1/10/2004	73.19
2004 November	1/11/2004	79.04
2004 December	1/12/2004	89.83
2005 January	1/01/2005	85.77
2005 February	1/02/2005	70.48
2005 March	1/03/2005	65.61
2005 April	1/04/2005	48.89
2005 May	1/05/2005	38.89
2005 June	1/06/2005	33.27
2005 July	1/07/2005	39.78
2005 August	1/08/2005	30.69
2005 Septembe	1/09/2005	43.45
2005 October	1/10/2005	71.49
2005 November	1/11/2005	74.82
2005 December	1/12/2005	98.69
2006 January	1/01/2006	79.87
2006 February	1/02/2006	71.69
2006 March	1/03/2006	51.6
2006 April	1/04/2006	36.45
2006 May	1/05/2006	22.92
2006 June	1/06/2006	30.3
2006 July	1/07/2006	38.98
2006 August	1/08/2006	43.54
2006 Septembe	1/09/2006	53.69
2006 October	1/10/2006	59.52
2006 November	1/11/2006	71.96
2006 December	1/12/2006	73.32
2007 January	1/01/2007	88.23
2007 February	1/02/2007	67.61
2007 March	1/03/2007	66.55

2007	April	1/04/2007	44.85
2007	May	1/05/2007	39.88
2007	June	1/06/2007	30.36
2007	July	1/07/2007	36.93
2007	August	1/08/2007	37.06
2007	Septembe	1/09/2007	50
2007	October	1/10/2007	62.46
2007	November	1/11/2007	75.2
2007	December	1/12/2007	80.01
2008	January	1/01/2008	76.64
2008	February	1/02/2008	61.82
2008	March	1/03/2008	67.32
2008	April	1/04/2008	40.64
2008	May	1/05/2008	37.73
2008	June	1/06/2008	33.67
2008	July	1/07/2008	38.12
2008	August	1/08/2008	39.38
2008	Septembe	1/09/2008	51.1
2008	October	1/10/2008	74.25
2008	November	1/11/2008	69.28
2008	December	1/12/2008	85.97
2009	January	1/01/2009	87.65
2009	February	1/02/2009	71.28
2009	March	1/03/2009	68.77
2009	April	1/04/2009	43.49
2009	May	1/05/2009	37.63
2009	June	1/06/2009	32.46
2009	July	1/07/2009	38.94
2009	August	1/08/2009	46.08
2009	Septembe	1/09/2009	51.48
2009	October	1/10/2009	66.69
2009	November	1/11/2009	91.2
2009	December	1/12/2009	93.46
2010	January	1/01/2010	85.84
2010	February	1/02/2010	66.47
2010	March	1/03/2010	65.72
2010	April	1/04/2010	45
2010	May	1/05/2010	36.8
2010	June	1/06/2010	31.58
2010	July	1/07/2010	38.59
2010	August	1/08/2010	40.82
2010	Septembe	1/09/2010	48.08
2010	October	1/10/2010	66.17
2010	November	1/11/2010	72.77
2010	December	1/12/2010	81.25
2011	January	1/01/2011	81.1
2011	February	1/02/2011	69.13
2011	March	1/03/2011	63.22
2011	April	1/04/2011	42.4
2011	May	1/05/2011	35.63
2011	June	1/06/2011	31.47
2011	July	1/07/2011	37.72
2011	August	1/08/2011	43.97
2011	Septembe	1/09/2011	50.56
2011	October	1/10/2011	66.48
2011	November	1/11/2011	75.48
2011	December	1/12/2011	73.21
2012	January	1/01/2012	72.99

2012 February	1/02/2012	62.35
2012 March	1/03/2012	62.12
2012 April	1/04/2012	43.82
2012 May	1/05/2012	36.65
2012 June	1/06/2012	31.76
2012 July	1/07/2012	38.73
2012 August	1/08/2012	42.58
2012 Septembe	1/09/2012	47.26
2012 October	1/10/2012	67.9
2012 November	1/11/2012	60.8
2012 December	1/12/2012	80.73
2013 January	1/01/2013	90.8
2013 February	1/02/2013	65.52
2013 March	1/03/2013	62.35
2013 April	1/04/2013	40.31
2013 May	1/05/2013	37.88
2013 June	1/06/2013	32.71
2013 July	1/07/2013	40.66
2013 August	1/08/2013	39.05
2013 Septembe	1/09/2013	41.07
2013 October	1/10/2013	59.21
2013 November	1/11/2013	73.36
2013 December	1/12/2013	85.73
2014 January	1/01/2014	87.86
2014 February	1/02/2014	64.62
2014 March	1/03/2014	64.59
2014 April	1/04/2014	43.83
2014 May	1/05/2014	30.58
2014 June	1/06/2014	30.53
2014 July	1/07/2014	28.87
2014 August	1/08/2014	34.86
2014 Septembe	1/09/2014	49.75
2014 October	1/10/2014	77.69
2014 November	1/11/2014	76.97
2014 December	1/12/2014	90.17
2015 January	1/01/2015	78.95
2015 February	1/02/2015	68.34
2015 March	1/03/2015	70.31
2015 April	1/04/2015	42.29
2015 May	1/05/2015	37.5
2015 June	1/06/2015	32.6
2015 July	1/07/2015	37.22
2015 August	1/08/2015	40.65
2015 Septembe	1/09/2015	48.95
2015 October	1/10/2015	72.44
2015 November	1/11/2015	81.66
2015 December	1/12/2015	83.1
2016 January	1/01/2016	76.34
2016 February	1/02/2016	75.86
2016 March	1/03/2016	72.31
2016 April	1/04/2016	39.74
2016 May	1/05/2016	27.29
2016 June	1/06/2016	29.36
2016 July	1/07/2016	39.98
2016 August	1/08/2016	42.1
2016 Septembe	1/09/2016	46.49
2016 October	1/10/2016	68.55
2016 November	1/11/2016	82.86

2016	December	1/12/2016	95.36
2017	January	1/01/2017	92.71
2017	February	1/02/2017	79.88
2017	March	1/03/2017	67.35
2017	April	1/04/2017	42.4
2017	May	1/05/2017	32.35
2017	June	1/06/2017	32.59
2017	July	1/07/2017	25.09
2017	August	1/08/2017	39.63
2017	Septembe	1/09/2017	31.09
2017	October	1/10/2017	60.65
2017	November	1/11/2017	75.93
2017	December	1/12/2017	93.31
2018	January	1/01/2018	89.6
2018	February	1/02/2018	73.06
2018	March	1/03/2018	71.57
2018	April	1/04/2018	51.09
2018	May	1/05/2018	27.07
2018	June	1/06/2018	30.41
2018	July	1/07/2018	33.14
2018	August	1/08/2018	36.32
2018	Septembe	1/09/2018	49.43
2018	October	1/10/2018	71.54
2018	November	1/11/2018	77.39
2018	December	1/12/2018	96.82
2019	January	1/01/2019	96.74
2019	February	1/02/2019	72.59
2019	March	1/03/2019	70.59
2019	April	1/04/2019	46.87
2019	May	1/05/2019	37.77
2019	June	1/06/2019	31.82
2019	July	1/07/2019	40.13
2019	August	1/08/2019	32.69
2019	Septembe	1/09/2019	52.33
2019	October	1/10/2019	78.72
2019	November	1/11/2019	76.01
2019	December	1/12/2019	71.67
2020	January	1/01/2020	85.22
2020	February	1/02/2020	70.71
2020	March	1/03/2020	64.16
2020	April	1/04/2020	44.02
2020	May	1/05/2020	35.9
2020	June	1/06/2020	32.52
2020	July	1/07/2020	39.69
2020	August	1/08/2020	41.14
2020	Septembe	1/09/2020	50.62
2020	October	1/10/2020	64.78
2020	November	1/11/2020	82.27
2020	December	1/12/2020	82.38

Rainfall scenario with irrigation - 40% rain

Assumptions:
Bare ground
Sandy clay
No initial moisture content set
100% runoff available

Year	Month	Date form	Evapotranspiration
1921	January	1/01/1921	79.87
1921	February	1/02/1921	68.38
1921	March	1/03/1921	65.49
1921	April	1/04/1921	44.6
1921	May	1/05/1921	38.89
1921	June	1/06/1921	32.25
1921	July	1/07/1921	39.76
1921	August	1/08/1921	40.31
1921	Septembe	1/09/1921	49.93
1921	October	1/10/1921	68.18
1921	November	1/11/1921	79.75
1921	December	1/12/1921	88.21
1922	January	1/01/1922	78.07
1922	February	1/02/1922	68.54
1922	March	1/03/1922	66.39
1922	April	1/04/1922	47.14
1922	May	1/05/1922	37.59
1922	June	1/06/1922	31.63
1922	July	1/07/1922	37.8
1922	August	1/08/1922	41.12
1922	Septembe	1/09/1922	48.23
1922	October	1/10/1922	72.26
1922	November	1/11/1922	79.37
1922	December	1/12/1922	90.44
1923	January	1/01/1923	79.79
1923	February	1/02/1923	70.48
1923	March	1/03/1923	68.81
1923	April	1/04/1923	45.33
1923	May	1/05/1923	39.13
1923	June	1/06/1923	32.65
1923	July	1/07/1923	38.28
1923	August	1/08/1923	41.47
1923	Septembe	1/09/1923	47.78
1923	October	1/10/1923	70.02
1923	November	1/11/1923	72.94
1923	December	1/12/1923	92.47
1924	January	1/01/1924	79.02
1924	February	1/02/1924	69.37
1924	March	1/03/1924	66.17
1924	April	1/04/1924	42.02
1924	May	1/05/1924	36.82
1924	June	1/06/1924	31.03
1924	July	1/07/1924	38.37
1924	August	1/08/1924	42.86
1924	Septembe	1/09/1924	49.33
1924	October	1/10/1924	70.8
1924	November	1/11/1924	75.27
1924	December	1/12/1924	84.17
1925	January	1/01/1925	77.73

1925	February	1/02/1925	68.07
1925	March	1/03/1925	65.34
1925	April	1/04/1925	44.88
1925	May	1/05/1925	38.14
1925	June	1/06/1925	32.51
1925	July	1/07/1925	36.62
1925	August	1/08/1925	40.96
1925	Septembe	1/09/1925	45.5
1925	October	1/10/1925	70.22
1925	November	1/11/1925	77.14
1925	December	1/12/1925	89.57
1926	January	1/01/1926	79.04
1926	February	1/02/1926	73.03
1926	March	1/03/1926	67.66
1926	April	1/04/1926	44.6
1926	May	1/05/1926	36.35
1926	June	1/06/1926	32.19
1926	July	1/07/1926	38.84
1926	August	1/08/1926	42.84
1926	Septembe	1/09/1926	48.47
1926	October	1/10/1926	71.12
1926	November	1/11/1926	70.24
1926	December	1/12/1926	84.37
1927	January	1/01/1927	80.15
1927	February	1/02/1927	67.06
1927	March	1/03/1927	66.19
1927	April	1/04/1927	43.49
1927	May	1/05/1927	35.88
1927	June	1/06/1927	30.08
1927	July	1/07/1927	29.52
1927	August	1/08/1927	24.75
1927	Septembe	1/09/1927	44.9
1927	October	1/10/1927	72.71
1927	November	1/11/1927	78.06
1927	December	1/12/1927	87.02
1928	January	1/01/1928	78
1928	February	1/02/1928	71.31
1928	March	1/03/1928	67.29
1928	April	1/04/1928	45.21
1928	May	1/05/1928	35.83
1928	June	1/06/1928	31.41
1928	July	1/07/1928	38.51
1928	August	1/08/1928	44.07
1928	Septembe	1/09/1928	51.07
1928	October	1/10/1928	70.8
1928	November	1/11/1928	78.55
1928	December	1/12/1928	88.84
1929	January	1/01/1929	80.07
1929	February	1/02/1929	66.88
1929	March	1/03/1929	66.8
1929	April	1/04/1929	43.18
1929	May	1/05/1929	36.63
1929	June	1/06/1929	30.65
1929	July	1/07/1929	35.39
1929	August	1/08/1929	41.45
1929	Septembe	1/09/1929	47.23
1929	October	1/10/1929	70.2
1929	November	1/11/1929	75.5

1929	December	1/12/1929	88.42
1930	January	1/01/1930	79.59
1930	February	1/02/1930	70.19
1930	March	1/03/1930	66.5
1930	April	1/04/1930	43.3
1930	May	1/05/1930	37.44
1930	June	1/06/1930	32.91
1930	July	1/07/1930	39.74
1930	August	1/08/1930	42.46
1930	Septembe	1/09/1930	47.38
1930	October	1/10/1930	72.61
1930	November	1/11/1930	77.54
1930	December	1/12/1930	87.87
1931	January	1/01/1931	79.33
1931	February	1/02/1931	68.31
1931	March	1/03/1931	66.64
1931	April	1/04/1931	43.5
1931	May	1/05/1931	38.18
1931	June	1/06/1931	31.98
1931	July	1/07/1931	38
1931	August	1/08/1931	41.61
1931	Septembe	1/09/1931	46.64
1931	October	1/10/1931	69.24
1931	November	1/11/1931	75.99
1931	December	1/12/1931	87.21
1932	January	1/01/1932	84.56
1932	February	1/02/1932	70.35
1932	March	1/03/1932	66.96
1932	April	1/04/1932	43.75
1932	May	1/05/1932	37.72
1932	June	1/06/1932	30.6
1932	July	1/07/1932	37.29
1932	August	1/08/1932	42.97
1932	Septembe	1/09/1932	48.6
1932	October	1/10/1932	68.92
1932	November	1/11/1932	78.13
1932	December	1/12/1932	87.72
1933	January	1/01/1933	79.76
1933	February	1/02/1933	66.93
1933	March	1/03/1933	68.64
1933	April	1/04/1933	43.87
1933	May	1/05/1933	37.39
1933	June	1/06/1933	31.84
1933	July	1/07/1933	39.42
1933	August	1/08/1933	39.75
1933	Septembe	1/09/1933	47.85
1933	October	1/10/1933	72.54
1933	November	1/11/1933	75.19
1933	December	1/12/1933	86.99
1934	January	1/01/1934	80.01
1934	February	1/02/1934	66.8
1934	March	1/03/1934	67.91
1934	April	1/04/1934	43.97
1934	May	1/05/1934	37.84
1934	June	1/06/1934	30.66
1934	July	1/07/1934	39.02
1934	August	1/08/1934	42.56
1934	Septembe	1/09/1934	49.31

1934	October	1/10/1934	68.4
1934	Novembei	1/11/1934	75.91
1934	December	1/12/1934	85.54
1935	January	1/01/1935	78.7
1935	February	1/02/1935	66.86
1935	March	1/03/1935	64.99
1935	April	1/04/1935	43.34
1935	May	1/05/1935	36.06
1935	June	1/06/1935	30.03
1935	July	1/07/1935	37.82
1935	August	1/08/1935	42.94
1935	Septembe	1/09/1935	47.35
1935	October	1/10/1935	71.81
1935	Novembei	1/11/1935	77.14
1935	December	1/12/1935	87.81
1936	January	1/01/1936	79.37
1936	February	1/02/1936	69.18
1936	March	1/03/1936	65.3
1936	April	1/04/1936	42.48
1936	May	1/05/1936	37.52
1936	June	1/06/1936	30.03
1936	July	1/07/1936	38.99
1936	August	1/08/1936	43.73
1936	Septembe	1/09/1936	46.95
1936	October	1/10/1936	72.38
1936	Novembei	1/11/1936	64.7
1936	December	1/12/1936	86.96
1937	January	1/01/1937	79.76
1937	February	1/02/1937	67.17
1937	March	1/03/1937	65.66
1937	April	1/04/1937	42.9
1937	May	1/05/1937	36.62
1937	June	1/06/1937	30.88
1937	July	1/07/1937	36.92
1937	August	1/08/1937	43.31
1937	Septembe	1/09/1937	49.35
1937	October	1/10/1937	72.58
1937	Novembei	1/11/1937	77.92
1937	December	1/12/1937	92.49
1938	January	1/01/1938	80.86
1938	February	1/02/1938	67.3
1938	March	1/03/1938	69.49
1938	April	1/04/1938	45.99
1938	May	1/05/1938	39.16
1938	June	1/06/1938	31.49
1938	July	1/07/1938	37.29
1938	August	1/08/1938	41.62
1938	Septembe	1/09/1938	48.38
1938	October	1/10/1938	74.25
1938	Novembei	1/11/1938	80.76
1938	December	1/12/1938	91.8
1939	January	1/01/1939	85.4
1939	February	1/02/1939	72.38
1939	March	1/03/1939	67.36
1939	April	1/04/1939	45.18
1939	May	1/05/1939	39.04
1939	June	1/06/1939	32.02
1939	July	1/07/1939	36.14

1939	August	1/08/1939	42.16
1939	Septembe	1/09/1939	47.09
1939	October	1/10/1939	68.95
1939	November	1/11/1939	76.11
1939	December	1/12/1939	89.19
1940	January	1/01/1940	82.89
1940	February	1/02/1940	72.27
1940	March	1/03/1940	70.58
1940	April	1/04/1940	44.33
1940	May	1/05/1940	36.03
1940	June	1/06/1940	31.2
1940	July	1/07/1940	35.47
1940	August	1/08/1940	31.68
1940	Septembe	1/09/1940	40.95
1940	October	1/10/1940	73.94
1940	November	1/11/1940	76.32
1940	December	1/12/1940	91.61
1941	January	1/01/1941	77.53
1941	February	1/02/1941	65.89
1941	March	1/03/1941	64.63
1941	April	1/04/1941	44.97
1941	May	1/05/1941	36.81
1941	June	1/06/1941	31
1941	July	1/07/1941	38.16
1941	August	1/08/1941	36.66
1941	Septembe	1/09/1941	48.9
1941	October	1/10/1941	69.26
1941	November	1/11/1941	79.61
1941	December	1/12/1941	88.22
1942	January	1/01/1942	78.6
1942	February	1/02/1942	66.5
1942	March	1/03/1942	67.63
1942	April	1/04/1942	44.91
1942	May	1/05/1942	39.6
1942	June	1/06/1942	32.59
1942	July	1/07/1942	38.14
1942	August	1/08/1942	42.81
1942	Septembe	1/09/1942	48.13
1942	October	1/10/1942	69.19
1942	November	1/11/1942	76.23
1942	December	1/12/1942	88.57
1943	January	1/01/1943	78.57
1943	February	1/02/1943	68.72
1943	March	1/03/1943	69.57
1943	April	1/04/1943	42.94
1943	May	1/05/1943	36.99
1943	June	1/06/1943	29.99
1943	July	1/07/1943	35.98
1943	August	1/08/1943	39.22
1943	Septembe	1/09/1943	46.38
1943	October	1/10/1943	69.43
1943	November	1/11/1943	72.82
1943	December	1/12/1943	85.7
1944	January	1/01/1944	83.07
1944	February	1/02/1944	70.39
1944	March	1/03/1944	65.27
1944	April	1/04/1944	41.65
1944	May	1/05/1944	36.26

1944	June	1/06/1944	30.17
1944	July	1/07/1944	37.82
1944	August	1/08/1944	41.75
1944	Septembe	1/09/1944	48.68
1944	October	1/10/1944	73.43
1944	Novembei	1/11/1944	82.66
1944	December	1/12/1944	89.19
1945	January	1/01/1945	76.4
1945	February	1/02/1945	66.75
1945	March	1/03/1945	65.05
1945	April	1/04/1945	43.84
1945	May	1/05/1945	36.46
1945	June	1/06/1945	33.16
1945	July	1/07/1945	36.96
1945	August	1/08/1945	42.7
1945	Septembe	1/09/1945	47.21
1945	October	1/10/1945	65.09
1945	November	1/11/1945	73.96
1945	December	1/12/1945	89.84
1946	January	1/01/1946	86.13
1946	February	1/02/1946	70.44
1946	March	1/03/1946	64.2
1946	April	1/04/1946	42.9
1946	May	1/05/1946	36.74
1946	June	1/06/1946	30.36
1946	July	1/07/1946	39.25
1946	August	1/08/1946	36.27
1946	Septembe	1/09/1946	40.99
1946	October	1/10/1946	67.78
1946	Novembei	1/11/1946	80.01
1946	December	1/12/1946	90.61
1947	January	1/01/1947	82
1947	February	1/02/1947	68.99
1947	March	1/03/1947	67.15
1947	April	1/04/1947	44.05
1947	May	1/05/1947	39.07
1947	June	1/06/1947	31.78
1947	July	1/07/1947	37.72
1947	August	1/08/1947	41.23
1947	Septembe	1/09/1947	48.12
1947	October	1/10/1947	69.34
1947	Novembei	1/11/1947	72.99
1947	December	1/12/1947	87.05
1948	January	1/01/1948	74.9
1948	February	1/02/1948	71.29
1948	March	1/03/1948	63.31
1948	April	1/04/1948	42.1
1948	May	1/05/1948	35.97
1948	June	1/06/1948	31.87
1948	July	1/07/1948	35.92
1948	August	1/08/1948	28.31
1948	Septembe	1/09/1948	48.3
1948	October	1/10/1948	70.55
1948	November	1/11/1948	75.66
1948	December	1/12/1948	90.6
1949	January	1/01/1949	76.79
1949	February	1/02/1949	67.23
1949	March	1/03/1949	66.65

1949	April	1/04/1949	42.12
1949	May	1/05/1949	36.75
1949	June	1/06/1949	30.06
1949	July	1/07/1949	37.77
1949	August	1/08/1949	41.65
1949	Septembe	1/09/1949	48.18
1949	October	1/10/1949	74.07
1949	November	1/11/1949	75.28
1949	December	1/12/1949	88.27
1950	January	1/01/1950	79.66
1950	February	1/02/1950	66.56
1950	March	1/03/1950	67.24
1950	April	1/04/1950	44.14
1950	May	1/05/1950	37.46
1950	June	1/06/1950	32.96
1950	July	1/07/1950	40.35
1950	August	1/08/1950	41.72
1950	Septembe	1/09/1950	50.28
1950	October	1/10/1950	70.27
1950	November	1/11/1950	74.31
1950	December	1/12/1950	89.15
1951	January	1/01/1951	77.85
1951	February	1/02/1951	68.45
1951	March	1/03/1951	68.96
1951	April	1/04/1951	42.03
1951	May	1/05/1951	37.21
1951	June	1/06/1951	33.1
1951	July	1/07/1951	37.41
1951	August	1/08/1951	40.18
1951	Septembe	1/09/1951	50.2
1951	October	1/10/1951	69.09
1951	November	1/11/1951	75.53
1951	December	1/12/1951	87.73
1952	January	1/01/1952	83.71
1952	February	1/02/1952	69.94
1952	March	1/03/1952	66.72
1952	April	1/04/1952	43.76
1952	May	1/05/1952	36.37
1952	June	1/06/1952	32.08
1952	July	1/07/1952	37.97
1952	August	1/08/1952	42.81
1952	Septembe	1/09/1952	48.03
1952	October	1/10/1952	70.54
1952	November	1/11/1952	73.68
1952	December	1/12/1952	87.02
1953	January	1/01/1953	77.79
1953	February	1/02/1953	65
1953	March	1/03/1953	66.85
1953	April	1/04/1953	46.03
1953	May	1/05/1953	37.35
1953	June	1/06/1953	30.74
1953	July	1/07/1953	34.04
1953	August	1/08/1953	33.47
1953	Septembe	1/09/1953	47.15
1953	October	1/10/1953	69.08
1953	November	1/11/1953	76
1953	December	1/12/1953	91.58
1954	January	1/01/1954	78.59

1954	February	1/02/1954	66.64
1954	March	1/03/1954	65.33
1954	April	1/04/1954	45.62
1954	May	1/05/1954	36.49
1954	June	1/06/1954	31.29
1954	July	1/07/1954	38.05
1954	August	1/08/1954	42.87
1954	Septembe	1/09/1954	46.92
1954	October	1/10/1954	71.11
1954	November	1/11/1954	77.99
1954	December	1/12/1954	88.57
1955	January	1/01/1955	80.67
1955	February	1/02/1955	67.27
1955	March	1/03/1955	68.74
1955	April	1/04/1955	45.63
1955	May	1/05/1955	36.85
1955	June	1/06/1955	31.55
1955	July	1/07/1955	36.74
1955	August	1/08/1955	42.4
1955	Septembe	1/09/1955	48.3
1955	October	1/10/1955	70.93
1955	November	1/11/1955	74.63
1955	December	1/12/1955	84.16
1956	January	1/01/1956	78.16
1956	February	1/02/1956	69.2
1956	March	1/03/1956	67.71
1956	April	1/04/1956	43.93
1956	May	1/05/1956	37.15
1956	June	1/06/1956	31.21
1956	July	1/07/1956	37.22
1956	August	1/08/1956	40.37
1956	Septembe	1/09/1956	45.85
1956	October	1/10/1956	67.56
1956	November	1/11/1956	72.82
1956	December	1/12/1956	88.76
1957	January	1/01/1957	82.57
1957	February	1/02/1957	67.04
1957	March	1/03/1957	66.43
1957	April	1/04/1957	45.12
1957	May	1/05/1957	35.92
1957	June	1/06/1957	30.5
1957	July	1/07/1957	35.99
1957	August	1/08/1957	42.15
1957	Septembe	1/09/1957	48.38
1957	October	1/10/1957	70.53
1957	November	1/11/1957	80.81
1957	December	1/12/1957	96.52
1958	January	1/01/1958	81.51
1958	February	1/02/1958	69.35
1958	March	1/03/1958	68.25
1958	April	1/04/1958	45.6
1958	May	1/05/1958	39.11
1958	June	1/06/1958	32.14
1958	July	1/07/1958	37.75
1958	August	1/08/1958	43.17
1958	Septembe	1/09/1958	46.31
1958	October	1/10/1958	69.73
1958	November	1/11/1958	81.47

1958	December	1/12/1958	86.84
1959	January	1/01/1959	81.25
1959	February	1/02/1959	69.9
1959	March	1/03/1959	67.7
1959	April	1/04/1959	44.75
1959	May	1/05/1959	36.22
1959	June	1/06/1959	31.56
1959	July	1/07/1959	38.32
1959	August	1/08/1959	42.27
1959	Septembe	1/09/1959	47.97
1959	October	1/10/1959	67.42
1959	Novembei	1/11/1959	82.8
1959	December	1/12/1959	87.37
1960	January	1/01/1960	85.42
1960	February	1/02/1960	70.33
1960	March	1/03/1960	66.24
1960	April	1/04/1960	43.6
1960	May	1/05/1960	34.93
1960	June	1/06/1960	30.07
1960	July	1/07/1960	38.52
1960	August	1/08/1960	40.98
1960	Septembe	1/09/1960	47.6
1960	October	1/10/1960	70.43
1960	Novembei	1/11/1960	73.8
1960	December	1/12/1960	86.36
1961	January	1/01/1961	79.93
1961	February	1/02/1961	68.23
1961	March	1/03/1961	66.55
1961	April	1/04/1961	44.42
1961	May	1/05/1961	35.97
1961	June	1/06/1961	31.45
1961	July	1/07/1961	37.3
1961	August	1/08/1961	40.84
1961	Septembe	1/09/1961	47.75
1961	October	1/10/1961	74.51
1961	Novembei	1/11/1961	78.32
1961	December	1/12/1961	88.7
1962	January	1/01/1962	77.84
1962	February	1/02/1962	68.11
1962	March	1/03/1962	66.21
1962	April	1/04/1962	43.38
1962	May	1/05/1962	35.57
1962	June	1/06/1962	32.95
1962	July	1/07/1962	35.09
1962	August	1/08/1962	41.36
1962	Septembe	1/09/1962	47.61
1962	October	1/10/1962	67.62
1962	Novembei	1/11/1962	78.24
1962	December	1/12/1962	84.93
1963	January	1/01/1963	78.93
1963	February	1/02/1963	68.04
1963	March	1/03/1963	65.55
1963	April	1/04/1963	44.09
1963	May	1/05/1963	38.37
1963	June	1/06/1963	31.45
1963	July	1/07/1963	36.74
1963	August	1/08/1963	41.59
1963	Septembe	1/09/1963	47.81

1963	October	1/10/1963	71.13
1963	November	1/11/1963	73.75
1963	December	1/12/1963	88.3
1964	January	1/01/1964	80.66
1964	February	1/02/1964	69.13
1964	March	1/03/1964	66.06
1964	April	1/04/1964	44.13
1964	May	1/05/1964	36.12
1964	June	1/06/1964	31.6
1964	July	1/07/1964	37.64
1964	August	1/08/1964	41.44
1964	Septembe	1/09/1964	48.39
1964	October	1/10/1964	66.03
1964	November	1/11/1964	77.96
1964	December	1/12/1964	86.94
1965	January	1/01/1965	77.21
1965	February	1/02/1965	69.54
1965	March	1/03/1965	68.6
1965	April	1/04/1965	42.54
1965	May	1/05/1965	36.63
1965	June	1/06/1965	30.87
1965	July	1/07/1965	36.26
1965	August	1/08/1965	42.47
1965	Septembe	1/09/1965	51.85
1965	October	1/10/1965	72.44
1965	November	1/11/1965	75.06
1965	December	1/12/1965	88.3
1966	January	1/01/1966	79.96
1966	February	1/02/1966	67.2
1966	March	1/03/1966	65.59
1966	April	1/04/1966	43.82
1966	May	1/05/1966	35.42
1966	June	1/06/1966	31.19
1966	July	1/07/1966	35.39
1966	August	1/08/1966	36.33
1966	Septembe	1/09/1966	46.52
1966	October	1/10/1966	67.8
1966	November	1/11/1966	75.46
1966	December	1/12/1966	85.57
1967	January	1/01/1967	79.81
1967	February	1/02/1967	66.71
1967	March	1/03/1967	62.14
1967	April	1/04/1967	43.69
1967	May	1/05/1967	36.64
1967	June	1/06/1967	33.16
1967	July	1/07/1967	37.07
1967	August	1/08/1967	39.82
1967	Septembe	1/09/1967	46.66
1967	October	1/10/1967	70.91
1967	November	1/11/1967	76.84
1967	December	1/12/1967	85.2
1968	January	1/01/1968	79.21
1968	February	1/02/1968	72.66
1968	March	1/03/1968	68.09
1968	April	1/04/1968	45.06
1968	May	1/05/1968	35.08
1968	June	1/06/1968	29.97
1968	July	1/07/1968	34.22

1968	August	1/08/1968	35.58
1968	Septembe	1/09/1968	46.28
1968	October	1/10/1968	69.62
1968	November	1/11/1968	77.91
1968	December	1/12/1968	85.72
1969	January	1/01/1969	83.42
1969	February	1/02/1969	68.26
1969	March	1/03/1969	66.84
1969	April	1/04/1969	44.02
1969	May	1/05/1969	36.42
1969	June	1/06/1969	31.13
1969	July	1/07/1969	38.49
1969	August	1/08/1969	43.63
1969	Septembe	1/09/1969	44.37
1969	October	1/10/1969	68.59
1969	November	1/11/1969	74.08
1969	December	1/12/1969	87.2
1970	January	1/01/1970	80.79
1970	February	1/02/1970	74.04
1970	March	1/03/1970	66.14
1970	April	1/04/1970	45.12
1970	May	1/05/1970	35.11
1970	June	1/06/1970	31.99
1970	July	1/07/1970	37.7
1970	August	1/08/1970	40.67
1970	Septembe	1/09/1970	44.14
1970	October	1/10/1970	73.43
1970	November	1/11/1970	73.01
1970	December	1/12/1970	88.59
1971	January	1/01/1971	80.53
1971	February	1/02/1971	68.02
1971	March	1/03/1971	70.24
1971	April	1/04/1971	45.46
1971	May	1/05/1971	37.02
1971	June	1/06/1971	31.13
1971	July	1/07/1971	36.55
1971	August	1/08/1971	42.08
1971	Septembe	1/09/1971	49.77
1971	October	1/10/1971	76.49
1971	November	1/11/1971	74.14
1971	December	1/12/1971	84.13
1972	January	1/01/1972	73.95
1972	February	1/02/1972	69.27
1972	March	1/03/1972	66.22
1972	April	1/04/1972	43.83
1972	May	1/05/1972	37.06
1972	June	1/06/1972	31.5
1972	July	1/07/1972	37.89
1972	August	1/08/1972	43.22
1972	Septembe	1/09/1972	53.98
1972	October	1/10/1972	70.33
1972	November	1/11/1972	77.69
1972	December	1/12/1972	100.82
1973	January	1/01/1973	88.89
1973	February	1/02/1973	61.98
1973	March	1/03/1973	68.15
1973	April	1/04/1973	44.92
1973	May	1/05/1973	38.17

1973	June	1/06/1973	31.53
1973	July	1/07/1973	39.74
1973	August	1/08/1973	41.26
1973	Septembe	1/09/1973	48.17
1973	October	1/10/1973	66.96
1973	November	1/11/1973	71.18
1973	December	1/12/1973	82.9
1974	January	1/01/1974	72.15
1974	February	1/02/1974	60.51
1974	March	1/03/1974	63.84
1974	April	1/04/1974	42.47
1974	May	1/05/1974	36.9
1974	June	1/06/1974	31.11
1974	July	1/07/1974	37.41
1974	August	1/08/1974	39.81
1974	Septembe	1/09/1974	43.79
1974	October	1/10/1974	64.91
1974	November	1/11/1974	70.71
1974	December	1/12/1974	92.56
1975	January	1/01/1975	83.52
1975	February	1/02/1975	66.69
1975	March	1/03/1975	62.85
1975	April	1/04/1975	41.01
1975	May	1/05/1975	37.2
1975	June	1/06/1975	31.93
1975	July	1/07/1975	39.26
1975	August	1/08/1975	41.02
1975	Septembe	1/09/1975	46.86
1975	October	1/10/1975	64.43
1975	November	1/11/1975	79.77
1975	December	1/12/1975	88.39
1976	January	1/01/1976	73.17
1976	February	1/02/1976	65.15
1976	March	1/03/1976	63.54
1976	April	1/04/1976	41.93
1976	May	1/05/1976	36.67
1976	June	1/06/1976	30.15
1976	July	1/07/1976	38.46
1976	August	1/08/1976	40.99
1976	Septembe	1/09/1976	44.01
1976	October	1/10/1976	61.04
1976	November	1/11/1976	74.36
1976	December	1/12/1976	99.07
1977	January	1/01/1977	85.94
1977	February	1/02/1977	71.02
1977	March	1/03/1977	66.34
1977	April	1/04/1977	45.38
1977	May	1/05/1977	36.64
1977	June	1/06/1977	30.76
1977	July	1/07/1977	36.47
1977	August	1/08/1977	43.8
1977	Septembe	1/09/1977	45.97
1977	October	1/10/1977	76.4
1977	November	1/11/1977	83.05
1977	December	1/12/1977	100.57
1978	January	1/01/1978	77.42
1978	February	1/02/1978	73.78
1978	March	1/03/1978	68

1978	April	1/04/1978	43.74
1978	May	1/05/1978	37.72
1978	June	1/06/1978	31
1978	July	1/07/1978	36.9
1978	August	1/08/1978	40.14
1978	Septembe	1/09/1978	45.32
1978	October	1/10/1978	67.92
1978	November	1/11/1978	74.23
1978	December	1/12/1978	82.45
1979	January	1/01/1979	93.73
1979	February	1/02/1979	78.92
1979	March	1/03/1979	66.76
1979	April	1/04/1979	44.79
1979	May	1/05/1979	36.27
1979	June	1/06/1979	32.76
1979	July	1/07/1979	37.6
1979	August	1/08/1979	41.38
1979	Septembe	1/09/1979	47.5
1979	October	1/10/1979	71.45
1979	November	1/11/1979	82.48
1979	December	1/12/1979	109.37
1980	January	1/01/1980	82.58
1980	February	1/02/1980	76.21
1980	March	1/03/1980	75.83
1980	April	1/04/1980	48.93
1980	May	1/05/1980	38.97
1980	June	1/06/1980	32.16
1980	July	1/07/1980	38.1
1980	August	1/08/1980	44.85
1980	Septembe	1/09/1980	56.87
1980	October	1/10/1980	79.33
1980	November	1/11/1980	90.32
1980	December	1/12/1980	98.84
1981	January	1/01/1981	90.91
1981	February	1/02/1981	70.1
1981	March	1/03/1981	71.63
1981	April	1/04/1981	48.78
1981	May	1/05/1981	37.88
1981	June	1/06/1981	30.99
1981	July	1/07/1981	37.62
1981	August	1/08/1981	40.76
1981	Septembe	1/09/1981	53.5
1981	October	1/10/1981	73.84
1981	November	1/11/1981	71.51
1981	December	1/12/1981	92.5
1982	January	1/01/1982	84.51
1982	February	1/02/1982	74.58
1982	March	1/03/1982	63.23
1982	April	1/04/1982	45.15
1982	May	1/05/1982	38.52
1982	June	1/06/1982	30.98
1982	July	1/07/1982	36.56
1982	August	1/08/1982	34.8
1982	Septembe	1/09/1982	44.87
1982	October	1/10/1982	73.15
1982	November	1/11/1982	95.31
1982	December	1/12/1982	95.81
1983	January	1/01/1983	94.21

1983	February	1/02/1983	79.59
1983	March	1/03/1983	77.77
1983	April	1/04/1983	42.79
1983	May	1/05/1983	38.59
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1983	August	1/08/1983	39.84
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1983	October	1/10/1983	69.11
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1984	February	1/02/1984	70.88
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1985	August	1/08/1985	41.28
1985	Septembe	1/09/1985	46.18
1985	October	1/10/1985	67.48
1985	Novembei	1/11/1985	73.34
1985	December	1/12/1985	88.2
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1986	April	1/04/1986	49.5
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1986	August	1/08/1986	41.64
1986	Septembe	1/09/1986	48.46
1986	October	1/10/1986	65.89
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1987	March	1/03/1987	62.64
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1987	Novembei	1/11/1987	76.92

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1988	March	1/03/1988	64.68
1988	April	1/04/1988	41.75
1988	May	1/05/1988	37.94
1988	June	1/06/1988	32.43
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1988	August	1/08/1988	40.26
1988	Septembe	1/09/1988	49.56
1988	October	1/10/1988	79.75
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1991	March	1/03/1991	75.25
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1991	May	1/05/1991	38.88
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1997	March	1/03/1997	68.8
1997	April	1/04/1997	47.93
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2009	December	1/12/2009	93.46
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2010	February	1/02/2010	66.47
2010	March	1/03/2010	65.72
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2011	November	1/11/2011	78.71
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2013	July	1/07/2013	40.67
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2014	Novembei	1/11/2014	90.78
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2015	January	1/01/2015	78.96
2015	February	1/02/2015	68.35
2015	March	1/03/2015	70.31
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2015	May	1/05/2015	37.5
2015	June	1/06/2015	32.6
2015	July	1/07/2015	37.22
2015	August	1/08/2015	42.41
2015	Septembe	1/09/2015	48.95
2015	October	1/10/2015	78.64
2015	Novembei	1/11/2015	81.81
2015	December	1/12/2015	92.4
2016	January	1/01/2016	76.35
2016	February	1/02/2016	75.87
2016	March	1/03/2016	72.32
2016	April	1/04/2016	48.12
2016	May	1/05/2016	38.61
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2016	July	1/07/2016	39.99
2016	August	1/08/2016	42.11
2016	Septembe	1/09/2016	46.5
2016	October	1/10/2016	68.57
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2017	March	1/03/2017	67.36
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2019	April	1/04/2019	46.87
2019	May	1/05/2019	37.77
2019	June	1/06/2019	31.82
2019	July	1/07/2019	40.13
2019	August	1/08/2019	42.54
2019	Septembe	1/09/2019	52.33
2019	October	1/10/2019	78.73
2019	November	1/11/2019	92.94
2019	December	1/12/2019	106.43
2020	January	1/01/2020	93.65
2020	February	1/02/2020	70.75
2020	March	1/03/2020	64.19
2020	April	1/04/2020	44.02
2020	May	1/05/2020	35.9
2020	June	1/06/2020	32.52
2020	July	1/07/2020	39.69
2020	August	1/08/2020	41.15
2020	Septembe	1/09/2020	50.63
2020	October	1/10/2020	71.43
2020	November	1/11/2020	82.28
2020	December	1/12/2020	82.39

ghd.com → The Power of Commitment

Appendix D

Contact Water and Leachate Treatment Options

Contact Water and Leachate Treatment Options

Bell Quarry Appeal

Bell Quarry Rehabilitation Project Pty Ltd

19 November 2021

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		Name	Signature	Name	Signature	Date
1	P McFadyen	M Brannock		A Dixon	a. Dixon	19/11/21

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Appendices

1. Introduction

1.1 Overview

This report has been prepared to support the amendments to the Development Application related to contact water and leachate quality treatment.

GHD Pty Ltd (GHD) have prepared a contingency water quality treatment strategy to manage excess contact water in the unlikely event it cannot be managed on site in a fully contained system (see the Revised Water Resources Assessment GHD, 2021). If the volumetric contact water storage trigger were exceeded in the contact water storage, a treatment plant would be commissioned and operated to treat the contact water to a high quality to ensure that any water to be discharged off-site will have a neutral or beneficial effect NorBE) on receiving water quality.

The Bell Quarry Rehabilitation Project has the benefit that a detailed study was undertaken by the NSW Office and Environment and Heritage (OEH 2015), and more recent surface water monitoring as summarised in the Revised Water Resources Assessment (GHD, 2021). These provide a detailed data set of background surface water quality in the area. As such, a contingency contact water treatment plant is proposed.

The treatment process has been designed to treat the contact water and leachate and achieve background water quality (OEH 2015).

Based on the available data it is expected that the trigger values for groundwater quality in the Revised Water Resources Assessment (GHD, 2021) will not be exceeded. It would be a period of time (if it ever eventuated) before groundwater levels exceeded and presented a risk of seeping out of the lined cells. The strategy involves a detailed monitoring program to confirm the leachate quality should it be needed to be treated and confirm the treatment plant's specifications are also suitable for it.

However, potential treatment of the leachate has been considered in this assessment in the case that it is necessary. Treatment of the leachate represents the worst-case scenario in terms of water treatment on the site and ability to meet the discharge water quality targets as discussed further in section 2.1.

1.2 Purpose of this report

This report presents the alternative treatment options that are able to achieve the background water quality (OEH 2015).

1.3 Definitions and Abbreviations

Table 1.1 outlines various definitions of key terms used throughout this report.

Table 1.1 Definitions

Term	Definition
Leachate	Water which seeps through the proposed fill
Contact Water	Water which runs off the exposed fill
Clean Water	Water which runs off rehabilitated areas and water which is stored in the ponds and not influenced by leachate, contacted water or potentially sediment laden water
Potentially sediment laden water	Water which runoffs disturbed areas of the site including those undergoing rehabilitation
Groundwater	Water within the in-situ geology

Table 1.2 outlines the abbreviations used throughout this report.

Table 1.2 *Abbreviations*

Abbreviation	Definition
AC	Alternating Current
AS	Antiscalant
ASLP	Australian Standard Leaching Procedure
CF	Cartridge Filter
DA	Development Application
EIS	Environmental Impact Statement
ENM	Excavated Natural Material
ID	Insufficient Data
LEC	Land and Environment Court
OEH	Office and Environment and Heritage
RO	Reverse Osmosis
RtS	Response to Submission
SEPP	State Environmental Planning Policy
SMBS	Sodium Metabisulfite
SRD	State and Regional Development
TOC	Total Organic Carbon
TSS	Total Suspended Solids
UCPR	Uniform Civil Procedures Rules
UF	Ultrafiltration
VENM	Virgin Excavated Natural Material
WRPP	Western Regional Planning Panel

1.4 Background

Bell Quarry Rehabilitation Project Pty Ltd (the Applicant) seeks to rehabilitate the Bell Quarry site, located on Sandham Road at Newnes Junction, approximately ten kilometres east of Lithgow in NSW. The development application (DA) seeks to achieve the final rehabilitated landform via importation of virgin excavated natural material (VENM), excavated natural material (ENM) or comparable material (that meets an exemption pursuant to clauses 91 and 92 of the Protection of the Environmental Operations (Waste) Regulation 2014), sourced from earthworks projects across Sydney and the local regional area (the Project).

The DA (294/18) is Designated Development and is also defined as Regional Development under clause 7, Schedule 7 of the State Environmental Planning Policy (State and Regional Development) 2011 (SRD SEPP). The DA was notified and assessed by Lithgow City Council (Council), and subject to consent by the Western Regional Planning Panel (WRPP).

An Environmental Impact Statement (EIS) was prepared by GHD to support the DA and submitted to Council in October 2018 (GHD, 2018). The DA and EIS were placed on exhibition for a 60-day period from 19 January to 20 March 2019. A Response to Submissions (RtS) Report was prepared by GHD in June 2019 to address the issues raised in submissions during exhibition and additional responses were provided to Council in October and November 2019.

The WRPP refused the DA on 6 April 2020 following a public panel meeting. The primary reasons for the refusal were based around the potential for adverse environmental impacts upon the downstream receiving environment in the Greater Blue Mountains World Heritage Area and disruption to the amenity of the local community.

The Supplementary EIS modifies the original DA to rehabilitate a former quarry site via importation of VENM and ENM or comparable material (that meets an exemption pursuant to clauses 91 and 92 of the Protection of the Environmental Operations (Waste) Regulation 2014), sourced from earthworks projects across Sydney and the local regional area (the Project).

Modifications to the original DA related to water quality management include:

- Adjusted staging plans to facilitate the separation of clean, contact and potentially sediment laden waters
- Implementation of a refined surface water management system to mitigate the contact of surface flows with the fill material
- Implementation of a contact management system to provide detention and irrigation of contact water and filtration of sediment prior to release to the receiving environment
- Management plans to control filling, sequencing, runoff, and the different water types.

2. Water treatment

Based on the current water quality observed at the quarry (Hydrological Study Proposed Rehabilitation of Bell Quarry, Martens, November 2021), there will be a requirement to treat the contact water prior to discharge from the site (if contact water discharge is required as detailed in the Revised Water Resources Assessment (GHD, 2021)). This section outlines the basis of design, options investigated, preferred option and vendor engagement for the treatment of contact water and leachate to an acceptable limit as outlined in section 2.1.3.

To reiterate, based on the assessment contained in the Revised Water Resources Assessment (GHD, 2021), there is a low likelihood that the treatment plant will be needed as it is predicted that the contact water will be able to be fully contained on the site. The conditions under which the treatment plant would be required are detailed in the Revised Water Resources Assessment (GHD, 2021).

2.1 Basis of Design

Figure 2.1 depicts an aerial of the Bell Quarry site.

Figure 2.1 ***Bells Quarry Site at Newnes Junction, NSW***

2.1.1 Feed Flow

Feed to the treatment process will come from the approximately 35 ML eastern void storage on site. If treatment is required, there would be a requirement to treat approximately 85 kL/d of flow (weather dependent) which will be drawn from this pond. Treated water from the selected technology will be discharged off site with the location depicted on the staging plans for the project. The waste from the system will be initially contained in a tank and as needed transported to the active emplacement area and disposed on site as further described in the draft Environmental Management Plan (GHD, 2021).

2.1.2 Feed Water Quality

Feed water quality was based on the ADE data (ADE Consulting Group, 2017) plus some parameters were assumed based on previous project experience as outlined in Section 2.1.4. As it is predicted there will be a period of several operational years before any treatment plant is required (if ever), there will be the opportunity to undertake additional sampling prior to detailed design.

ASLP data based on 12 analytical results from 9 soil samples has been used to estimate the feed water quality. The ASLP is expected to be a conservative representation of the contact water quality directed to the contact water pond. This is because of the difference between the conditions which generate site run-off contact water (contact time and intensity of water/soil mixing) and the method used for ASLP testing.

To provide explanation and context for the ASLP testing method, it is based on samples being agitated with a leaching solution for a period of 18 hours. Each sample is screened to remove larger particles and placed in the rotary agitation apparatus with the leaching fluid. Each sample is rotated in an end-over-end fashion at a speed of 30+/- 2 rotations per minute for a period of 18 hours (+/- 2 hours).

The water in rainfall run-off from the site fill will have limited contact because it is flowing over the surface rather than being mixed within the material as is the case with ASLP testing. Further, once run-off is initiated, surface flow will be quick and the contact time with the fill will be short, minimising the time for partitioning from soil to water. ASLP, on the other hand, agitates soil samples in solution for 18 hours.

It is noted that in some instances water may pond in dedicated locations across the site for short periods before being pumped to the contact pond, which will increase the contact time relative to rainfall run-off. However, the nature of a ponded water column still limits contact with the underlying sediment (relative to ASLP) and any water contacting and migrating into the sediment will ultimately become leachate in the pits as opposed to being directed to the contact water pond.

Leachate from the rainwater and groundwater that seeps into the fill material will have a longer contact time for chemical reactions and dissolution of contaminants to occur. Therefore, the ASLP data is expected to more closely represent the leachate water quality than the contact water quality.

The ASLP data has been adopted as the basis of design for feedwater quality to a water treatment plant and this is expected to reflect worst-case conditions (leachate rather than contact water). Typically, the volume of leachate is expected to be small relative to that of contact water or clean water from the site, so the feed water quality to the plant should generally be of higher quality than the ASLP data.

Water quality available at this point in time is outlined within Table 2.1.

Note that the sample data is pre the approximately 35 ML eastern void storage and as such flow entering the treatment process will be slightly different in composition due to the benefit and chemistry effects that occur in feed ponds. This includes but is not limited to minor offgassing of CO_2 leading to pH change and the precipitation of some metals. Due to the limited number of samples available currently there is potential for higher concentrations of some substances in the eastern void storage. As outlined above, further sampling will occur to further define this feed water quality in future phases.

It is also noted that there are several parameters that are important for treatment design and performance purposes were not analysed in the ASLP testing; this is discussed in subsequent sections. Additional sampling is to include laboratory analysis of the analytes/parameters provided in Table 2.2 to enable assessment of treatment requirements (if treatment is determined to be necessary). Additional field analyses are required to complement these laboratory analyses as outlined in the Revised Water Resources Assessment (GHD, 2021). The collection and assessment of operational phase water quality data for the contact water and leachate will be utilised in the final design of the treatment plant, if treatment is found to be necessary.

A number of contingencies are available in the event that additional water quality data indicates contact water or leachate water has higher contaminant concentrations than the RO system can treat to achieve the required limits. These are discussed further in section 2.2.3.

Table 2.1 *Water Quality Sampling data (Samples taken November 2017, Sample Reference Number 12950).*

Analyte/Parameter	Units	Tuggerah (ASLP Leachate using Quarry Water - SAND)	Faulconbridge (ASLP Leachate using Quarry Water - Silty SAND)	Blacktown (ASLP Leachate using Quarry Water - Silty CLAY)	Ashfield (ASLP Leachate using Quarry Water - Weathered Shale)	Glenorie (ASLP Leachate using Quarry Water - Silt/Silty CLAY)	Lucas Heights (ASLP Leachate using Quarry Water - Clayey SAND)	Hawkesbury (ASLP Leachate using Quarry Water - SANDSTONE)	South Creek (ASLP Leachate using Quarry Water - Silty SAND)	Disturbed Terrain (DI) QAQC-ASLP Leachate using Deionised Water - Silty SAND	Tuggerah (DI) QAQC-ASLP Leachate using Deionised Water - SAND	12950-BR1 (QAQC-Duplicate of 12950-Tuggerah)	12950-SR1 (QAQC-Duplicate of 12950-Tuggerah)
4,4 - DDT	ug/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	
Ammonia N	ug/L	110	<10	<10	<10	<10	<10	<10	<10	10	<10	80	
Anthracene	ug/L	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	
Arochlor 1242	ug/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	
Arochlor 1254	ug/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	
Arsenic total	ug/L	<1	<1	1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzo(a)pyrene	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
C10-C16 Fraction	ug/L	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
C16-C34 Fraction	ug/L	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
C34-C40 Fraction	ug/L	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
Cadmium total	ug/L	<0.1	0.2	0.4	0.2	<0.1	<0.1	<0.1	0.3	0.2	0.3	<0.1	<0.1
Calcium total	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	
Chloride	mg/L	5	8	20	10	5	5	5	48	9	<1	5	
Chlorpyrifos	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Chromium total	ug/L	1	2	7	1	<1	<1	<1	7	<1	15	14	<1
Copper total	ug/L	<1	2	13	2	<1	<1	<1	7	1	3	5	<1
E.coli	CFU/100mL	<2	<1	<2	<1	<1	<1	<1	<2	<1	<2	<1	
Electrical Conductivity	uS/cm	30	36	124	58	35	33	31	248	43	4	31	
Endosulfan	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Endrin	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Faecal Coliforms	CFU/100mL	2600	<1	<2	<2	<1	<1	<1	<2	<1	32	3	
Heptachlor	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Lead total	ug/L	<1	3	10	4	<1	<1	<1	7	<1	2	2	<1
Magnesium total	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	
Mercury	ug/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.05
Naphthalene	ug/L	<1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	
Nickel total	ug/L	<1	1	6	<1	<1	6	<1	4	2	6	7	<1
Nitrate	ug/L	10	20	2350	20	20	30	<10	40	130	<10	20	
Nitrite	ug/L	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
pH	pH Unit	6.67	6.16	6.38	6.04	4.86	5.28	5.76	6.42	6.42	5.93	5.65	
Phosphorus total	ug/L	40	<10	80	<10	10	<10	<10	<10	<10	20	<10	
Potassium total	mg/L	<1	<1	<1	<1	<1	2	<1	<1	<1	<1	<1	
Reactive Phosphorous	ug/L	<10	<10	<10	<10	10	<10	<10	<10	<10	30	20	
Sodium total	mg/L	4	16	23	11	5	4	6	43	8	<1	5	
Sulfate	mg/L	2	2	21	8	8	6	5	21	2	<1	2	

Analyte/Parameter	Units	Tuggerah (ASLP Leachate using Quarry Water - SAND)	Faulconbridge (ASLP Leachate using Quarry Water - Silty SAND)	Blacktown (ASLP Leachate using Quarry Water - Silty CLAY)	Ashfield (ASLP Leachate using Quarry Water - Weathered Shale)	Glenorie (ASLP Leachate using Quarry Water - Silt/Silty CLAY)	Lucas Heights (ASLP Leachate using Quarry Water - Clayey SAND)	Hawkesbury (ASLP Leachate using Quarry Water - SANDSTONE)	South Creek (ASLP Leachate using Quarry Water - Silty SAND)	Disturbed Terrain (DI) QAQC-ASLP Leachate using Deionised Water - Silty SAND	Tuggerah (DI) QAQC-ASLP Leachate using Deionised Water - SAND	12950-BR1 (QAQC-Duplicate of 12950-Tuggerah)	12950-SR1 (QAQC-Duplicate of 12950-Tuggerah)
Total Alkalinity	mg/L	5	3	3	<1	<1	<1	<1	4	4	<1	6	
Total Kjeldahl Nitrogen	ug/L	400	200	600	<100	100	<100	100	<100	200	400	200	
Total Nitrogen	ug/L	400	200	3000	<100	100	<100	100	<100	300	400	200	
Zinc total	ug/L	30	74	484	54	43	135	42	64	160	528	22	9

Note: values above with '<' are less than the limit of detection for the test used

Table 2.2 *Contact Water and Leachate Sample Analysis Requirements*

Analyte/Parameter	Analyte/Parameter	Analyte/Parameter
pH Value	Arsenic (Total and Dissolved)	**Boron (Total and Dissolved)**
Electrical Conductivity	Beryllium (Total and Dissolved)	**Free Chlorine**
Total Dissolved Solids 25°C	**Barium (Total and Dissolved)**	**Silica (reactive)**
Total Dissolved Solids (sum ions)	Cadmium (Total and Dissolved)	**Silica (total)**
Total Suspended Solids	Chromium (Total and Dissolved)	**Ammonia as N**
Turbidity	Cobalt (Total and Dissolved)	**Nitrite as N**
Hydroxide Alkalinity as $CaCO_3$	Copper (Total and Dissolved)	**Nitrate as N**
Carbonate Alkalinity as $CaCO_3$	Lead (Total and Dissolved)	**Nitrite + Nitrate as N**
Bicarbonate Alkalinity as $CaCO_3$	**Manganese (Total and Dissolved)**	Total Kjeldahl Nitrogen as N
Total Alkalinity as $CaCO_3$	Molybdenum (Total and Dissolved)	Total Nitrogen as N
Carbon Dioxide	Nickel (Total and Dissolved)	Total Phosphorus as P
Bicarbonate	Vanadium (Total and Dissolved)	**Reactive Phosphorus as P**
Carbonate	Zinc (Total and Dissolved)	**Total Organic Carbon**
Calcium Hardness as $CaCO_3$	**Iron (Total and Dissolved)**	COD
Magnesium Hardness as $CaCO_3$	**Strontium (Total and Dissolved)**	Meta- & para-Xylene
Total Hardness $CaCO_3$	**Aluminium (Total and Dissolved)**	Naphthalene
Sulfate as SO_4	Antimony (Total and Dissolved)	Ortho-Xylene
Hydrogen Sulfide	Lithium (Total and Dissolved)	Benzene
Chloride	Selenium (Total and Dissolved)	Cyanide
Fluoride	Thallium (Total and Dissolved)	Total Anions
Bromide	Uranium (Total and Dissolved)	Total Cations
Calcium	Tin (Total and Dissolved)	**Oil & Grease**
Magnesium	Titanium (Total and Dissolved)	N/A
Sodium	Silver (Total and Dissolved)	**Bacterial Analyses (total plate count)**
Potassium	Mercury (Total and Dissolved)	

Note: Bold indicates necessary for treatment plant design

The analytes in Table 2.2 represent those necessary for the design of a treatment plant and also those required to allow comparison of estimated treated water quality concentrations with background concentrations. Per Table 17 in the Bell Quarry Appeal, Revised Water Resources Assessment (2021), this analysis suite would be undertaken quarterly for the first year of the project for leachate and contact water. Following the first year, these may be rationalised to remove those analytes that will be comfortably treated in the treatment plant to the background limits (if the treatment plant is ever required).

Once the monthly monitoring of contact water and leachate is initiated following the 30% contact water storage capacity trigger, at least 6 months of full treatment design sample analyses (bolded in Table 2.2) will be required to enable confident design of the treatment plant.

Per the Revised Water Resources Assessment (GHD, 2021), when the eastern void exceeds 45% of the total capacity, receival of material would cease. Covering of all exposed fill areas is commenced and completed within 40 days. After this the catchment would be diverted around the eastern void. This was determined as the period of time required to minimise the risk of high water level in the eastern void, enabling sufficient time for the treatment plant to be implemented.

The likelihood of the historical climate exceeding the 45% capacity trigger is approximately 15 percent of the time and when climate change is considered, the likelihood reduces to 11% (Revised Water Resources Assessment

GHD, 2021). Noting that this is based on the critical phase modelled in the water balance only represents one stage of the project, and as there is approximately 12 months before the first stage of filling extends above the land surrounding the quarry void, there is sufficient time to retain contact water in the void, if needed and not exceed the 45% capacity trigger. During this time the 6 months of full treatment design sample analyses (bolded in Table 2.2) to enable confident design of the treatment plant would be able to be obtained should the 30% contact water storage capacity be exceeded. Also if needed, this may involve reducing the filling area to less than 1.3 Ha to slow down the rise of contact water in the storage.

Manual dosing of chemical flocculants into the sediment basins to manage water quality for discharge from those basins will be carefully managed as it is acknowledged flocculants can foul the membranes in a reverse osmosis treatment plant. If a treatment plant is implemented, consultation with the vendor on appropriate flocculants and pond dosing methodologies will occur. Non-polymer flocculants (e.g. gypsum) are preferred upstream of membrane treatment systems.

2.1.3 Treatment Requirements

Table 2.3 outlines the treated water quality targets adopted for this project, with the analysis being based on the Specification. The specification represents the 80th %ile water quality data for the background water quality (Office of Environment and the Heritage, 2015).

Table 2.3 Treated Water Quality Targets

Analyte/Parameter	Specification - Based on Receiving water stream 80th %ile (mg/L)
Aluminium dissolved	0.192
Aluminium total	0.516
Ammonia N	0.02
Antimony Dissolved	0.0006
Antimony total	0.00102
Arsenic dissolved	0.00175
Arsenic total	0.001409
Barium dissolved	0.01132
Barium total	0.013
Benzene	Not Included
Beryllium dissolved	0.000151
Beryllium total	0.000152
Bicarbonate Alkalinity	3
Boron dissolved	0.05
Boron total	0.05
Cadmium dissolved	0.000117
Cadmium total	9.28E-05
Calcium dissolved	0.377011
Calcium total	0.3
Carbonate Alkalinity	3
Chloride	7.5
Chromium dissolved	0.000503
Chromium total	0.000576
Cobalt dissolved	0.00167

Analyte/Parameter	Specification - Based on Receiving water stream 80th %ile (mg/L)
Cobalt total	0.00199
Conductivity	34.2
Copper dissolved	0.0005
Copper total	0.0005
Cyanide	Not Included
Dissolved Oxygen	Not Included
Electrical Conductivity	Not Included
Fluoride	0.15
Free Active Phosphorus	0.004
Hardness	3
Hydrogen Sulfide	Not Included
Hydroxide Alkalinity	3
Iron dissolved	0.99
Iron total	1.878
Lead dissolved	0.000583
Lead total	0.000981
Lithium dissolved	0.00058
Lithium total	0.0004995
Magnesium dissolved	0.56
Magnesium total	0.5
Manganese dissolved	0.066385
Manganese total	0.07575
Mercury	0.000025
Meta- & para-Xylene	Not Included
Molybdenum dissolved	0.000529
Molybdenum total	0.000969
Naphthalene	Not Included
Nickel dissolved	0.00099
Nickel total	0.00085
Nitrite and Nitrate	Not Included
NOx N	0.25
Ortho-Xylene	Not Included
pH	5.9
Phosphorus dissolved	0.02
Phosphorus total	0.02
Potassium dissolved	0.3
Potassium total	0.5
Reactive Phosphorous	Not Included
Selenium dissolved	0.002

Analyte/Parameter	Specification - Based on Receiving water stream 80th %ile (mg/L)
Selenium total	0.001
Silicon dissolved	2.81823
Silicon total	3.21257
Silver dissolved	0.00005
Silver total	0.00005
Sodium dissolved	4.3
Sodium total	4.6
Strontium dissolved	0.0047
Strontium total	0.0047
Sulfate	2.5
Sulfur total	0.68314
Thallium dissolved	0.290637
Thallium total	0.00192
Tin dissolved	0.002418
Tin total	0.000798
Titanium dissolved	0.005
Titanium total	0.006168
Total Kjeldahl Nitrogen	0.7
Total Alkalinity	3
Total Dissolved Solids	27
Total Nitrogen	0.15
Total Phosphorus	0.023383
Total Suspended Solids	5
Turbidity	Not Included
Vanadium dissolved	0.00685
Vanadium total	0.001404
Zinc dissolved	0.0059
Zinc total	0.0055

Note: Several of the parameters above were not tested in the ASLP sample data currently available

2.1.4 Assumptions

Due to the limited existing water quality data reflecting the characteristics of run-off and leachate associated with the operational phase (i.e. future fill materials - VENM, ENM, or comparable material), the following assumptions were made for the design of the water treatment options:

- TSS is to be at an upper limit of 200 mg/L when entering the treatment process
- Dissolved Iron and Manganese are to be less than 0.1 mg/L
- Free Chlorine is less than 0.1 mg/L
- Total Organic Carbon less than 1 mg/L
- Chromium is in Cr (VI) form

- Algae growth in the dam will not be an issue (if it is then additional pre-treatment or in-dam algae management strategies will need to be further considered – data/observations on algae presence can be gathered during operational phase prior to potential treatment plant operation and management strategies developed). GHD is not aware of previous algae issues, which is supported by the existing water quality monitoring data for the voids.

If these assumptions are not realised, the implications would likely be limited to additional pre-treatment stages and/or chemical dosing, which are cost implications rather than impacts affecting the ability to treat to the required water quality. The assumptions above will be verified through operational phase water quality monitoring (the contact water and leachate) prior to final design of the treatment plant, if treatment is found to be necessary.

2.1.5 Shortlisted Options

Based on the water quality data for feed and treated water the following options were considered for the management of water onsite:

1. Additional pond storage for evaporation
- This option includes the installation of additional pond storages or tank storage to provide additional evaporation area reducing the water volume and then dispose any residual salt or sludge within the emplaced material (draft Environmental Management Plan GHD, 2021)
2. Assisted evaporation systems
- This option includes the installation of assisted evaporation units to enhance evaporation rates over the water storages to further reduce the water volume and then dispose any residual salt or sludge within the emplaced material (draft Environmental Management Plan GHD, 2021)
3. Thermal Evaporation with distillate / water recovery
- This option includes the installation of a thermal evaporation system with distillate recovery, likely in the form of concentrator and crystalliser
4. Thermal Evaporation to atmosphere
- This option includes the installation of a thermal evaporation system with the evaporative steam released to the atmosphere
5. Humidification to atmosphere
- This option includes the installation of a humidification system with the evaporative steam released to the atmosphere
6. Ion-Exchange
- This option involves the installation of an ion exchange unit with resin recovery and regeneration
7. Reverse Osmosis (RO) with pre-treatment
- This option involves the installation of a reverse osmosis system with relevant pre-treatment for membrane protection

2.1.6 Pros and cons

To assess the various options outlined in Section 2.1.5 to determine a preferred option for this scenario, a pros and cons list was developed as outlined in Table 2.4.

Table 2.4 Pros and Cons assessment of the shortlisted treatment options

Option	Pros	Cons
1. Pond Storages	– "Low tech" option – Minimal operational requirements	– Requires large amount of land and limited at the site

Option	Pros	Cons
2. Assisted Evaporation Systems	– Lower cost than thermal evaporation – Weather station controller available to limit operation of evaporation units to appropriate weather conditions	– Overspray (salt drift) from surface evaporators may cause damage to adjacent vegetation – Wind conditions need to be appropriate to enable evaporator operation, reducing potential for assisted evaporation – Concentrated residual remains in pond for subsequent removal
3. Thermal Evaporation with Water Recovery	– Robust removal of a wide range of analytes	– Likely long lead time for thermal treatment options (>18-24 months) – Significantly more expensive in comparison to other options – Very high energy requirements – Potentially complex to operate – Due to the treated water requirement will require a remineralisation step via calcite filter or chemical dosing
4. Thermal Evaporation to Atmosphere	– No liquid recovery for disposal or management	– Likely long lead time for thermal treatment options – Significantly more expensive in comparison to other options – Potentially complex to operate although service agreements may be available to allow specialists to operate – Very high energy requirements
5. Humidification to Atmosphere	– No liquid recovery for disposal or management	– Likely long lead time for thermal treatment options – Significantly more expensive in comparison to other options – Potentially complex to operate – High energy requirements
6. Ion-Exchange	– Good removal of hardness and some metals (depending on form)	– Targets a limited number of analytes – Ion Exchange resin can be difficult to maintain and requires disposal – Additional cost of resin to replace – Potentially complex to operate
7. Reverse Osmosis	– Robust removal of a wide range of analytes – Proven and readily available technology with a large number of applications (enables easy sourcing of maintenance, spare parts and support including operational contracts) – Brine stream to be managed onsite	– Treatment via reverse osmosis removes the majority of dissolved substances from the raw water (i.e. both undesirable contaminants and salts are removed). Some salts (e.g. calcium carbonate) will need to be re-added to the treated water stream to ensure that the water is chemically compatible (i.e. does not excessively dissolve or scale contact materials) with downstream infrastructure and environment.

Based on the summary presented above, reverse osmosis has been selected as the preferred option to be investigated or implemented (if ever required). This is based on the robustness of the technology to treat a wider range of analytes and it being a proven technology used in a number of similar applications (e.g. mine water treatment, landfill leachate etc) with the following reference citing 55 case studies for such applications within Australia from one vendor (MAK Water, 2021). RO operation is typically less complex and has lower delivery times compared with the other technologies considered (with the exception of pond storage) and would achieve similar performance outcomes.

2.2 Preferred Option

2.2.1 Vendor Engagement

Based on the preferred option being RO and the size of the treatment process required being relatively small, two vendors who specialise in these areas were contacted:

- MAK Water
- Watercore.

Two independent vendors' assessments were sufficient to provide a confirmation of suitability of the required technology options and their relative merits.

2.2.2 General Treatment Process

The general treatment process for this system would involve:

- Pump system to remove water from the pond storage to the RO treatment process
- Ultrafiltration (UF) pre-treatment – for the removal of suspended solids, algae and any other potential issues to the membrane
- Cartridge filtration (CF) – used as a polishing step and as a failsafe to protect the RO membrane from any unexpected solids breakthroughs
- Antiscalant (AS) dosing – for removal of scaling and fouling from the membranes
- RO membrane – for removal of problematic analytes within the water. Both vendors estimated RO recovery would be approximately 70% (i.e. 70% of the feed water would report to the treated water stream and 30% of the feed water would report to waste, discussed further in section 2.2.7).
- Calcite filter or chemical dosing – likely to be required for remineralisation of permeate
- Associated instrumentation for control and operation of the system

Figure 2.2 outlines the general treatment process for the system as supplied by MAK Water, with the media filter being an alternative to ultrafiltration.

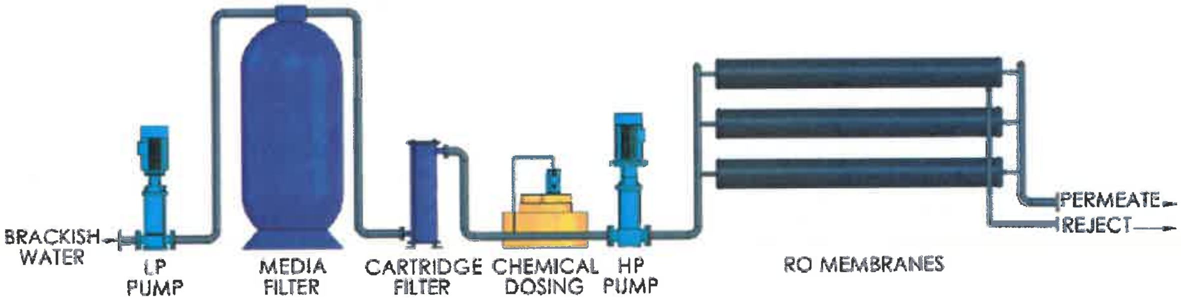

Figure 2.2 Example simplified process schematic (courtesy of MAK Water)

As part of the treatment process there will be a requirement to backwash the membranes and filters and apply antiscalant dosing to extend membrane life through prevention of scaling. This is addressed via the control system and will be an automatic process based on water quality produced to trigger these actions. In the event the unit is required to be stopped due to no or low level in the storage pond, it is recommended that the membranes are flushed and kept hydrated with RO permeate even if the system itself is not operational for a period of days, which the vendors have the capability to do. If the plant is not operational for a period of weeks, the RO membranes will need to be preserved in a sodium bisulphate solution or similar.

2.2.3 Estimated Treatment Performance

Based on the treated water quality requirements outlined in Table 2.3 within Section 2.1.3, there are some potential risks in meeting the target requirements. In particular analytes such as chloride, nitrate and total nitrogen are too high in some of the feed samples (South Creek, Blacktown) to meet the nominated treated water requirements if treated by RO. Therefore, as additional contact water pond and leachate sampling occurs, further clarity will be achieved around likely feed water quality and resultant treated water quality.

Other analytes important for technology design include total suspended solids (TSS), dissolved iron and manganese, free chlorine and total organic carbon (TOC), which are not included within the existing sampling data. Realistic values have been assumed, as outlined in the assumptions, based on previous project experience. However, there is a risk that this will vary resulting in some variation from the values recommended within this study. Supplementary runoff water quality sampling will be required once the fill material is brought on site and more representative runoff samples are available.

The sample data provided does not indicate which form of chromium the sample is based on, with the type of chromium effecting the removal. In water quality analysis the common chromium of interest is Cr(VI), which is what has been assumed for this assessment. If it is found that it is in fact Cr(III) (which is relatively insoluble), or a mixture of the two forms of chromium, then the removal of the precipitated Cr(III) via pre-treatment filtration would result in higher overall removal within the entire treatment process.

In addition, once more sampling data is available, if the treated water quality objectives are not able to be met with single pass RO system, an additional RO pass (i.e. another RO in series) can be utilised to improve overall contaminant rejection rates. Although, this may decrease the overall recovery and consequently increase the volume of waste reintroduced into the emplaced material. These additional volumes could be balanced if needed by the application of cover to increase the shedding of rainfall and reduce infiltration during the operational phase.

There is potential to estimate treated water quality for those parameters not included in the existing sample analyses or to back-calculate from the treated water quality requirements to determine a feed water quality limit for the feed water. However, treatment performance is specific to individual analytes and their interaction, so generalisations or rules-of-thumbs for contaminant removals would be very approximate. Estimates would require further assumptions to be made including pre-treatment removal contribution and the effects of feed pond buffer storage.

This further supports the need for additional sampling during the operational phase for both contact water and leachate per the sampling schedule in the Revised Water Resources Assessment (GHD, 2021). This will provide a more informed water quality dataset for specifying the water treatment technology requirements and arrangement. Individual analytes varying from the assumptions may lead to lower recoveries (i.e. higher waste stream volumes) or multiple pass treatment systems (as outlined above) increasing complexity and costs. There is potential to offset this variation through introducing clean water to dilute the treatment plant feed however the benefit or requirement for this will need to be considered further when more data is available.

In the event that future contact water or leachate has higher contaminant concentrations (for example from different fill materials) than the RO system can treat to achieve the required limits, a number of contingencies are available, which will be employed if necessary:

- Clean water runoff from rehabilitated or natural catchments can be blended with the RO system feed water to assist in achieving the required discharge water quality
- If there is no immediate pressure to discharge from the contact water pond (i.e. there is still sufficient available storage capacity in the pond), treated water may be recycled back into the pond (or a tank to be blended with the pond water for treatment) to gradually improve pond water quality, to a point where the feed water quality can again be treated to meet the treated water quality

Therefore, it is expected that with the treatment system configuration contingencies available, the treated water quality requirements will be achievable (if the treatment plant is required).

2.2.4 Delivery and Commissioning Timeframe

Delivery and commissioning of the system based on the two vendor responses would be in approximately 10-20 weeks. This includes:

- Procurement and manufacturing
  - Design
  - Fabrication

  - Factory Acceptance and Site Acceptance Testing
- Delivery to site via road freight
- Setup and commissioning onsite

The mechanisms to achieve this are described further in the Revised Water Resources Assessment (GHD, 2021).

2.2.5 Footprint

The footprint of the plant and equipment would be approximately one 40-foot shipping container excluding pipelines and feed pump arrangement from feed pond (eastern void storage), and associated tanks. This will comfortably fit within the existing site.

2.2.6 Electrical Requirements

Electrical requirements for the system are estimated to be approximately 30 kW (+/- 20%) installed power, AC 380~450 V, 3 Phase, 50/60 Hz. Given the current site does not have available power supply, it is expected that a generator would provide the necessary power to operate the treatment plant. Noise related impacts of the use of a generator are addressed in the Supplementary EIS Report (GHD, 2021).

2.2.7 Waste Management

A typical and important component of an RO process is the management of the salty waste streams produced (in this case very low brackish salinity i.e. 200-1,000 uS/cm conductivity based on the available feed water quality data), often through a brine management strategy. For this process the following waste streams would be produced:

- Pre-Treatment waste – high in solids content
- RO waste (brine) – higher concentration of analytes
- CIP stream and UF/RO shutdown maintenance chemical waste – diluted and often neutralised chlorine, acid and alkali cleaning waste

These wastes will be consolidated and reintroduced into the lined emplacement for containment. In this way a closed circuit is maintained.

Details on the containment of the untreated contact water, liner, leachate and groundwater assessment are provided in the Revised Water Resources Assessment (GHD, 2021) and draft Environmental Management Plan (GHD, 2021).

3. Conclusion

Whilst it is deemed unlikely that there will be a requirement for water treatment onsite, this assessment has been conducted to demonstrate that there is a feasible water treatment solution available if onsite water management cannot be maintained to contain site runoff on site. The conditions under which the treatment plant would be required are detailed in the Revised Water Resources Assessment (GHD, 2021). A number of shortlisted options were considered with reverse osmosis being selected as the preferred technology.

This option involves the installation of a pump station and piping to deliver water from the onsite storage dam to a containerised treatment system which would include pre-treatment, chemical dosing, RO unit, process waste management and remineralisation of treated water. Waste would be returned to the lined emplacement for containment with treated water discharged to the downstream system.

Once the project commences, as more water quality data is obtained during the operational phase from the insitu runoff, contact water and leachate, and refinement of the water quality data occurs, further assessment will be undertaken to better inform subsequent design stages (if treatment is required).

Contingencies are available and achievable in the event that additional water quality data indicates contact water or leachate water has higher contaminant concentrations than the RO system can treat to achieve the required limits. These include blending of clean water runoff with RO system feed water (contact water or a combination of contact and leachate water) or blending of treated water with RO feed water to aid in achieving treated water discharge limits.

4. References

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Appendix A

Assessment Team

Appendix A – Assessment Team

I (Paul McFadyen) prepared this report with the assistance of GHD's Dr Matthew Brannock and Mr Brendan Dagg.

My and the supporting team's qualifications and experience are summarised below.

Paul McFadyen

Qualifications:

BE: Chemical Engineering (Hons) UQ, 1998

Professional affiliations:

Registered Professional Engineer of Queensland (RPEQ #10778))

Position in GHD:

Technical Director - Water, Water Process and Systems Brisbane

Experience:

Paul McFadyen has 20 years' professional experience as an engineer in the management of mining, industrial and municipal water and waste and the design and commissioning of coal preparation plants. I have considered treatment of water and wastes from the CSG, mining, power generation, alumina refining, metal finishing, food and beverage, pulp and paper, and meat processing industries through investigations, jar trials, pilot plants, design, specification, tendering, installation, commissioning and operations.

Matthew Brannock

Qualifications:

BE: Chemical Engineering (Hons) UQ, 1998

PhD: Environmental Engineering UQ, 2003

Professional affiliations:

MIChemE – Member of Institution of Chemical Engineers

CEng – Chartered Engineer

CSci – Chartered Scientist

Registered Professional Engineer of Queensland (RPEQ #11618)

Member of Australian Water Association

Position in GHD:

Technical Director – Water and Brine, Water Process and Systems Brisbane

Experience:

Matthew Brannock has 20 years of experience in water and wastewater treatment plant design, process modelling and process chemistry. Particularly in the areas covering membrane technology, water treatment, industrial water, desalination, brine management & thermal technology.

Brendan Dagg

Qualifications:

BE: Chemical Engineering (Hons) UON, 2019

Professional affiliations:

Member of Australian Water Association, Regional Representative of NSW Young Water Professional Committee, Secretary of Newcastle Sub-Committee of the NSW Branch

Member of Engineers Australia, Secretary of Newcastle Chemical Branch Committee

Position in GHD:

Process Engineer – Water, Newcastle

Experience:

Brendan has experience in the upgrades of water and wastewater treatment plants including site assessments, capacity assessments, options development, concept and detailed designs. He has additional experience in industrial water including desalination, recycled water, stormwater harvesting, water balances and pipe network modelling. Brendan has worked for clients across Australia and the Pacific including water utilities, local councils and industrial clients in mining, coal loading and coal seam gas.

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Appendix F

Supplementary Ecological Information

Rehabilitation of the Former Bell Quarry - DA 294/19

Supplementary Ecological Information

HWL Ebsworth Lawyers

19 November 2021

Final

cumberland ecology

Report No. 20109RP2

Version	Date Issued	Amended by	Details
1	19 November 2021		Final issued for submission

Approved by:	**Dr David Robertson**
Position:	Director
Signed:	David Robertson
Date:	19 November, 2021

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Glossary

Term / Abbreviation	Definition
BQRP	Bell Quarry Rehabilitation Project Pty Ltd
BQRP	Bell Quarry Rehabilitation Project Pty Ltd
Council	Lithgow City Council
DA	Development Application
DPE	NSW Department of Planning and Environment
EIS	Environmental Impact Statement
ENM	Excavated natural material
EP&A Act	NSW *Environmental Planning and Assessment Act 1979*
EPA	NSW Environment Protection Authority
EPL	Environment Protection Licence
GBMWHA	Greater Blue Mountains World Heritage Area
GDE	Groundwater dependent ecosystem
NSW	New South Wales
OEH	NSW Office of Environment and Heritage
the Project	The Bell Quarry Rehabilitation Project
RMP	Rehabilitation Management Plan
SEARs	Secretary's Environmental Assessment Requirements
Subject land	Lot 23 DP 751631
VENM	Virgin excavated natural material
WRPP	Western Regional Planning Panel

1. Introduction

Cumberland Ecology has been requested by HWL Ebsworth Lawyers on behalf of Bell Quarry Rehabilitation Project Pty Ltd (BQRP) to undertake a supplementary ecological investigation for the Bell Quarry Rehabilitation Project (the 'Project'). The Project sought designated and integrated development consent under Part 4 of the New South Wales (NSW) *Environmental Planning and Assessment Act 1979* (EP&A Act). The Development Application (DA) for the Project was refused by the Western Regional Planning Panel (WRPP) in April 2020. Additional ecological investigations were undertaken for the Project to address some of the reasons for refusal of the DA. These investigations were undertaken within the investigation area, which includes swamp vegetation and adjoining areas, as shown in **Figure 1**.

1.1. Purpose

The purpose of this document is to present the findings of additional ecological investigations for the Project. Specifically, this report will:

- Detail the desktop and field survey methods used;
- Present the findings of the additional ecological investigations, including revised mapping of swamp vegetation and targeted threatened species surveys;
- Provide further details regarding the implications of alterations to the hydrological regime, include surface water and groundwater flows and water quality, on the swamp and habitats/species occurring along the drainage line and swamp; and
- Assess the impacts to the Blue Mountains National Park in accordance with the *Developments adjacent to National Parks and Wildlife Service lands: Guidelines for consent and planning authorities* (NSW Government 2020b); and
- Summarise the proposed rehabilitation works proposed for the Project.

1.2. Project Background

1.2.1. Site Background

Bell Quarry is located on Sandham Road, Dargan, approximately 10 km east of Lithgow, New South Wales (NSW) (the 'subject land') (**Figure 1**). The quarry was in operation under existing use rights between 1967 and 1994, and subsequently operated under a DA approval from Lithgow City Council (Council) and an Environment Protection Licence (EPL) issued by the NSW Environment Protection Authority (EPA) (GHD 2018b). Active operations with the quarry ceased and the EPL was surrendered to the EPA on 24 October 2014 (GHD 2018b). BQRP acquired the quarry site and subsequently undertook future land use planning for the subject land.

The subject land covers a total area of approximately 13.7 hectares (ha) and is divided by the Main Western Railway. The subject land is zoned E3 Environmental Management under *Lithgow Environmental Plan 2014*. It is located adjacent to the Greater Blue Mountains World Heritage Area (GBMWHA), and within the upper reaches of the Wollangambe River Catchment, which forms part of the broader Hawksbury-Nepean catchment.

1.2.2. Project Overview

BQRP is seeking to rehabilitate the subject land, with the final rehabilitated landform to be achieved via importation of virgin excavated natural material (VENM), excavated natural material (ENM) or comparable material (that meets an exemption pursuant to clauses 91 and 92 of the *Protection of the Environmental Operations (Waste) Regulation 2014)*, sourced from earthworks projects across Sydney and the local regional area.

The key features of the Project are identified by GHD (2021b) as follows:

- Importation of approximately 1.2 million cubic metres of VENM, ENM or comparable material (that meets an exemption pursuant to clauses 91 and 92 of the *Protection of the Environmental Operations (Waste) Regulation 2014)*, sourced from earthworks projects across Sydney and the local regional area;
- Vehicle haulage at a rate of up to 140,000 tonnes per annum;
- Emplacement and compaction of soil material within the existing quarry voids;
- Shaping of fill to closely represent the pre-quarry landform and to allow surface water drainage across the final landform;
- Development of a water management system to control surface water discharges throughout the rehabilitation program and from the final landform including a lined contact water pond; and
- Revegetation of the site with locally endemic species to provide effective integration with the surrounding landscape.

1.2.3. Assessment History

1.2.3.1. Secretary's Environmental Assessment Requirements

Secretary's Environmental Assessment Requirements (SEARs) were issued for the Project on 18 November 2016 by the then NSW Department of Planning and Environment (DPE). The SEARs identified the following requirement in relation to biodiversity:

- *accurate predictions of any vegetation clearing on site or for any road upgrades;*
- *a detailed assessment of the potential impacts on any threatened species, populations, endangered ecological communities or their habitats, groundwater dependent ecosystems and any potential for offset requirements; and*
- *a detailed description of the measures to avoid, minimise, mitigate and offset biodiversity impacts.*

The SEARs were developed in consultation with other agencies, including WaterNSW, the Environment Protection Authority and the Department of Primary Industries. The detailed requirements recommended by WaterNSW included biodiversity requirements relating to groundwater dependent ecosystems (GDEs), watercourses, wetlands and riparian land, and stream rehabilitation. At the time the SEARs were issued, the Office of Environment and Heritage (OEH) were unable to provide input to the SEARs, and therefore DPE indicated a requirement for the proponent to consult directly with DPE. OEH subsequently issued requirements on 25 January 2017. These requirements included:

- *assessment of cumulative impacts,*
- *biodiversity [either via the BioBanking Assessment Methodology (BBAM) or a detailed biodiversity assessment, and*
- *impacts to OEH estate.*

1.2.3.2. Environmental Impact Statement

In 2018, BQRP submitted an Environmental Impact Statement (EIS) to support an application for designated and integrated development for the site under Part 4 of the EP&A Act. The EIS was prepared by GHD and included assessment of soil and water resources, biodiversity, traffic, air quality, noise and vibration, cultural heritage, and world heritage. The EIS included a number of supporting documents, including:

- Biodiversity Impact Assessment (GHD 2018a); and
- Water Resources Assessment (GHD 2018c).

1.2.3.3. Submissions and Responses

The DA and associated EIS were placed on public exhibition for 60 days between 19 January and 20 March 2020. Over 500 submissions were lodged, including submissions from NSW government agencies, local councils and the community. A Submissions Report was subsequently prepared by GHD (2019c) to respond to the issues raised in the submissions. The issues raised within the submissions related to the approval pathway, traffic, flora and fauna, water, contamination, social and economic, as well as general issues.

Following the lodgement of the Submissions Report further correspondences relating to environmental matters were issued by OEH (2019), EPA (2019a, c, b, 2020), Lithgow City Council, NSW Department of Planning, Industry and Environment (2019), National Parks and Wildlife Service (2019), and additional information provided by GHD (2019a, b).

1.2.3.4. Refusal

On 6 March 2020 Council issued an assessment report for the Project and recommended that Project be refused. A total of 12 reasons for refusal were provided in the assessment report. The Project was subsequently assessed by the WRPP. The WRPP made a determination to refuse the Project on 6 April 2020. A total of 11 reasons for the refusal were documented in the Determination and Statement of Reasons document issued by the WRPP.

The reasons for refusal primarily relate to environmental harm, including the following reason which is the subject of this review:

> 2. The Environment Protection Authority considers, based on its submissions to Council, that the proposal will have unacceptable environmental impacts on the Greater Blue Mountains World Heritage Area, arising from the following:
>
> i. *it is likely that some of the soil leachates will adversely alter the natural characteristics and ionic balance of water draining into the Greater Blue Mountains World Heritage Area and the Colo River, Greater Blue Mountains World Heritage Area (GBMWHA).*

ii. proposed discharges into a tributary of the Wollangambe River were identified that would impact on a swamp located on the tributary approximately 200m downstream of where the discharge is proposed. The tributary (and its connected swamp) is proposed to receive pumped out water from the quarry pits, any leachate from the material that is emplaced in the pits and overland flow once the area is rehabilitated. The tributary and swamp are in the GBMWHA.

iii. The Biodiversity Impact Assessment identified the Prickly Tea-tree - sedge wet heath swamp below the quarry discharge location as a Newnes Plateau Shrub Swamp (EEC under the TSC Act) and Temperate Highland Peat Swamps on Sandstone (EEC under the EPBC Act).

iv. The existence of the swamp in the headwaters of the drainage line downstream of Bell Quarry strongly suggests that there is a groundwater source which helps support/maintain the swamp in this location.

v. The Water Resources Assessment Section of the EIS has not clearly defined the downstream swamp as a Groundwater Dependent Ecosystem (GOE); it has not assessed the level of groundwater dependence for the swamp and the likely pathways (e.g. disruption of groundwater connections, reduction in groundwater quality) by which the project might impact on the swamp; and it does not consider issues surrounding water discharge rates or their effect on geomorphic stability for the swamp. It has therefore not appropriately assessed the risk the project will have on the THPS swamp.

vi. The dewatering of the quarry voids is likely to present a significant potential to destabilise sediments in the downstream swamp. If an erosional nick-point is established in the swamp, it could lead to the loss of the swamp in its entirety through erosion and gullying.

2. Methodology

2.1. Document Review

A review of key literature relevant to the Project was undertaken to provide an understanding of the Project and relevant biodiversity values. Key documents reviewed for this peer review include:

- DPE (2016): Waste Management Facility. Bell Quarry, Sandham Road, Newnes Junction (Part Lot 23 in DP 751631). Secretary's Environmental Assessment Requirements (SEAR) 1105;
- OEH (2017b): Bell Quarry Rehabilitation – EAR 1105. Letter dated 25 January 2017;
- GHD (2018a): Bell Quarry Rehabilitation Project. Biodiversity Impact Assessment;
- GHD (2018c): Bell Quarry Rehabilitation Project. Water Resources Assessment;
- GHD (2018b): Bell Quarry Rehabilitation Project. Volume 1 – Environmental Impact Statement;
- OEH (2019): Bell Quarry rehabilitation project – DA 294/18. Letter dated 5 February 2019;
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- GHD (2019b): Bell Quarry Rehabilitation Project. Response to Additional EPA Comments – DA294/18. Letter dated 1 November 2019;
- EPA (2020). Bell Quarry Rehabilitation Project DA294/18. Letter dated 13 January 2020;
- Lithgow City Council (2020): Council Assessment Report DA294/18; and
- Western Regional Planning Panel (2020). Determination and Statement of Reasons. 2018WES020 - Lithgow - DA294/18.
- GHD (2021a). Bell Quarry Appeal. Revised Water Resources Assessment.
- GHD (2021b). Bell Quarry Rehabilitation Project. Supplementary Environmental Impact Statement.

- Martens and Associates (2021). Hydrological Study: Proposed Rehabilitation of Bell Quarry.

2.2. Database Analysis

A number of databases were utilised during the preparation of this report, including:

- Environment, Energy and Science (EES) BioNet Atlas;
- EES Threatened Biodiversity Data Collection;
- EES BioNet Vegetation Classification database;
- Commonwealth Department of Agriculture, Water and the Environment (DAWE) Species Profile and Threat Database; and
- DAWE Protected Matters Search Tool.

2.3. Aerial Photography Review

To examine the changes to the swamp extent pre, during and post operation of the quarry, a review of aerial photographs was undertaken. Aerial were obtained as follows:

- 1961 aerial: Provided by GHD;
- 1984, 1991, 1998, 1999 aerials: Downloaded from NSW Department Finance, Services and Innovation Spatial Services Historical Map Viewer; and
- 2021 aerial: Downloaded from NearMap.

2.4. Field Surveys

Field surveys were undertaken within the investigation area between 15 and 19 March 2021. Field surveys included vegetation mapping, plot-based floristic survey, targeted threatened flora survey, habitat assessment, targeted threatened fauna surveys, and incidental observations. Further details of field survey methods are provided below.

2.4.1. Vegetation Mapping

Previous vegetation mapping of the investigation by GHD (2018a) was reviewed prior to the survey, as well as vegetation mapping of nearby areas by DEC (2006). The swamp vegetation was ground-truthed by Cumberland Ecology. Where vegetation community boundaries were found to differ from the existing GHD (2018a) mapping, records were made of new boundaries using a hand-held Global Positioning System and mark-up of aerial photographs. The data collected was analysed and the resultant information was synthesised using a Geographic Information System to produce a revised map of the swamp vegetation with the investigation area.

2.4.2. Plot-based Floristic Survey

Plot-based floristic surveys were undertaken within the swamp vegetation. Surveys followed the Biodiversity Assessment Method (BAM) (NSW Government 2020a) and included establishment of a 20 m x 50 m plot (or equivalent 10 m x 100 m plot) within which the following data was collected:

- Composition for each growth form group by counting the number of native plant species recorded for each growth form group within a 20 m x 20 m plot;
- Structure of each growth form group as the sum of all the individual projected foliage cover estimates of all native plant species recorded within each growth form group within a 20 m x 20m plot;
- Cover of 'High Threat Exotic' weed species within a 20 m x 20m plot;
- Assessment of function attributes within a 20 m x 50 m plot, including:
    - Count of number of large trees;
    - Tree stem size classes, measured as 'diameter at breast height over bark' (DBH);
    - Regeneration based on the presence of living trees with stems <5 cm DBH;
    - The total length in metres of fallen logs over 10 cm in diameter;
- Assessment of litter cover within five 1 m x 1 m plots evenly spread within the 20 m x 50 m plot; and
- Number of trees with hollows that are visible from the ground within the 20 m x 50 m plot.

A total of two plots were surveyed within the swamp vegetation and their locations are shown on **Figure 2**.

All vascular plants recorded or collected were identified using keys provided in *PlantNET* (Botanic Gardens Trust 2021).

2.4.3. Threatened Flora Searches

Three threatened flora species were identified as potentially impacted by the project by GHD (2018a) as detailed in **Table 1**. Targeted threatened flora surveys were undertaken using parallel transects on 18 March 2021 within the swamp vegetation. The location of parallel transects undertaken within the swamp vegetation are shown on **Figure 2**.

Table 1 Potentially impacted threatened flora species and survey period

Scientific Name	Common Name	BC Act Status	EPBC Act Status	Recommended Survey Period	Surveys Undertaken?
Veronica blakelyi		V		Jan-Feb, Dec	Yes
Boronia deanei	Deane's Boronia	V	V	Oct, Nov	Yes
Persoonia hindii		E		Jan-Dec	Yes

2.4.4. Habitat Assessment

A general fauna habitat assessment was undertaken within the investigation area during field surveys. This assessment included consideration of important indicators of habitat conditions and complexity as well as the occurrence of micro-habitats such as tree hollows, fallen logs and riparian areas. An assessment of the structural complexity of the vegetation, the age structure of the forest and the nature and extent of human disturbance was also undertaken. Notes were taken on specific habitat features that may be utilised by threatened fauna species known to occur in the locality.

2.4.5. Threatened Fauna Surveys

Five threatened fauna species were identified as potentially impacted by the project by GHD (2018a) as detailed in **Table 2**. Targeted threatened fauna surveys for three of the potentially impacts species were undertaken between 15 and 19 March 2021. Details of surveys methods and species targeted are provided below.

Table 2 Potentially impacted threatened fauna species and survey period

Scientific Name	Common Name	BC Act Status	EPBC Act Status	Recommended Survey Period	Surveys Undertaken?
Petalura gigantea	Giant Dragonfly	E	-	Jan, Dec	No
Heleioporus australiacus	Giant Burrowing Frog	V	V	Jan-May, Sep-Dec	Yes
Pseudophryne australis	Red-crowned Toadlet	V	-	Jan-Dec	Yes
Litoria littlejohni	Littlejohn's Tree Frog	V	V	Jul-Nov	No
Eulamprus leuraensis	Blue Mountains Water Skink	E	E	Jan-Mar, Oct-Dec	Yes

2.4.5.1. Trapping Transects

Species Targeted: Blue Mountains Water Skink

Two trapping transects were established within the swamp vegetation and included:

- A line of five buckets, spaced approximately 5 m apart, with no drift fence; and
- A line of drift fence with two funnel traps placed at each end of the drift fence.

Trapping transects were check in the morning and early evening, and any fauna captured were identified and released. The location of trapping transects are shown on **Figure 2**.

2.4.5.2. Spotlighting and Call Playback

Species Targeted: Giant Burrowing Frog, Red-crowned Toadlet

Spotlight surveys were conducted using a hand-held spotlight while walking, Spotlighting was undertaken along the length of the swamp as well as approximately 100 m past either end, along the associated drainage line. Spotlighting was undertaken for a period of one hour by two personnel each night, over a total of four nights.

In conjunction with spotlighting surveys, call playback for the Giant Burrowing Frog and Red-crowned Toadlet was also undertaken. Call playback was followed with quiet listening and spotlighting in the immediate vicinity. Call playback was undertaken at two locations within the drainage line associated with the swamp, as shown in **Figure 2**. Call playback was undertaken at each location for four nights.

2.4.5.3. Tadpole Searches

Species Targeted: Giant Burrowing Frog, Red-crowned Toadlet

Diurnal tadpole searches were undertaken within the approximately 100 m of drainage line at either end of the swamp. Two diurnal tadpole searches were undertaken using a dip net. Any tadpole captured were identified and released. The location of tadpole searches are shown on **Figure 2**.

2.4.6. Incidental Observations

Any incidental vertebrate fauna species that was observed, heard calling or otherwise detected on the basis of tracks or signs were recorded and listed in the total species list for the study area.

2.4.7. Weather Conditions

A summary of weather conditions in the wider locality of the investigation area (BOM Weather Station 063226 – Lithgow) during the field survey is provided in **Table 1**. Survey conditions were wet during the survey, with rainfall falling on all survey days.

Table 3 Weather conditions during surveys

Date	Temperature Minimum (°C)	Temperature Maximum (°C)	Rainfall (mm)
15/03/2021	6.9	19.0	8.6
16/03/2021	9.0	16.7	0*
17/03/2021	1.5	14.8	3.2
18/03/2021	12.4	17.9	6.6
19/03/2021	13.5	17.2	22.4

** Rainfall observed on site, despite not being recorded at the local weather station*

2.4.8. Limitations

2.4.8.1. Flora Surveys

With the exception of *Persoonia hindii* which can be surveyed all year round, the targeted flora surveys were not undertaken in the recommended survey period. For *Veronica blakelyi* the surveys in March 2021 were taken just outside the December to February survey period, and it is likely that any late flowering plants would have been detectable. As this species resprouts after fire, conditions after the 2019/2020 bushfires would have been suitable for detection of this species. For *Boronia deanei* the March 2021 surveys were well outside the

October to November recommended survey period, which coincides with late spring flowering. However, as this species is a small shrub with strongly aromatic foliage, it should be detectable when not in flower. Fire ecology for *Boronia deanei* is uncertain, but too intense or too frequent fires can hinder survival and recruitment. As such it is likely that the 2019/2020 bushfires could have impacted on the detectability of this species (if present) in the March 2021 surveys. However, this species was also not detected by GHD (2018a) prior to the 2019/2020 bushfires.

2.4.8.2. Fauna Surveys

Although surveys for the Giant Burrowing Frog were undertaken in the recommended survey period, surveys should also be undertaken within a week of heavy rainfall (i.e. >50 mm in 24 hours or > 100 mm over three days) as detailed in the *NSW Survey Guide for Threatened Frogs* (DPIE 2020b). The rainfall data in **Table 3** indicates that approximately 38 mm of rainfall fell over the five-day survey period. In the three days prior to the survey a further 23 mm of rainfall fell at the BOM Weather Station 063226 – Lithgow. Overall this was a relatively wet period with rain recorded daily (very heavy rainfall fell in the days preceding the survey). As such, while the rainfall detailed in the *NSW Survey Guide for Threatened Frogs* (DPIE 2020b) did not fall during or prior to the surveys, it was part of a wet period, suitable for the detection of frog species.

In contrast, for the Red Crown Toadlet, surveys should not be undertaken if three significant rainfall events > 50 mm in 24 hours) have occurred in the previous three months, or during periods of heavy rainfall (DPIE 2020). Review of rainfall records for BOM Weather Station 063226 – Lithgow indicates that no such rainfall events occurred in the three months prior to the surveys. Despite this, conditions on the final day of surveys when 22.4 mm fell would likely have been unsuitable for detection of this species.

The *Survey guidelines for Australia's threatened reptiles* (SEWPaC 2011) recommend that surveys for the Blue Mountains Water Skink be undertaken between December and January when the species are most likely to be active. However, the species is active on warm sunny days between September and April and as such conditions at the time of survey would have been suitable, with the exception of the relatively cool conditions on 17 March 2021. In addition to the recommended pitfall trapping, the surveys also included the use of funnel traps to supplement the pitfall trapping.

3. Results

3.1. Swamp Vegetation

3.1.1. Floristic Description

The swamp vegetation within the investigation area includes a *Leptospermum*-dominated southern extent and a sedge dominated northern extent. Due to the 2019/2020 bushfires, the margins of the swamp were readily identifiable on ground, with clear edges where the swamp vegetation transitioned to eucalypt forest. The *Leptospermum*-dominated portion of the swamp is shown in **Photograph 1** and the sedge-dominated portion of the swamp is shown in **Photograph 2**.

Emergent trees occur within the central and southern extent of the swamp, and predominantly are *Eucalyptus piperita* (Sydney Peppermint). Shrubs are very common in the southern extent of the swamp, occurring less frequently in the northern extent. Commonly recorded shrubs include *Acacia longifolia*, *Leptospermum polygalifolium* (Tantoon), *Leptospermum grandifolium* (Woolly Teatree), and *Baeckea linifolia* (Weeping Baeckea). A diversity of rushes, sedges and grasses occur throughout the swamp. This includes *Lepidosperma limicola*, *Eurychorda complanata*, *Empodisma minus*, *Entolasia stricta* (Wiry Panic), *Deyeuxia mckiei*, *Xyris gracilis*, *Baloskion australe*, and *Microlaena stipoides* (Weeping Grass). Commonly occurring forbs include *Hydrocotyle hirta* (Hairy Pennywort), *Gonocarpus micranthus* (Ivy-leaved Violet), *Viola hederacea*, *Opercularia varia* (Variable Stinkweed), *Geranium potentilloides* var. *abditum*, *Pseudognaphalium luteoalbum* (Jersey Cudweed) and *Wahlenbergia gracilis* (Sprawling Bluebell). Exotic species are rare within the swamp vegetation, and included *Hypochoeris radicata* (Catsear), *Conyza bilbaoana*, and *Conyza bonariensis* (Flaxleaf Fleabane).

Photograph 1 *Leptospermum*-dominated swamp vegetation

Photograph 2 Sedge-dominated swamp vegetation

3.1.2. Geomorphic Description

Martens and Associates (2021) have identified the following geomorphic conditions relevant to the swamp:

- The swamp has formed within a relatively narrow and evenly graded valley floor which accumulates a range of coarse sediments including bushfire charcoals;
- No defined channel is present within the swamp, although there is evidence of historic intermittent erosion and subsequent deposition events during periods of channelisation. These likely occurred drying heavy rainfall when vegetation cover was diminished or distressed (for example after a bushfire or during extended dry periods);
- Water inflow at the upstream end of the swamp arrives via a narrow channel approximately 0.5-1.0 m wide and up to 0.5 -1.0 m deep. However, the channel form diminishes to nothing at the entry point to the swamp where surface flows are infiltrated into the sandy sediment; and
- Water outflows, including shallow groundwater seepage and overland flows, are reconcentrated at the downstream end of the swamp, where a small approximately 1.0 m wide and 0.5 m deep channel re-emerges.

3.1.3. Plant Community Type

Identification of the swamp vegetation PCT was guided by the results of the surveys undertaken by Cumberland Ecology. The data collected during surveys of the swamp was analysed in conjunction with a review of the PCTs held within the BioNet Vegetation Classification database. In selecting PCTs, consideration was given to the following:

- Occurrence within the Wollemi IBRA subregion;
- Frequently recorded species;
- Vegetation formation;
- Alignment with TECs;
- Landscape position; and
- Association with nearby vegetation map units by DEC (2006).

Table 2 details the process of PCT selection for swamp vegetation. The swamp vegetation has been assessed as conforming to PCT 1078 Prickly Tea-tree - sedge wet heath on sandstone plateaux, central and southern Sydney Basin Bioregion.

Table 4 Process of PCT selection for swamp vegetation

PCT Filtering Criteria Used	PCTs Considered	Selected PCT	Associated Species
1. Within the Wollemi IBRA subregion, and the presence of at least two of: *Lepidosperma limicola, Acacia longifolia, Leptospermum polygalifolium, Eurychorda complanata, Empodisma minus*	657, 788, 1078, 1828	1078 Prickly Tea-tree - sedge wet heath on sandstone plateaux, central and southern Sydney Basin Bioregion	Mid Stratum Species: *Baeckea linifolia* *Banksia ericifolia* Ground Stratum Species: *Drosera binata* *Empodisma minus* *Lepidosperma limicola*
2. Formation: Freshwater Wetlands	657, 788, 1078,		
3. Associated with the Newnes Plateau Shrub Swamp in the Sydney Basin Bioregion TEC (see Section 3.1.3)	657, 1078		
4. Landscape position: Gently sloping headwaters on sandstone	657, 1078		
5. Associated with MU50 and MU51 of The Vegetation of the Western Blue Mountains (DEC (NSW) 2006)	1078		

3.1.4. Threatened Ecological Community

i. NSW

Within the BioNet Vegetation Classification database, PCT 1078 is associated with the following TECs:

- Blue Mountains Swamps in the Sydney Basin Bioregion;
- Coastal Upland Swamp in the Sydney Basin Bioregion;
- Montane Peatlands and Swamps of the New England Tableland, NSW North Coast, Sydney Basin, South East Corner, South Eastern Highlands and Australian Alps bioregions; and
- Newnes Plateau Shrub Swamp in the Sydney Basin Bioregion.

Based on distributional information and floristic composition, the swamp vegetation was considered to potentially conform to the Blue Mountains Swamp TEC or the Newnes Plateau Shrub Swamp TEC. These two TECs are closely related and include shared species and some environmental variables. The two TECs are known to transition near Bell and Clarence at approximately 850-950m above sea level (NSW Scientific Committee 2011b, a). The Blue Mountains Swamp TEC spans an altitudinal range of approximately 500-950 m above sea level (NSW Scientific Committee 2011a), and the Newnes Plateau Shrub Swamp TEC occurs at approximately 900-1,200 m above sea level (NSW Scientific Committee 2011b). Due to the significant overlap in floristic and environmental attributes, the determination of the TEC within the investigation area is based on the altitudinal range of the communities. As the swamp vegetation within the investigation area is located between 1,000 and 1,030 m above sea level, it has been associated with the Newnes Plateau Shrub Swamp TEC.

Attributes which align the swamp vegetation with the Newnes Plateau Shrub Swamp TEC include:

- Vegetation dominated by shrubs and sedges;
- Located in an area with impeded drainage in a low slope headwater valley;
- Forms a narrow, elongated swamp in a low slope headwater valley;
- Includes numerous characteristic species, including *Baeckea linifolia, Baloskion australe, Blechnum nudum, Daviesia latifolia, Drosera spatulata, Empodisma minus, Epacris paludosa, Gahnia sieberiana, Gonocarpus micranthus, Goodenia bellidifolia, Juncus continuus, Lepidosperma limicola, Leptospermum continentale, Leptospermum grandifolium, Lepyrodia scariosa, Lomandra longifolia, Xanthosia dissecta*, and *Xyris gracilis*;
- Located between 1,000 and 1,030 m above sea level; and
- Occurs on deep sandy sediments that are permanently or periodically waterlogged.

Newnes Plateau Shrub Swamp TEC is listed as an endangered ecological community under the BC Act.

ii. Commonwealth

The Newnes Plateau Shrub Swamp TEC listed under the BC Act is included in the EPBC Act listed endangered ecological community Temperate Highland Peat Swamps on Sandstone (DEWHA 2005). The EPBC Act listing specifically applies to swamps with peaty soils. Temperate Highland Peat Swamps on Sandstone are associated with black to grey coloured acid, peaty soils, have moderate to high organic matter content and generally a sandy or loamy texture, and are poorly drained and hence permanently or periodically/intermittently waterlogged. In the Newnes Plateau and Blue Mountains, the soils have been described as peat, peaty loam, loam, clay loam, humic loam, humic peat, silty clay, peaty sand, sandy peat and organic sand. The deep sandy sediments that are permanently waterlogged that the support swamp vegetation in the investigation area are consistent with peaty soils, and therefore the EPBC Act listed community. The swamp vegetation includes numerous characteristic species, including *Blechnum* sp., *Microtis* sp., *Eleocharis* sp., *Empodisma minus*, *Isolepis* sp., *Juncus* sp., *Lepidosperma limicola*, *Lepyrodia scariosa*, *Schoenus apogon*, *Hemarthria uncinata*, *Epacris microphylla*, *Epacris paludosa*, *Epacris* sp., *Baeckea linifolia*, *Banksia spinulosa*, *Hakea* sp., and *Leptospermum* sp.

3.2. Swamp Extent

3.2.1. Current Extent

The current extent of the swamp vegetation is shown in **Figure 3** and covers a total of 0.87 ha.

3.2.2. Historical Extent

Figure 4 shows historical (1961, 1984, 1991, 1998 and 1999) and current (2021) aerial imagery of the investigation area. In 1961 the swamp vegetation is difficult to detect due to image quality, however shadowing on the image suggest the swamp vegetation is largely in the same location as the current, with a second narrow swamp located upstream. This second swamp was cleared prior to 1984. In the 1984, 1991 and 1999, the extent of swamp vegetation appears to be slightly to the north west of the current distribution, however this is likely due to imagery alignment and shadowing. In the 1998 arial imagery swamp vegetation is similar to the current extent. Post bushfire in 2021 the swamp vegetation is clearly visible on aerial imagery due to removal of surrounding dense vegetation through fire. Overall there is little identifiable change in the extent of swamp vegetation in historical aerial imagery since 1961, including after the establishment of the quarry.

3.3. Swamp Interaction with Surface Water and Groundwater

Martens and Associates (2021) have undertaken studies within the swamp to ascertain the swamp's reliance on surface and groundwater flows, and document existing swamp geomorphic conditions to provide supplementary detailed data on existing site and downstream hydrological conditions. Martens and Associates (2021) provides the following observations regarding surface water and groundwater interaction at the swamp:

- Groundwater within the swamp develops in response to direct rainfall and surface inflows arriving from the catchment which are developed both within the subject land but also within adjoining valley areas;
- As surface water inflows enter the swamp, these spread out and typically flow in an unchannelised manner over the swamp surface where due to the high sand content of swamp soils, there is a high degree of infiltration;
- Infiltrated surface water causes a perched water table to develop which sits over the underlying sandstone bedrock. This water table is ephemeral and has the capacity to recharge the underlying permanent water table;

- Perched water within the swamp exits at the downstream portion of the swamp into a narrow formed channel; and
- The swamp surface does not appear to have been the subject of any current significant erosion, although there is evidence that historical erosive events have occurred.

The surface water quality monitoring undertaken by Martens and Associates (2021) found the following:

- Surface waters are fresh and slightly acidic;
- Nutrient are generally low, although elevated levels were found in the quarry ponds;
- Heavy metals and hydrocarbon concentrations were low or below the detection limit; and
- The area downstream of the subject land is classified as a disturbed ecosystem due to historical catchment urban and quarrying activities, and construction of roads and clearing within the catchment. Surface water chemistry is generally within ANZG criteria for slightly to moderately disturbed freshwater ecosystems.

Martens and Associates (2021) describe the flow regime associated with the swamp as follows:

- Flows to the hanging swamp appear to be directly related to incidence of local rainfall (i.e. flows rely on surface flows from rainfall as opposed to base flows from groundwater); and
- Local catchments have a relative rapid response with flows commencing not long after commencement of precipitation. Hydrographs are correspondingly short with relatively short rising limb to the peak and then a somewhat longer falling limb of the hydrograph denoting that flows continue for some time afterwards (Figure 14). This response is characteristic of the relatively shallow sandy catchment soils and frequent bedrock outcropping within the catchment.

3.4. Threatened Flora Species

No threatened flora species were detected in the surveys by GHD (2018a) or Cumberland Ecology. The full list of flora species detected is listed in **Appendix A**. While some species could only be identified to the genus level, there are no locally occurring threatened species from within those genera.

3.5. Threatened Fauna Species

No threatened fauna species were detected in the surveys by GHD (2018a) or Cumberland Ecology, with the exception of a possible (unconfirmed) ANABAT call detection for the Large Bent-winged Bat (*Miniopterus orianae oceanensis*) by GHD (2018a). The Large Bent-winged Bat is listed as vulnerable under the BC Act. The full list of fauna species detected is listed in **Appendix B**.

4. Discussion

4.1. Assessment of Impacts to the Swamp

The Project does not directly impact the swamp located downslope of the subject land. The Project does however have the potential to indirectly impact the swamp through an altered hydrological regime. Martens and Associates (2021) identified the following potential implications to the swamp as a result of the findings on the groundwater interaction at the swamp (see ***Section 3.3***):

- Groundwater flows from the filled quarry voids is not likely to contribute to groundwater flows within the swamp because these are controlled by surface water inflows and direct rainfall;
- Perched groundwater that occurs within the swamp will at times recharge deeper groundwater; and
- Surface flows discharged from the subject land during filling operations and following completion of the final landform will likely enter the swamp area and contribute to the hydrology and water chemistry of the perched water table.

As investigations indicate that the swamp is not hydraulically connected to groundwater emanating from the subject land, it has been conservatively assumed that groundwater discharges to the creek line directly down gradient of the swamp and that the nearest ecological receptor is located at this point (GHD 2021a). Groundwater discharge is expected to be further downgradient than this location (GHD 2021a).

During the upper void dewatering stage, groundwater heads below the swamp will be reduced.by around 0.5 m compared to existing conditions, effectively returning the head pressures to pre-quarry conditions (Martens and Associates 2021). This is not considered to affect groundwater conditions in the swamp because the groundwater will continue to be controlled by surface inflows and direct recharge (Martens and Associates 2021).

Martens and Associates (2021) indicate that following completion of the final design surface, including retaining the lower void, modelling indicates that there will be no material changes to the existing hydrological regime at the swamp, with some return of flows towards those experienced under pre-quarrying conditions for mid-range flows.

The findings of both GHD (2021a) and Martens and Associates (2021) suggest that indirect impacts through an altered hydrological regime and minimal. Notwithstanding this, it is recommended that ongoing monitoring is undertaken so that, if required, corrective actions can be implemented. Monitoring includes both hydrological regime monitoring, and monitoring of floristic variables within the swamp vegetation.

4.2. Assessment of the Do Nothing Scenario on the Swamp

There is no evidence that the quarrying upstream of the swamp has had major detrimental impacts on the swamp composition or ecology. The swamp appears to have been relatively stable since the cessation of quarrying. Under current conditions the major threat to the viability and integrity of the swamp is via climate change as explained below.

The final determination for the Newnes Plateau Shrub Swamp (NSW Scientific Committee 2011b) identifies the following threats as being relevant to the TEC:

- Small-scale clearing, fragmentation, erosion and sedimentation associated with roadworks, quarrying and periodic timber harvesting from adjacent plantations;
- Changes to drainage and moisture conditions caused by damming of swamp watercourses; roading across the swamps; sedimentation and erosion associated with roadways, quarries, mines and plantation harvesting within swamp catchments; and disposal of waste water from underground coal mines; and
- Subsidence of the land surface, and associated fracturing of bedrock between the coal seam and the surface, occurs after longwall mining, and this may change the hydrology of catchments and swamps they contain.

Invasion of exotic species, including species of *Pinus*, and changes to fire regimes may also pose a threat to the TEC if any of the aforementioned processes result in physical displacement of vegetation, increased influx of sediments and/or nutrients or significant drying of the swamps (NSW Scientific Committee 2011b).

In the do nothing scenario, no detrimental land use activities are likely to occur without approval and consideration of impacts and implementation of mitigation measures. Therefore, the do nothing scenario would comprise the persistence of current threats to the TEC. These current threats include:

- Alteration of the natural flow regime of the associated waterway, resulting from the previous land uses upstream;
- Weed invasion resulting from public access within the Blue Mountains National Park; and
- Human caused climate change.

As noted in ***Section 3.2***, based upon examination of aerial photography there has been little identifiable change in the extent of the swamp since 1961. This is despite the establishment of the quarry and historic alteration of natural flow regimes. Groundwater within the swamp has been found to develop in response to direct rainfall and surface inflows arriving from the catchment which are developed both within the subject land but also within adjoining valley areas (Martens and Associates 2021). Therefore the swamp has continued to be sustained by direct rainfall and surface inflows during, and post, use of the quarry.

The historic altered flow regime may have impacted the species composition within the swamp and could continue to do so within the do nothing scenario, though no long term monitoring data is available to substantiate this. Species composition can change in response changing flow volume and frequency, and water chemistry. Flow volume and frequency can affect the characteristics of the swamp. These impacts could be positive (e.g. increased availability of water and potential expansion of the swamp area) or negative (e.g. transfer of swamp soils downstream). Changes to water chemistry have the potential to alter both flora and fauna species composition, as certain conditions are favoured by other species and detrimental to others. In the do nothing scenario, water chemistry is not anticipated to change from current conditions.

Weed invasion may occur within the swamp due to the nearby access track intersecting the drainage line that flows into the swamp, as well as propagules entering the drainage system. Weeds can compete with and displace native species altering the floristic composition of the swamp. In the do nothing scenario, the threat of weed invasion is not anticipated to change from current conditions. However, there is no evidence of this at present.

Human induced climate change can involve both changes in average temperature conditions and changes to the frequency of occurrence of extreme events (OEH 2017a). Changes to temperature conditions and frequency of fire events can readily impact swamp vegetation and habitat. The swamp was recently impacted by the 2019/2020 bushfires. Observable impacts to the swamp include the burning of the *Leptospermum*-dominated southern extent of the swamp. The bushfire may have impacted local surface flow regimes upslope of and within the swamp, by reducing surface cover and changes to infiltration characteristics of local soils (Martens and Associates 2021). Changes in temperature conditions, and subsequent changes to hydrological regimes, can also lead to a contraction of swamp extent and alteration of the floristic composition. In the absence of any other observable harmful changes, human induced climate change is the greatest long term threat to swamp vegetation. In the do nothing scenario, the threat of human induced climate change is not anticipated to change from current conditions.

4.3. Assessment of Impacts to the Blue Mountains National Park

The subject land is connected directly to Blue Mountains National Park to the east and north to the south and east (see **Figure 1**). An assessment of impacts to the Blue Mountains National Park has been undertaken in accordance with the *Developments adjacent to National Parks and Wildlife Service lands: Guidelines for consent and planning authorities* (NSW Government 2020b). These guidelines identified the following issues as requiring consideration:

- Erosion and sediment control;
- Stormwater runoff;
- Wastewater;
- Pests, weeds and edge effects;
- Fire and the location of asset protection zones;
- Boundary encroachments and access through NPWS land;
- Visual, odour, noise, vibration, air quality and amenity impacts;
- Threats to ecological connectivity and GDEs;
- Cultural heritage; and
- Access to parks.

Each of these issues is discussed below.

4.3.1. Erosion and Sediment Control

Erosion and sedimentation can result in deposition of sediments on vegetation and in creeks, rivers, wetlands and other aquatic habitats, including changes to the hydrology of streams (NSW Government 2020b)..

Erosion and sedimentation impacts are most likely to occur in proximity to roads, tracks, infrastructure and adjacent to the subject land.

The Project has the potential to alter hydrological flows within the investigation area. The waterways within the investigation area flow into a tributary of the Wollangambe River through the swamp located on the tributary approximately 200m downstream of where the discharge is proposed.

The aim of erosion and sediment control on NPWS estate is to prevent erosion and the movement of sediment onto NPWS land, and ensure no detrimental change to hydrological regimes (NSW Government 2020b). The potential impacts will be minimised by erosion and sediment controls implemented as part of a surface water management plan for the Project. Any discharges into waterways within the investigation area will be undertaken in accordance with approved guidelines. NPWS estate is not considered to be significantly impacted by erosion and sedimentation as a result of the Project.

4.3.2. Stormwater Runoff

The aim of stormwater runoff management on NPWS estate is for nutrient levels to be minimised, and for stormwater flow regimes and patterns to mimic natural levels before it reaches the NPWS estate (NSW Government 2020b).. The potential impacts will be minimised through the implementation of a surface water management plan for the Project. Any discharges into waterways within the investigation area will be undertaken in accordance with the relevant stormwater guidelines. The Project would modify surface flows within the drainage line exiting the subject land and potentially affect water quality in this area of the Blue Mountains National Park (GHD 2018a). These changes would be relatively minor and temporary. Following the completion of rehabilitation the NPWS estate will not be significantly impacted by stormwater runoff as a result of the Project.

4.3.3. Wastewater

The aim of wastewater management on NPWS estate is to ensure there are no adverse impacts due to wastewater (NSW Government 2020b). The potential impacts will be minimised through the implementation of a water management plan for the Project that will address discharges of water within the investigation area. Discharges into waterways within the investigation area will be undertaken in accordance with approved guidelines. NPWS estate is not considered to be significantly impacted by wastewater as a result of the Project.

4.3.4. Pests, Weeds and Edge Effects

The aims for management of pests, weeds and edge effects on NPWS estate are to ensure an adjoining project does not (NSW Government 2020b):

- Lead to increased impacts from invasive species (weeds and pests), domestic pets and stock;

- Facilitate unmanaged visitation, including informal tracks, resulting in negative impacts on cultural or natural heritage values;
- Lead to impacts associated with changes to the nature of the vegetation surrounding the reserve; and
- Impede NPWS access for management purposes, including inappropriate fencing.

The investigation area and adjoining National Parks are currently impacted by a suite of feral species including foxes (*Vulpes vulpes*), dogs (*Canis lupus*), pigs (*Sus scrofa*) and goats (*Capra hircus*). The Project has the potential to result in the exacerbation of the impacts of weeds and feral animals. Weed and feral animal management will also be incorporated into management of land within the investigation area during construction and operation of the Project . The Project is not considered to result in increased impacts from invasive species to NPWS estate.

The subject land is located in close proximity to the boundary of the adjoining Blue Mountains National Park.

Access to the Blue Mountains National Park from the investigation area is currently limited. No formal access tracks enter these areas. Sandham Road, which currently provides access to the quarry forms the boundary to the Blue Mountains National Park, and this is not anticipated to change. As such, the Project is not expected to impede the existing access to the Blue Mountains National Park. Should any fencing be required at the boundary of the quarry, it will be undertaken in accordance with the *Boundary Fencing Policy* (DPIE 2020a).

4.3.5. Fire and the Location of Asset Protection Zones

The aim of fire and asset protection zones management on NPWS estate is to ensure all asset protection measures are undertaken within the development area and there is no expectation for NPWS to alter its fire management regime (NSW Government 2020b). The Project does not include the provision of asset protection zones. Bushfire hazards within the investigation area will be assessed and managed in accordance with the relevant legislative requirements. As such, it is not considered that the NPWS fire management regime for the adjoining National Parks will be required to change.

4.3.6. Boundary Encroachments and Access through NPWS Land

The aim of boundary encroachment and access management on NPWS estate is to ensure no pre-construction, construction or post-construction activity occurs on NPWS estate and that access to the estate must be legally authorised and comply with park management objectives.

No additional clearing is proposed in close proximity to the boundaries of adjoining National Parks. No access to the Blue Mountains National Park is proposed.

4.3.7. Visual, Odour, Noise, Vibration Air Quality and Amenity Impacts

The aim of visual, odour, noise, vibration, air quality and amenity impact management on NPWS estate is to ensure there is no reduction of amenity on NPWS estate due to adjoining developments (NSW Government 2020b). The visual disturbance associated with the Project will be located in the vicinity of rehabilitation of the existing quarry. Visibility of the quarry is largely restricted to the perimeter fence. Rehabilitation of the site will involve emplacement of clean fill within the existing footprint to enable the site to be returned to a condition closely representing the original landform and be visually integrated with the adjoining Blue Mountains National Park (GHD 2018b). The final landform would be progressively revegetated with locally endemic species to provide effective control or erosion and integration with the surrounding landscape. As rehabilitation progresses and vegetation grows, visual impacts of the quarry will be reduced. The visual disturbance generated by the Project is not considered to reduce the amenity of the Blue Mountains National Park.

The Project has potential to generate dust through the rehabilitation activities and vehicle haulage along Sandham Road which adjoins the Blue Mountains National Park. The site is located in a rural environment and periodically experiences high level of background dust generated from surrounding landuse including nearby mining and quarry operations and vehicles travelling on unsealed roads (GHD 2018b). The Project is anticipated to have a small incremental impact on dust emissions in the immediate vicinity of the quarry. All impacts will fall within the relevant EPA air quality criteria and is not anticipated to significantly impact upon any sensitive receivers within the Blue Mountains National Park (GHD 2018b). Dust will also be generated by haulage vehicles travelling along unsealed sections of Sandham Road which is used for access to the site. Detailed air quality modelling demonstrates that adoption water spraying along Sandham Road in dry and windy conditions will limit the potential for dust impacts within the Blue Mountains National Park and comply with EPA criteria (GHD 2018b).

Vibration impacts may result from works associated with the Project, such as heavy vehicle movement and construction and operational activities (GHD 2018a). Historically vibration would have been substantially higher during quarrying activities, however since quarrying ceased, vibration levels within the subject land are low. Typical vibration levels from activities such as use of a vibratory roller are generally negligible at distances greater than 100 metres, including within the adjacent Blue Mountains National Park (GHD 2018a).

All noise generating works associated with the Project are predicted comply with the project noise trigger levels at surrounding residential receivers (GHD 2018b) The maximum noise emission levels from the site are not greater than Laeq 50 dBA (NPI's recommended amenity noise level for passive recreational area) when calculated to either 200 metres south, north-east or north of the site boundary. The National Park areas will likely receive noise levels from the quarry site below Laeq 50 dBA (GHD 2018b).

4.3.8. Threats to Ecological Connectivity and Groundwater Dependent Ecosystems

The aims of ecological connectivity and GDE management on NPWS estate are to ensure (DECCW 2010):

- Native vegetation and other flora and fauna habitats that provide a linkage, buffer, home range or refuge role on land that is adjacent to reserves are maintained and enhanced, where possible; and
- GDEs in NPWS estate are protected.

The Project will not remove additional habitat (beyond that previously cleared for the operation of the quarry) for native flora and fauna adjacent to National Parks. The land previously cleared has connectivity to the adjacent Blue Mountains National Park and is effectively an 'island' of cleared land surrounded by intact native vegetation on all sides. As the quarry is progressively rehabilitated the growth of vegetation will improve connectivity with the adjacent National Park and other native vegetation outside the National Park.

Observations of groundwater interaction at the swamp in the National Park by Martens and Associates (2021) have indicated that groundwater develops in response to direct rainfall and surface inflows arriving from the catchment which are developed both within the subject land but also within adjoining valley areas. Therefore altered groundwater flows resulting from the Project is not likely to contribute to groundwater flows within the swamp.

4.3.9. Cultural Heritage

All rehabilitation activities will be undertaken with the existing quarry footprint and haulage will utilise the existing public road network. There is considered minimal potential to disturb natural ground surface of culturally modified trees. The site has been disturbed during the previous extraction activities and there is no evidence that the site was previously used intensively by Aboriginal people (GHD 2018b).

The target resource for the original quarry was a weathered sandstone and no sandstone outcrops suitable for Aboriginal occupations have been identified in the area. The landform was previously steep and lacked permanent water making it unsuitable for a large camp site. GHD 2018b). As such, it is considered highly unlikely that rehabilitation would impact on cultural heritage within the adjacent Blue Mountains National Park.

4.3.10. Access to Parks

No additional access is proposed to the Blue Mountains National Park and no additional access will be created. Vehicle haulage for rehabilitation will be along Sandham Road which forms the boundary of the Blue Mountains National Park. However this road will remain accessible to the public.

4.4. Rehabilitation Works

A key objective of the Project is to rehabilitate the project area to a condition closely representing the original landform and that of the adjoining Blue Mountains National Park (GHD 2018b). A Rehabilitation Management Plan (RMP) will be prepared for the Project and will include details on:

- Objectives of rehabilitation works;
- Staging of rehabilitation works;
- Rehabilitation phases; and
- Species composition for PCTs being rehabilitated; and
- Monitoring requirements.

Indicative details of these aforementioned parameters are provided below. Detailed completion criteria will be contained within the RMP. The rehabilitation works will be undertaken both within the Project area and portions of Lot 7031 and 7032 DP 1066257.

4.4.1. Objectives

The objectives of the rehabilitation works within the Project area are to:

- Undertake staged rehabilitation across the Project area;

- Reprofile the land within the Project area to create a stable landform that integrates with the surrounding landscape;
- Establish a soil profile suitable for revegetation works;
- Revegetate the land within the Project Area with native plant species that are representative of the native PCT adjoining the Project area, and using local provenance plants; and
- Conduct monitoring and maintenance of the rehabilitation works.

4.4.2. Staging

The Project will be undertaken during four key stages.. Within the four key stages, rehabilitation is proposed to occur progressively, as per **Table 5**. The staging plans are provided within the Supplementary Environmental Impact Statement (GHD 2021b).

In addition to these stages, rehabilitation works will cover the office/ amenities area to the south of the contact water pond and the temporary stockpile area in the north-east corner of the project area.

Table 5 Extent of rehabilitation works by project stage

Stage	Total (ha)	Cumulative Total (ha)
1A	-	-
1B	0.40	0.40
2	1.19	1.59
3A	-	1.59
3B	1.17	2.76
3C	0.82	3.57
3D	1.01	4.59
4	2.22	6.81

4.4.3. Phases

Rehabilitation works will be undertaken across the following key phases:

- Landform reshaping. This will include the filling of voids to final landform levels;
- Soil replacement. This will include the capping of areas as they reach final surface levels;
- Revegetation. This will include the seeding and planting of native plant species that are representative of the native PCT adjoining the Project area, and using local provenance sources of seeds and plants.
- Maintenance. This will include ongoing maintenance and follow up activities within rehabilitated areas.
- Monitoring. This will include annual monitoring of rehabilitation works until completion criteria are met. Where required, corrective actions, such as plant replacement, weeding, erosion control will be undertaken.

4.4.4. Species Composition

All revegetation works within the rehabilitated land will focus on the creation of PCT 1248: Sydney Peppermint - Silvertop Ash heathy open forest. This PCT is located both within the Project area and in surrounding land. Approximately 6.81 ha of PCT 1248 will be revegetated within the Project area (see **Table 5**). A list of species suitable for use in rehabilitation works is provided in **Appendix C**.

4.4.5. Monitoring Requirements

A monitoring program will be implemented to assess the progression of rehabilitation works against performance criteria, and to identify corrective actions required to address non-conformances. Monitoring will include both annual monitoring and long-term monitoring.

The monitoring will include, but not be limited to:

- Assessment of revegetation success rates;
- Assessment of weed invasion;
- Assessment of landform (erosion);
- Plot-based vegetation monitoring; and
- Assessment of performance criteria.

Should performance criteria not be met, a range of correction actions may need to be undertaken. This may include:

- Supplementary seeding/planting;
- Increase weed management activities or implementation of alternative techniques; and
- Remediation of erosion.

A Trigger Action Response Plan will be developed as part of the RMP.

4.5. Terrestrial Biodiversity

Under the *Lithgow Local Environmental Plan 2014*, the northern and western extents of the project area are included on the 'Terrestrial Biodiversity' map. The objective of this clause is to maintain terrestrial biodiversity by:

a. protecting native fauna and flora, and

b. protecting the ecological processes necessary for their continued existence, and

c. encouraging the conservation and recovery of native fauna and flora and their habitats.

The portions of the project area that are included on the 'Terrestrial Biodiversity' layer includes land that has been disturbed by previous quarrying activities. These areas currently comprise either the existing void or regrowth vegetation. Key elements of the Project include:

- Shaping of fill to closely represent the pre-quarry landform and to allow surface water drainage across the final landform;
- Development of a water management system to control surface water discharges throughout the rehabilitation program and from the final landform including a lined contact water pond; and
- Revegetation of the site with locally endemic species to provide effective integration with the surrounding landscape.

Therefore the Project is seeking to improve the current condition of the biodiversity values within the project area. These works will be facilitated by the implementation of a number of environmental management measures that will minimise indirect impacts to adjoining areas of biodiversity value.

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APPENDIX A :

Flora Species List

Table 6 Flora species list

Family	*	Scientific Name	Common Name	BC Act Status	EPBC Act Status	GHD	Cumberland Ecology		
							Plot 1	Plot 2	Incidental
Acanthaceae		*Brunoniella australis*	Blue Trumpet	-	-	X			
Apiaceae		*Daucus glochidiatus*	Native Carrot	-	-	X			
Apiaceae		*Hydrocotyle hirta*	Hairy Pennywort	-	-		X	X	X
Apiaceae		*Hydrocotyle laxiflora*	Stinking Pennywort	-	-				X
Apiaceae		*Platysace linearifolia*		-	-	X			X
Apiaceae		*Xanthosia atkinsoniana*		-	-		X	X	X
Apiaceae		*Xanthosia dissecta*	Cut-leaved Xanthosia	-	-		X		X
Apiaceae		*Xanthosia pilosa*	Woolly Xanthosia	-	-	X			
Araliaceae		*Polyscias sambucifolia*	Elderberry Panax	-	-	X			X
Asteraceae		*Arrhenechthites mixta*	Purple Fireweed	-	-	X			
Asteraceae		*Cassinia aculeata*	Dolly Bush	-	-	X			
Asteraceae		*Cassinia aculeata* subsp. *aculeata*		-	-				X
Asteraceae		*Chrysocephalum apiculatum*	Common Everlasting	-	-				X
Asteraceae		*Coronidium scorpioides*	Button Everlasting	-	-	X		X	X
Asteraceae		*Euchiton sphaericus*	Star Cudweed	-	-	X			X
Asteraceae		*Ozothamnus diosmifolius*	White Dogwood	-	-	X			X
Asteraceae		*Pseudognaphalium luteoalbum*	Jersey Cudweed	-	-		X	X	X
Asteraceae		*Solenogyne gunnii*	Solengyne	-	-		X	X	
Asteraceae	*	*Conyza bilbaoana*		-	-			X	
Asteraceae	*	*Conyza bonariensis*	Flaxleaf Fleabane	-	-		X		X

Family	*	Scientific Name	Common Name	BC Act Status	EPBC Act Status	GHD	Cumberland Ecology		
							Plot 1	Plot 2	Incidental
Asteraceae	*	*Conyza sumatrensis*	Tall fleabane	-	-			X	
Asteraceae	*	*Hypochoeris radicata*	Catsear	-	-	X	X	X	X
Asteraceae	*	*Senecio madagascariensis*	Fireweed	-	-				X
Blechnaceae		*Blechnum nudum*	Fishbone Water Fern	-	-				X
Campanulaceae		*Lobelia dentata*		-	-				X
Campanulaceae		*Wahlenbergia communis*	Tufted Bluebell	-	-				X
Campanulaceae		*Wahlenbergia gracilis*	Sprawling Bluebell	-	-	X	X	X	X
Campanulaceae		*Wahlenbergia* sp.	Bluebell	-	-	X			
Casuarinaceae		*Allocasuarina nana*	Dwarf She-oak	-	-	X			
Colchicaceae		*Burchardia umbellata*	Milkmaids	-	-	X			
Cyatheaceae		*Cyathea australis*	Rough Treefern	-	-				X
Cyperaceae		*Baumea acuta*		-	-		X	X	X
Cyperaceae		*Baumea rubiginosa*		-	-		X	X	X
Cyperaceae		*Caustis flexuosa*	Curly Wig	-	-			X	X
Cyperaceae		*Eleocharis gracilis*		-	-		X	X	
Cyperaceae		*Fimbristylis dichotoma*	Common Fringe-sedge	-	-		X	X	X
Cyperaceae		*Gahnia microstachya*		-	-	X			X
Cyperaceae		*Gahnia sieberiana*	Red-fruit Saw-sedge	-	-	X		X	X
Cyperaceae		*Gahnia* sp.		-	-				X
Cyperaceae		*Isolepis inundata*	Club-rush	-	-			X	X
Cyperaceae		*Lepidosperma laterale*	Variable Sword-sedge	-	-	X			X

Family	*	Scientific Name	Common Name	BC Act Status	EPBC Act Status	GHD	Cumberland Ecology		
							Plot 1	Plot 2	Incidental
Cyperaceae		*Lepidosperma limicola*		-	-	X	X	X	X
Cyperaceae		*Schoenus apogon*	Fluke Bogrush	-	-			X	X
Cyperaceae		*Schoenus* sp.		-	-	X			
Cyperaceae		*Schoenus villosus*		-	-		X		X
Cyperaceae		*Tetraria capillaris*		-	-			X	X
Cyperaceae	*	*Cyperus eragrostis*	Umbrella Sedge	-	-				X
Dennstaedtiaceae		*Pteridium esculentum*	Bracken	-	-	X			X
Droseraceae		*Drosera binata*	Forked Sundew	-	-		X		X
Droseraceae		*Drosera peltata*		-	-	X			X
Droseraceae		*Drosera spatulata*		-	-			X	
Ericaceae		*Epacris microphylla*	Coral Heath	-	-	X			
Ericaceae		*Epacris paludosa*	Swamp Heath	-	-		X		
Ericaceae		*Epacris pulchella*	Wallum Heath	-	-			X	X
Ericaceae		*Leucopogon lanceolatus*		-	-	X			
Ericaceae		*Leucopogon* sp.		-	-	X			
Ericaceae		*Monotoca scoparia*		-	-	X			X
Euphorbiaceae		*Amperea xiphoclada*		-	-	X	X	X	X
Euphorbiaceae		*Amperea xiphoclada* var. *xiphoclada*		-	-				X
Fabaceae (Faboideae)		*Daviesia latifolia*	Bitter-pea	-	-	X			X
Fabaceae (Faboideae)		*Podolobium scandens*	Netted Shaggy Pea	-	-	X			
Fabaceae (Faboideae)	*	*Cytisus scoparius* subsp. *scoparius*	English Broom	-	-	X			

Family	*	Scientific Name	Common Name	BC Act Status	EPBC Act Status	GHD	Cumberland Ecology		
							Plot 1	Plot 2	Incidental
Fabaceae (Faboideae)	*	*Trifolium subterraneum*	Subterranean Clover	-	-	X			
Fabaceae (Mimosoideae)		*Acacia baileyana*	Cootamundra Wattle	-	-	X			
Fabaceae (Mimosoideae)		*Acacia longifolia*		-	-	X	X	X	X
Fabaceae (Mimosoideae)		*Acacia* sp.	Wattle	-	-	X			
Fabaceae (Mimosoideae)		*Acacia terminalis*	Sunshine Wattle	-	-	X		X	X
Fabaceae (Mimosoideae)		*Acacia ulicifolia*	Prickly Moses	-	-	X	X	X	X
Gentianaceae	*	*Centaurium erythraea*	Common Centaury	-	-	X			X
Geraniaceae		*Geranium potentilloides* var. *abditum*		-	-		X	X	X
Geraniaceae	*	*Erodium cicutarium*	Common Crowfoot	-	-				X
Gleicheniaceae		*Gleichenia dicarpa*	Pouched Coral Fern	-	-	X			
Goodeniaceae		*Dampiera stricta*		-	-	X	X	X	X
Goodeniaceae		*Goodenia bellidifolia* subsp. *bellidifolia*		-	-			X	X
Goodeniaceae		*Goodenia heterophylla* subsp. *heterophylla*		-	-				X
Goodeniaceae		*Goodenia paniculata*		-	-	X			
Haemodoraceae		*Haemodorum planifolium*		-	-	X	X		X
Haloragaceae		*Gonocarpus micranthus*		-	-		X	X	X
Haloragaceae		*Gonocarpus tetragynus*	Poverty Raspwort	-	-	X			X
Iridaceae		*Patersonia sericea*	Silky Purple-Flag	-	-	X			X
Juncaceae		*Juncus continuus*		-	-		X		X
Juncaceae		*Juncus planifolius*		-	-		X	X	X

Family	*	Scientific Name	Common Name	BC Act Status	EPBC Act Status	GHD	Cumberland Ecology		
							Plot 1	Plot 2	Incidental
Juncaceae		*Juncus* sp.		-	-	X			
Juncaceae		*Juncus usitatus*		-	-	X			X
Lindsaeaceae		*Lindsaea linearis*	Screw Fern	-	-				X
Loganiaceae		*Mitrasacme polymorpha*		-	-				X
Lomandraceae		*Lomandra filiformis* subsp. *filiformis*		-	-	X			
Lomandraceae		*Lomandra glauca*	Pale Mat-rush	-	-				X
Lomandraceae		*Lomandra longifolia*	Spiny-headed Mat-rush	-	-	X		X	X
Lomandraceae		*Lomandra multiflora* subsp. *multiflora*	Many-flowered Mat-rush	-	-	X			
Malvaceae	*	*Modiola caroliniana*	Red-flowered Mallow	-	-				X
Malvaceae	*	*Sida rhombifolia*	Paddy's Lucerne	-	-				X
Myrtaceae		*Baeckea linifolia*	Weeping Baeckea	-	-	X	X	X	X
Myrtaceae		*Eucalyptus blaxlandii*	Blaxland's Stringybark	-	-				X
Myrtaceae		*Eucalyptus globoidea*	White Stringybark	-	-	X			
Myrtaceae		*Eucalyptus oreades*	Blue Mountains Ash	-	-	X			
Myrtaceae		*Eucalyptus piperita*	Sydney Peppermint	-	-	X		X	X
Myrtaceae		*Eucalyptus racemosa*	Narrow-leaved Scribbly Gum	-	-				X
Myrtaceae		*Eucalyptus radiata*	Narrow-leaved Peppermint	-	-			X	X
Myrtaceae		*Eucalyptus sclerophylla*	Hard-leaved Scribbly Gum	-	-	X			

Family	*	Scientific Name	Common Name	BC Act Status	EPBC Act Status	GHD	Cumberland Ecology		
							Plot 1	Plot 2	Incidental
Myrtaceae		*Eucalyptus sieberi*	Silvertop Ash	-	-	X			
Myrtaceae		*Leptospermum continentale*	Prickly Teatree	-	-	X	X		X
Myrtaceae		*Leptospermum grandifolium*	Woolly Teatree	-	-	X	X	X	X
Myrtaceae		*Leptospermum macrocarpum*		-	-	X	X		
Myrtaceae		*Leptospermum polygalifolium*	Tantoon	-	-	X	X	X	X
Myrtaceae		*Leptospermum rotundifolium*		-	-	X			
Myrtaceae		*Leptospermum trinervium*	Slender Tea-tree	-	-	X		X	
Orchidaceae		*Dipodium variegatum*		-	-				X
Orchidaceae		*Eriochilus cucullatus*	Parson's Bands	-	-		X		X
Orchidaceae		*Microtis* sp.		-	-	X			
Orchidaceae		*Orthoceras strictum*	Bird's-mouth Orchid	-	-				X
Orchidaceae		*Prasophyllum* sp.		-	-	X			
Orchidaceae		*Pterostylis* sp.	Greenhood	-	-				X
Orchidaceae		*Thelymitra* sp.		-	-	X			
Phormiaceae		*Dianella revoluta*	Blueberry Lily	-	-				X
Phormiaceae		*Dianella revoluta* var. *revoluta*		-	-	X			
Phyllanthaceae		*Phyllanthus hirtellus*	Thyme Spurge	-	-	X			
Phyllanthaceae		*Phyllanthus virgatus*	Wiry Spurge	-	-				X
Phyllanthaceae		*Poranthera microphylla*	Small Poranthera	-	-	X	X	X	X
Pittosporaceae		*Billardiera scandens*	Hairy Apple Berry	-	-	X	X	X	X
Plantaginaceae	*	*Plantago lanceolata*	Lamb's Tongues	-	-	X			X

Family	*	Scientific Name	Common Name	BC Act Status	EPBC Act Status	GHD	Cumberland Ecology		
							Plot 1	Plot 2	Incidental
Poaceae		*Austrostipa rudis*		-	-				X
Poaceae		*Austrostipa rudis* subsp. *nervosa*		-	-	X	X		
Poaceae		*Deyeuxia mckiei*		-	-		X	X	X
Poaceae		*Elymus scaber*	Common Wheatgrass	-	-	X			
Poaceae		*Entolasia stricta*	Wiry Panic	-	-	X	X	X	X
Poaceae		*Hemarthria uncinata*	Matgrass	-	-		X		X
Poaceae		*Microlaena stipoides*	Weeping Grass	-	-	X		X	X
Poaceae		*Poa sieberiana*	Snowgrass	-	-	X			X
Poaceae		*Rytidosperma pallidum*	Redanther Wallaby Grass	-	-		X		
Poaceae		*Rytidosperma* sp.		-	-	X			
Poaceae		*Rytidosperma tenuius*		-	-	X			X
Poaceae	*	*Cortaderia selloana*	Pampas Grass	-	-	X			
Poaceae	*	*Eragrostis curvula*	African Lovegrass	-	-	X			
Polygalaceae		*Comesperma ericinum*	Pyramid Flower	-	-	X			
Proteaceae		*Banksia ericifolia* var. *ericifolia*		-	-				X
Proteaceae		*Banksia serrata*	Old-man Banksia	-	-	X			
Proteaceae		*Banksia spinulosa*	Hairpin Banksia	-	-	X	X		X
Proteaceae		*Grevillea laurifolia*	Laurel-leaf Grevillea	-	-	X		X	X
Proteaceae		*Grevillea rosmarinifolia* subsp. *rosmarinifolia*	Rosmary Grevillea	-	-				X
Proteaceae		*Hakea dactyloides*	Finger Hakea	-	-	X			X
Proteaceae		*Hakea propinqua*		-	-		X		

Family	*	Scientific Name	Common Name	BC Act Status	EPBC Act Status	GHD	Cumberland Ecology		
							Plot 1	Plot 2	Incidental
Proteaceae		*Hakea sericea*	Needlebush	-	-	X			
Proteaceae		*Isopogon anemonifolius*	Broad-leaf Drumsticks	-	-	X			
Proteaceae		*Lomatia silaifolia*	Crinkle Bush	-	-	X	X		X
Proteaceae		*Persoonia chamaepitys*	Mountain Geebung	-	-				X
Proteaceae		*Persoonia lanceolata*	Lance Leaf Geebung	-	-	X			
Proteaceae		*Persoonia levis*	Broad-leaved Geebung	-	-	X			X
Proteaceae		*Persoonia linearis*	Narrow-leaved Geebung	-	-	X			
Proteaceae		*Petrophile canescens*	Conesticks	-	-				X
Proteaceae		*Petrophile pulchella*	Conesticks	-	-	X			X
Proteaceae		*Telopea speciosissima*	Waratah	-	-	X			X
Proteaceae	*	*Hakea laurina*		-	-	X			
Pteridaceae		*Pellaea falcata*	Sickle Fern	-	-				X
Restionaceae		*Baloskion australe*		-	-	X	X		X
Restionaceae		*Baloskion gracile*		-	-	X			
Restionaceae		*Empodisma minus*		-	-	X	X	X	X
Restionaceae		*Eurychorda complanata*		-	-	X	X	X	X
Restionaceae		*Lepyrodia cryptica*		-	-		X	X	X
Restionaceae		*Lepyrodia scariosa*		-	-	X	X		X
Restionaceae		Unknown sp.		-	-		X		
Rhamnaceae		*Pomaderris andromedifolia af. 'andromedifolia'*		-	-	X			

Family	*	Scientific Name	Common Name	BC Act Status	EPBC Act Status	GHD	Cumberland Ecology		
							Plot 1	Plot 2	Incidental
Rhamnaceae		*Pomaderris andromedifolia* subsp. *andromedifolia*		-	-				X
Rubiaceae		*Opercularia hispida*	Hairy Stinkweed	-	-		X		
Rubiaceae		*Opercularia varia*	Variable Stinkweed	-	-	X	X	X	X
Rubiaceae		*Pomax umbellata*	Pomax	-	-	X			X
Rutaceae		*Boronia microphylla*	Small-leaved Boronia	-	-	X			X
Solanaceae	*	*Solanum* sp.		-	-	X			X
Stackhousiaceae		*Stackhousia viminea*	Slender Stackhousia	-	-	X			X
Thymelaeaceae		*Pimelea linifolia* subsp. *collina*		-	-				X
Violaceae		*Hybanthus monopetalus*	Slender Violet-bush	-	-				X
Violaceae		*Hybanthus vernonii*		-	-	X			X
Violaceae		*Viola caleyana*	Swamp Violet	-	-				X
Violaceae		*Viola hederacea*	Ivy-leaved Violet	-	-		X	X	X
Xyridaceae		*Xyris gracilis*		-	-		X	X	X
Xyridaceae		*Xyris gracilis* subsp. *gracilis*		-	-				X
Xyridaceae		*Xyris ustulata*	Yellow Flag	-	-	X			

* Denotes exotic species

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APPENDIX B :

Fauna Species List

Table 7 Fauna species list

Family	Scientific Name	Common Name	GHD	Cumberland Ecology
Amphibians				
Hylidae	*Litoria peronii*	Peron's Tree Frog	X	
Hylidae	*Litoria tyleri*	Tyler's Tree Frog	X	
Hylidae	*Litoria verreauxii*	Verreaux's Frog	X	
Limnodynastidae	*Limnodynastes dumerilii*	Eastern Banjo Frog	X	X
Myobatrachidae	*Crinia signifera*	Common Eastern Froglet	X	X
Myobatrachidae	*Uperoleia laevigata*	Smooth Toadlet	X	
Birds				
Acanthizidae	*Acanthiza lineata*	Striated Thornbill	X	
Acanthizidae	*Acanthiza pusilla*	Brown Thornbill	X	X
Acanthizidae	*Gerygone mouki*	Brown Gerygone	X	
Acanthizidae	*Sericornis frontalis*	White-browed Scrubwren	X	X
Accipitridae	*Aquila audax*	Wedge-tailed Eagle	X	
Alcedinidae	*Dacelo novaeguineae*	Laughing Kookaburra	X	X
Anatidae	*Anas superciliosa*	Pacific Black Duck	X	
Anatidae	*Chenonetta jubata*	Australian Wood Duck	X	
Artamidae	*Cracticus torquatus*	Grey Butcherbird		X
Artamidae	*Gymnorhina tibicen*	Australian Magpie	X	X
Cacatuidae	*Alisterus scapularis*	Australian King-Parrot		X
Cacatuidae	*Zanda funereus*	Yellow-tailed Black-cockatoo	X	X
Charadriidae	*Vanellus miles*	Masked Lapwing	X	
Climacteridae	*Cormobates leucophaea*	White-throated Treecreeper	X	X
Corvidae	*Corvus mellori*	Little Raven	X	
Hirundinidae	*Hirundo neoxena*	Welcome Swallow	X	X
Hirundinidae	*Petrochelidon nigricans*	Tree Martin	X	
Maluridae	*Malurus cyaneus*	Superb Fairy-wren	X	X
Meliphagidae	*Acanthorhynchus tenuirostris*	Eastern Spinebill	X	
Meliphagidae	*Anthochaera carunculata*	Red Wattlebird	X	X
Meliphagidae	*Lichenostomus chrysops*	Yellow-faced Honeyeater	X	X

Family	Scientific Name	Common Name	GHD	Cumberland Ecology
Meliphagidae	*Phylidonyris novaehollandiae*	New Holland Honeyeater	X	X
Menuridae	*Menura novaehollandiae*	Superb Lyrebird	X	
Pachycephalidae	*Colluricincla harmonica*	Grey Shrike-thrush	X	
Pachycephalidae	*Pachycephala rufiventris*	Rufous Whistler	X	X
Pardalotidae	*Pardalotus punctatus*	Spotted Pardalote	X	X
Phalacrocoracidae	*Phalacrocorax sulcirostris*	Little Black Cormorant	X	
Podicipedidae	*Tachybaptus novaehollandiae*	Australasian Grebe	X	X
Psittacidae	*Platycercus elegans*	Crimson Rosella	X	X
Rhipiduridae	*Rhipidura albiscapa*	Grey Fantail	X	X
Dragonflies and Damselflies				
Coenagrionidae	*Xanthagrion erythroneurum*	Red and Blue Damsel	X	
Corduliidae	*Hemicordulia tau*	Tau Emerald	X	
Lestidae	*Austrolestes analis*	Slender Ringtail	X	
Lestidae	*Austrolestes leda*	Wandering Ringtail	X	
Libellulidae	*Nannophya dalei*	Eastern Pygmyfly	X	
Libellulidae	*Orthetrum caledonicum*	Blue Skimmer	X	
Mammals				
Macropodidae	*Macropus giganteus*	Eastern Grey Kangaroo	X	
Macropodidae	*Macropus rufogriseus*	Red-necked Wallaby	X	
Macropodidae	*Wallabia bicolor*	Swamp Wallaby	X	
Miniopteridae	*Miniopterus orianae oceanensis*	Large Bent-winged Bat	X^	
Molossidae	*Austronomus australis*	White-striped Freetail-Bat	X	
Vespertilionidae	*Chalinolobus gouldii*	Gould's Wattled Bat	X	
Vespertilionidae	*Vespadelus darlingtoni*	Large Forest Bat	X	
Vespertilionidae	*Vespadelus regulus*	Southern Forest Bat	X^	
Vombatidae	*Vombatus ursinus*	Common Wombat	X	
Reptiles				
Agamidae	*Amphibolurus muricatus*	Jacky Lizard	X	
Agamidae	*Intellagama lesueurii*	Eastern Water Dragon	X	

Family	Scientific Name	Common Name	GHD	Cumberland Ecology
Elapidae	*Hemiaspis signata*	Black-bellied Swamp Snake	X	
Scincidae	*Eulamprus heatwolei*	Yellow-bellied Water-skink	X	
Scincidae	*Lampropholis delicata*	Dark-flecked Garden Sunskink	X	
Scincidae	*Lampropholis guichenoti*	Pale-flecked Garden Sunskink	X	
Scincidae	*Lampropholis* sp.	Unidentified grass skink	X	
Scincidae	*Niveoscincus coventryi*	Southern Forest Cool-skink	X	

^ Possible call recording only

APPENDIX C :

Planting List

Table 8 Planting list for rehabilitation works

Growth Form Group	Family	Scientific Name	Common Name	Recorded in Surrounding Vegetation	BioNet Vegetation Classification
Tree (TG)	Cunoniaceae	*Ceratopetalum gummiferum*	Christmas Bush	X	
Tree (TG)	Myrtaceae	*Eucalyptus blaxlandii*	Blaxland's Stringybark	X	
Tree (TG)	Myrtaceae	*Eucalyptus globoidea*	White Stringybark	X	
Tree (TG)	Myrtaceae	*Eucalyptus oreades*	Blue Mountains Ash	X	
Tree (TG)	Myrtaceae	*Eucalyptus piperita*	Sydney Peppermint	X	X
Tree (TG)	Myrtaceae	*Eucalyptus radiata subsp. radiata*			X
Tree (TG)	Myrtaceae	*Eucalyptus sclerophylla*	Hard-leaved Scribbly Gum	X	X
Tree (TG)	Myrtaceae	*Eucalyptus sieberi*	Silvertop Ash	X	X
Tree (TG)	Myrtaceae	*Eucalyptus sparsifolia*	Narrow-leaved Stringybark		X
Tree (TG)	Proteaceae	*Banksia serrata*	Old-man Banksia	X	X
Shrub (SG)	Apiaceae	*Platysace lanceolata*	Shrubby Platysace	X	
Shrub (SG)	Apiaceae	*Platysace linearifolia*		X	X
Shrub (SG)	Araliaceae	*Polyscias sambucifolia*	Elderberry Panax	X	
Shrub (SG)	Asteraceae	*Cassinia aculeata*	Dolly Bush	X	
Shrub (SG)	Asteraceae	*Cassinia aculeata subsp. aculeata*		X	
Shrub (SG)	Asteraceae	*Ozothamnus diosmifolius*	White Dogwood	X	
Shrub (SG)	Casuarinaceae	*Allocasuarina nana*	Dwarf She-oak	X	
Shrub (SG)	Dilleniaceae	*Hibbertia obtusifolia*	Hoary Guinea Flower	X	
Shrub (SG)	Ericaceae	*Brachyloma daphnoides*	Daphne Heath	X	
Shrub (SG)	Ericaceae	*Epacris microphylla*	Coral Heath	X	

Growth Form Group	Family	Scientific Name	Common Name	Recorded in Surrounding Vegetation	BioNet Vegetation Classification
Shrub (SG)	Ericaceae	*Epacris pulchella*	Wallum Heath	X	
Shrub (SG)	Ericaceae	*Leucopogon lanceolatus*		X	
Shrub (SG)	Ericaceae	*Leucopogon spp.*		X	
Shrub (SG)	Ericaceae	*Monotoca scoparia*		X	X
Shrub (SG)	Euphorbiaceae	*Amperea xiphoclada*		X	
Shrub (SG)	Fabaceae (Faboideae)	*Bossiaea heterophylla*	Variable Bossiaea		X
Shrub (SG)	Fabaceae (Faboideae)	*Daviesia latifolia*	Bitter-pea	X	
Shrub (SG)	Fabaceae (Faboideae)	*Daviesia ulicifolia*	Gorse Bitter Pea		X
Shrub (SG)	Fabaceae (Faboideae)	*Podolobium scandens*	Netted Shaggy Pea	X	
Shrub (SG)	Fabaceae (Mimosoideae)	*Acacia baileyana*	Cootamundra Wattle	X	
Shrub (SG)	Fabaceae (Mimosoideae)	*Acacia brownii*	Heath Wattle	X	
Shrub (SG)	Fabaceae (Mimosoideae)	*Acacia longifolia*		X	
Shrub (SG)	Fabaceae (Mimosoideae)	*Acacia longifolia var. longifolia*	Sydney Golden Wattle	X	
Shrub (SG)	Fabaceae (Mimosoideae)	*Acacia spp.*	Wattle	X	
Shrub (SG)	Fabaceae (Mimosoideae)	*Acacia terminalis*	Sunshine Wattle	X	
Shrub (SG)	Fabaceae (Mimosoideae)	*Acacia ulicifolia*	Prickly Moses	X	

Growth Form Group	Family	Scientific Name	Common Name	Recorded in Surrounding Vegetation	BioNet Vegetation Classification
Shrub (SG)	Myrtaceae	*Baeckea linifolia*	Weeping Baeckea	X	
Shrub (SG)	Myrtaceae	*Leptospermum continentale*	Prickly Teatree	X	
Shrub (SG)	Myrtaceae	*Leptospermum grandifolium*	Woolly Teatree	X	
Shrub (SG)	Myrtaceae	*Leptospermum macrocarpum*		X	
Shrub (SG)	Myrtaceae	*Leptospermum polygalifolium*	Tantoon	X	
Shrub (SG)	Myrtaceae	*Leptospermum rotundifolium*		X	
Shrub (SG)	Myrtaceae	*Leptospermum trinervium*	Slender Tea-tree	X	X
Shrub (SG)	Phyllanthaceae	*Phyllanthus hirtellus*	Thyme Spurge	X	
Shrub (SG)	Polygalaceae	*Comesperma ericinum*	Pyramid Flower	X	
Shrub (SG)	Proteaceae	*Banksia ericifolia var. ericifolia*		X	
Shrub (SG)	Proteaceae	*Banksia marginata*	Silver Banksia	X	
Shrub (SG)	Proteaceae	*Banksia spinulosa*	Hairpin Banksia	X	X
Shrub (SG)	Proteaceae	*Grevillea laurifolia*	Laurel-leaf Grevillea	X	
Shrub (SG)	Proteaceae	*Grevillea rosmarinifolia subsp. rosmarinifolia*	Rosmary Grevillea	X	
Shrub (SG)	Proteaceae	*Hakea dactyloides*	Finger Hakea	X	X
Shrub (SG)	Proteaceae	*Hakea propinqua*		X	
Shrub (SG)	Proteaceae	*Hakea sericea*	Needlebush	X	
Shrub (SG)	Proteaceae	*Isopogon anemonifolius*	Broad-leaf Drumsticks	X	X
Shrub (SG)	Proteaceae	*Lambertia formosa*	Mountain Devil		X
Shrub (SG)	Proteaceae	*Lomatia silaifolia*	Crinkle Bush	X	X
Shrub (SG)	Proteaceae	*Persoonia chamaepitys*	Mountain Geebung	X	

Growth Form Group	Family	Scientific Name	Common Name	Recorded in Surrounding Vegetation	BioNet Vegetation Classification
Shrub (SG)	Proteaceae	*Persoonia lanceolata*	Lance Leaf Geebung	X	
Shrub (SG)	Proteaceae	*Persoonia laurina*	Laurel Geebung		X
Shrub (SG)	Proteaceae	*Persoonia levis*	Broad-leaved Geebung	X	X
Shrub (SG)	Proteaceae	*Persoonia linearis*	Narrow-leaved Geebung	X	
Shrub (SG)	Proteaceae	*Persoonia mollis subsp. mollis*		X	
Shrub (SG)	Proteaceae	*Petrophile canescens*	Conesticks	X	
Shrub (SG)	Proteaceae	*Petrophile pulchella*	Conesticks	X	
Shrub (SG)	Proteaceae	*Telopea speciosissima*	Waratah	X	X
Shrub (SG)	Rhamnaceae	*Pomaderris andromedifoli af. 'andromedifolia'*		X	
Shrub (SG)	Rutaceae	*Boronia microphylla*	Small-leaved Boronia	X	
Other (OG)	Pittosporaceae	*Billardiera scandens*	Hairy Apple Berry	X	
Grass & grasslike (GG)	Cyperaceae	*Caustis flexuosa*	Curly Wig		X
Grass & grasslike (GG)	Cyperaceae	*Eleocharis sphacelata*	Tall Spike Rush	X	
Grass & grasslike (GG)	Cyperaceae	*Gahnia microstachya*		X	
Grass & grasslike (GG)	Cyperaceae	*Gahnia sieberiana*	Red-fruit Saw-sedge	X	
Grass & grasslike (GG)	Cyperaceae	*Lepidosperma laterale*	Variable Sword-sedge	X	
Grass & grasslike (GG)	Cyperaceae	*Lepidosperma limicola*		X	
Grass & grasslike (GG)	Cyperaceae	*Schoenus spp.*		X	
Grass & grasslike (GG)	Juncaceae	*Juncus spp.*		X	
Grass & grasslike (GG)	Juncaceae	*Juncus usitatus*		X	
Grass & grasslike (GG)	Lomandraceae	*Lomandra cylindrica*		X	

Growth Form Group	Family	Scientific Name	Common Name	Recorded in Surrounding Vegetation	BioNet Vegetation Classification
Grass & grasslike (GG)	Lomandraceae	*Lomandra filiformis subsp. filiformis*		X	
Grass & grasslike (GG)	Lomandraceae	*Lomandra glauca*	Pale Mat-rush	X	X
Grass & grasslike (GG)	Lomandraceae	*Lomandra longifolia*	Spiny-headed Mat-rush	X	
Grass & grasslike (GG)	Lomandraceae	*Lomandra longifolia var. longifolia*	Spiny-headed Mat-rush	X	
Grass & grasslike (GG)	Lomandraceae	*Lomandra multiflora subsp. multiflora*	Many-flowered Mat-rush	X	
Grass & grasslike (GG)	Lomandraceae	*Lomandra obliqua*			X
Grass & grasslike (GG)	Poaceae	*Aristida ramosa*	Purple Wiregrass	X	
Grass & grasslike (GG)	Poaceae	*Austrostipa puberula*		X	
Grass & grasslike (GG)	Poaceae	*Austrostipa rudis*		X	
Grass & grasslike (GG)	Poaceae	*Austrostipa rudis subsp. nervosa*		X	
Grass & grasslike (GG)	Poaceae	*Cynodon dactylon*	Common Couch	X	
Grass & grasslike (GG)	Poaceae	*Echinopogon caespitosus*	Bushy Hedgehog-grass	X	
Grass & grasslike (GG)	Poaceae	*Elymus scaber*	Wheatgrass	X	
Grass & grasslike (GG)	Poaceae	*Entolasia stricta*	Wiry Panic	X	X
Grass & grasslike (GG)	Poaceae	*Microlaena stipoides*	Weeping Grass	X	
Grass & grasslike (GG)	Poaceae	*Poa sieberiana*	Snowgrass	X	
Grass & grasslike (GG)	Poaceae	*Rytidosperma pallidum*	Redanther Wallaby Grass	X	
Grass & grasslike (GG)	Poaceae	*Rytidosperma spp.*		X	
Grass & grasslike (GG)	Poaceae	*Rytidosperma tenuius*		X	
Grass & grasslike (GG)	Restionaceae	*Baloskion australe*		X	
Grass & grasslike (GG)	Restionaceae	*Baloskion gracile*		X	
Grass & grasslike (GG)	Restionaceae	*Empodisma minus*		X	

Growth Form Group	Family	Scientific Name	Common Name	Recorded in Surrounding Vegetation	BioNet Vegetation Classification
Grass & grasslike (GG)	Restionaceae	*Eurychorda complanata*		X	
Grass & grasslike (GG)	Restionaceae	*Lepyrodia scariosa*		X	
Grass & grasslike (GG)	Xyridaceae	*Xyris ustulata*	Yellow Flag	X	
Fern (EG)	Gleicheniaceae	*Gleichenia dicarpa*	Pouched Coral Fern	X	
Forb (FG)	Acanthaceae	*Brunoniella australis*	Blue Trumpet	X	
Forb (FG)	Apiaceae	*Daucus glochidiatus*	Native Carrot	X	
Forb (FG)	Apiaceae	*Hydrocotyle tripartita*	Pennywort	X	
Forb (FG)	Apiaceae	*Xanthosia pilosa*	Woolly Xanthosia	X	X
Forb (FG)	Asteraceae	*Arrhenechthites mixta*	Purple Fireweed	X	
Forb (FG)	Asteraceae	*Coronidium scorpioides*	Button Everlasting	X	
Forb (FG)	Asteraceae	*Craspedia variabilis*	Common Billy-buttons	X	
Forb (FG)	Asteraceae	*Euchiton sphaericus*	Star Cudweed	X	
Forb (FG)	Campanulaceae	*Wahlenbergia communis*	Tufted Bluebell	X	
Forb (FG)	Campanulaceae	*Wahlenbergia gracilis*	Sprawling Bluebell	X	
Forb (FG)	Campanulaceae	*Wahlenbergia spp.*	Bluebell	X	
Forb (FG)	Colchicaceae	*Burchardia umbellata*	Milkmaids	X	
Forb (FG)	Droseraceae	*Drosera peltata*		X	
Forb (FG)	Goodeniaceae	*Dampiera stricta*		X	X
Forb (FG)	Goodeniaceae	*Goodenia bellidifolia subsp. bellidifolia*		X	
Forb (FG)	Goodeniaceae	*Goodenia hederacea*	Ivy Goodenia	X	
Forb (FG)	Goodeniaceae	*Goodenia paniculata*		X	
Forb (FG)	Haemodoraceae	*Haemodorum planifolium*		X	

Growth Form Group	Family	Scientific Name	Common Name	Recorded in Surrounding Vegetation	BioNet Vegetation Classification
Forb (FG)	Haloragaceae	*Gonocarpus micranthus*		X	
Forb (FG)	Haloragaceae	*Gonocarpus tetragynus*	Poverty Raspwort	X	
Forb (FG)	Iridaceae	*Patersonia glabrata*	Leafy Purple-flag	X	
Forb (FG)	Iridaceae	*Patersonia sericea*	Silky Purple-Flag	X	X
Forb (FG)	Linaceae	*Linum marginale*	Native Flax	X	
Forb (FG)	Orchidaceae	*Diuris pardina*	Leopard Orchid	X	
Forb (FG)	Orchidaceae	*Microtis spp.*		X	
Forb (FG)	Orchidaceae	*Prasophyllum spp.*		X	
Forb (FG)	Orchidaceae	*Thelymitra ixioides*	Dotted Sun Orchid	X	
Forb (FG)	Orchidaceae	*Thelymitra spp.*		X	
Forb (FG)	Phormiaceae	*Dianella revoluta*	Blueberry Lily	X	
Forb (FG)	Phormiaceae	*Dianella revoluta var. revoluta*		X	
Forb (FG)	Phyllanthaceae	*Poranthera microphylla*	Small Poranthera	X	
Forb (FG)	Rubiaceae	*Opercularia hispida*	Hairy Stinkweed	X	
Forb (FG)	Rubiaceae	*Opercularia varia*	Variable Stinkweed	X	
Forb (FG)	Rubiaceae	*Pomax umbellata*	Pomax	X	
Forb (FG)	Stackhousiaceae	*Stackhousia viminea*	Slender Stackhousia	X	
Forb (FG)	Violaceae	*Hybanthus monopetalus*	Slender Violet-bush	X	
Forb (FG)	Violaceae	*Hybanthus vernonii*		X	
Forb (FG)	Violaceae	*Viola silicestris*		X	
Fern (EG)	Dennstaedtiaceae	*Pteridium esculentum*	Bracken	X	X

FIGURES

Figure 1. Location of the project

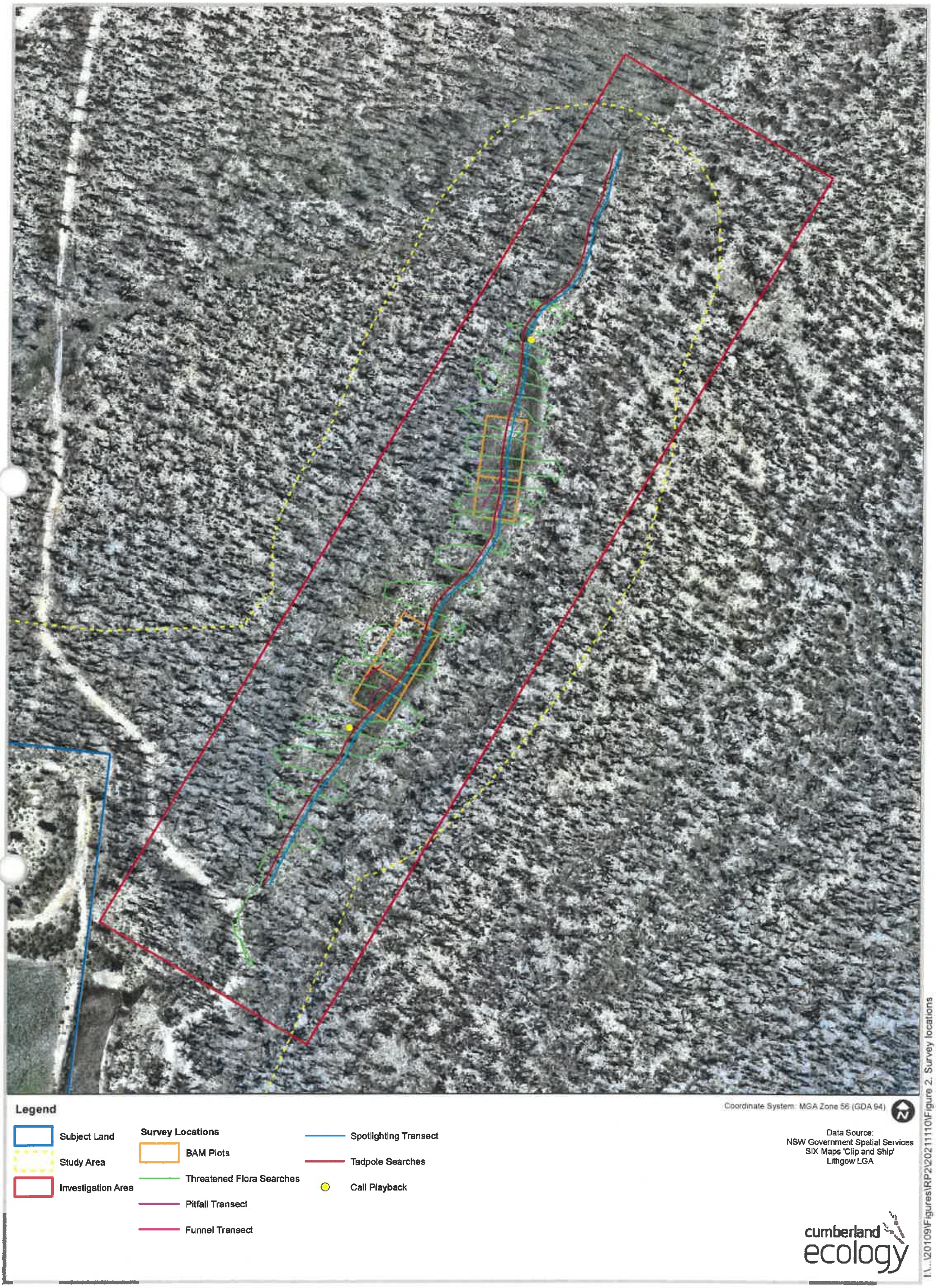


Figure 2. Survey locations

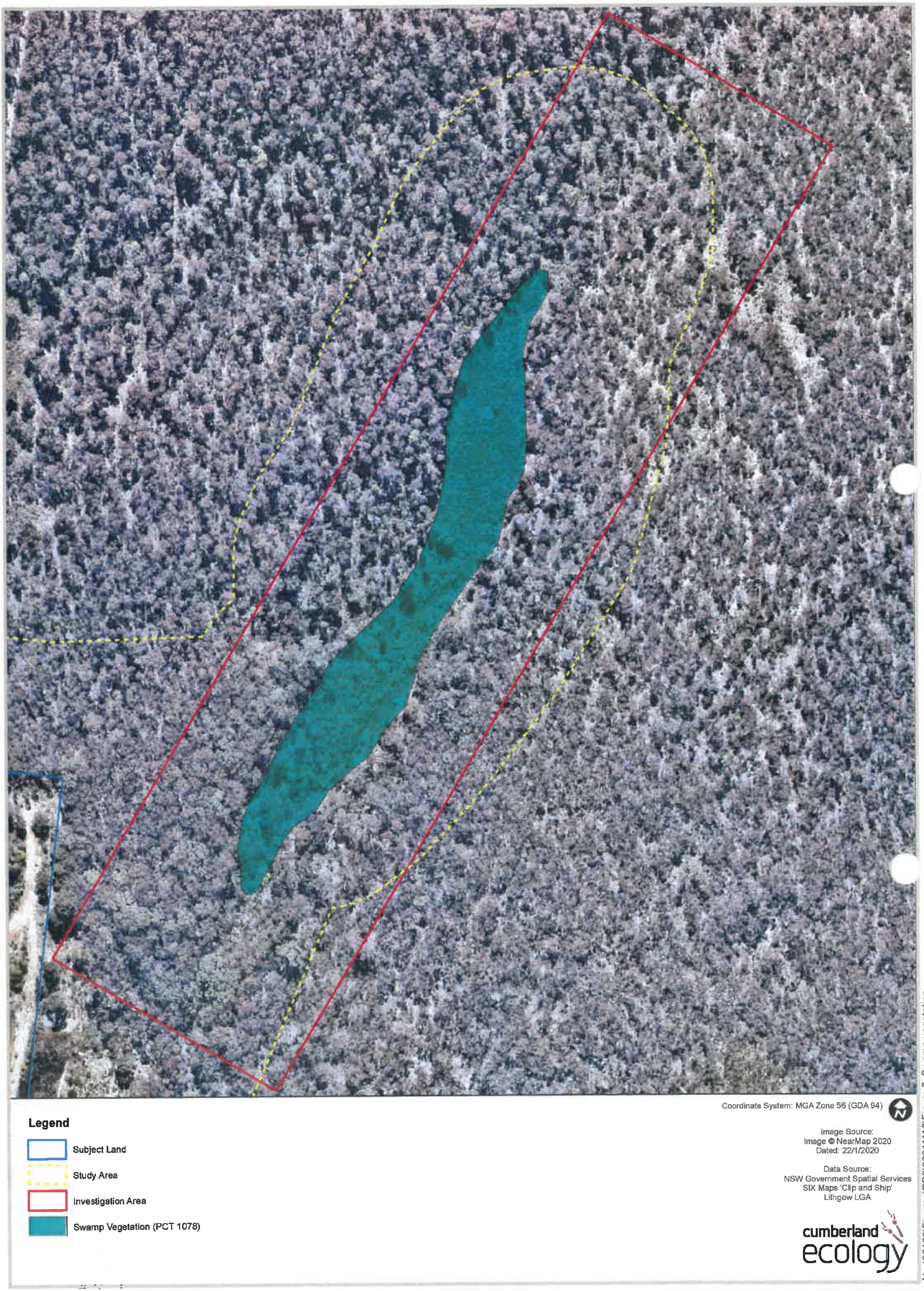
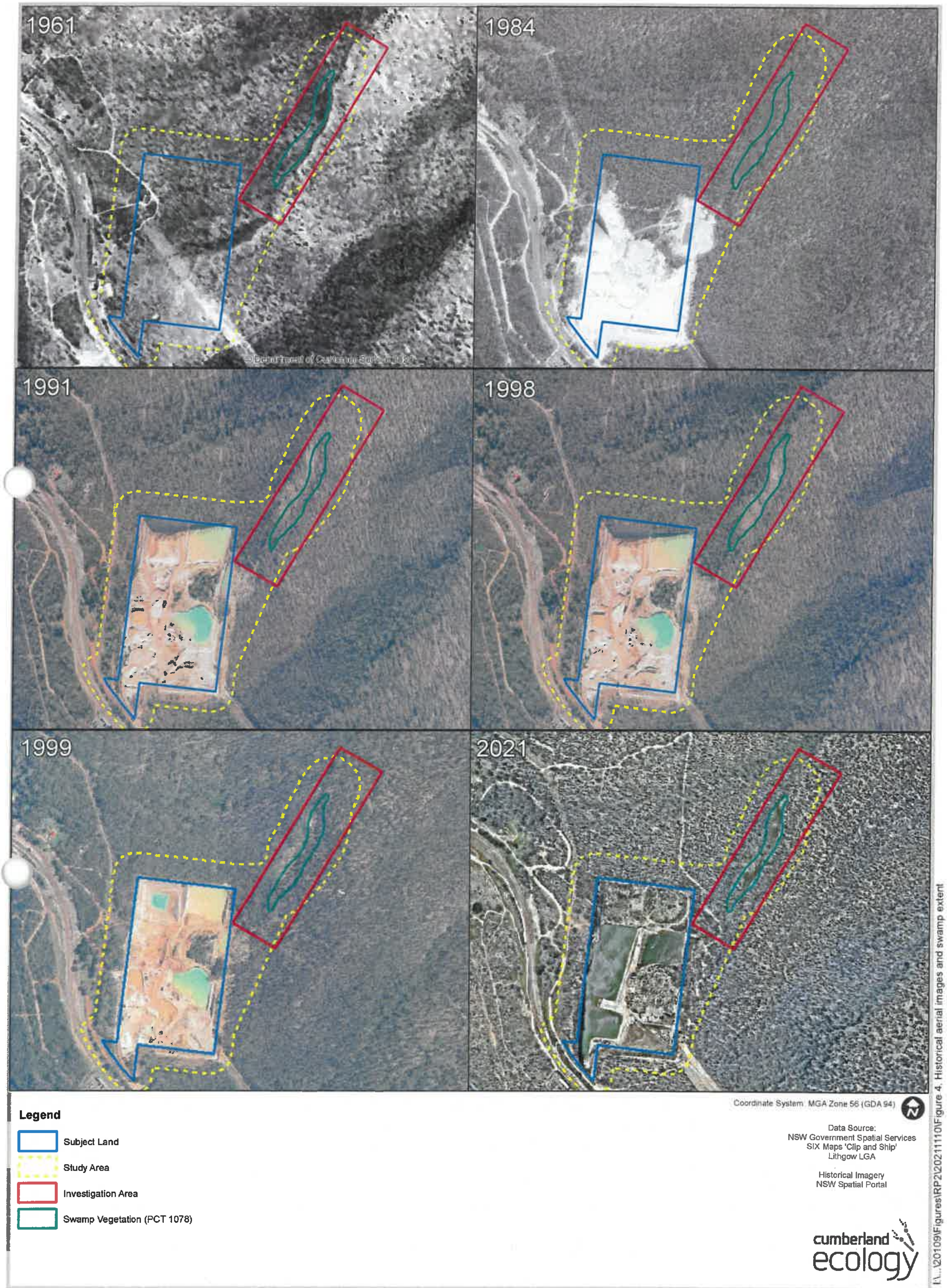


Figure 3. Swamp vegetation

0 50 m



Data Source:
NSW Government Spatial Services
SIX Maps 'Clip and Ship'
Lithgow LGA

Historical Imagery
NSW Spatial Portal

I:\...\20109\Figures\RP2\20211110\Figure 4. Historical aerial images and swamp extent

Figure 4. Historical aerial images and swamp extent

Appendix G

Traffic Considerations

LETTER

Transport Engineering

GTAconsultants
now
Stantec

REF: 864008

DATE: 15 November 2021

HWL Ebsworth Lawyers
Level 14, Australia Square
264-278 George Street
SYDNEY NSW 2000

Attention: Kara Mezinec (Senior Associate)

Dear Kara

RE: BELL QUARRY PREFERRED PROJECT – TRAFFIC STATEMENT

The following traffic statement has been prepared in response to the preferred project report and Lithgow City Council's contentions and particulars as relevant to traffic and transport (LEC case number 2021/00091361):

Contention 10

The proposed development will have unacceptable environmental and amenity impacts arising from the activity associated with the importation of fill to the former quarry site, contrary to s4.15(1)(b) of the EP&A Act.

- *a) There are a number of residences located on Sandham Road, between Bells Line of Road and the subject site, and others proximate to Sandham Road/Chifley Road that will be impacted by the following amenity concerns:*
  - *ii. public safety issues for school buses, cyclists and residents using Sandham Road given the existing condition and character of the road;*
- *b) Adverse traffic impacts on residents located on Bells Line of Road and Great Western Highway east of Mt Victoria from increase in heavy truck movements associated with the Project.*

To address this contention, the Applicant proposes to make a contribution, through a Voluntary Planning Agreement to fund certain road works as described in this letter.

Various locations along the currently sealed section of Sandham Road near Old Bells Line of Road can be widened by around 2 metres to allow for an effective sealed road width of 7 metres. This would allow for a vehicle to pull to one side of the road in the event that there is a vehicle approaching in the opposing direction. The effective sealed width of 7 metres is considered adequate to allow two heavy vehicles (or school buses, cyclists and residents in cars) to pass. An indicative scope of works for these upgrades has been prepared and included in Attachment 1.

Sandham Road has previously supported quarrying activities and the proposed measures will meet contemporary brownfields expectations, without unduly impacting the existing landform, trees/ vegetation and/or property boundaries and access driveways. Appropriate vehicle/ driver management measures, including a driver code of conduct for the rehabilitation project operational phases, can be implemented to further improve heavy vehicle interaction.

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The Bell Quarry TIA also indicates peak activity will result in up to 74 movements per day (38 trucks per day) based on a rate two times higher than the average traffic generation, however this peak activity will be offset by periods with less activity to maintain the capacity of the site to 140,000 tpa.

It seems that there may be a minor inconsistency (or rounding error) with these estimates and the traffic generation estimates for the project should instead be:

- Average haulage: 19 trucks per day (38 truck movements per day)
- Peak haulage: 38 trucks per day (76 truck movements per day).

The above-mentioned corrections are minor and do not impact the conclusions of the Bell Quarry TIA. The assessment assumes the traffic generation during the peak hour would equate to around 10 per cent of the total daily traffic, which is considered appropriate considering the proposed operational hours will equate to 11 hours between 7am and 6pm. In addition to the above, the Bell Quarry TIA assumes two light vehicles associated with staff would travel in and out from the site during peak periods (also consistent with the previous Quarry approval and SEE) for that former use.

These vehicle volumes are low and equate to a maximum frequency of one heavy vehicle every eight minutes. Detailed SIDRA modelling was completed as part of the Bell Quarry TIA, which indicated minimal difference between scenarios with and without the proposed development.

Bells Line of Road and the Great Western Highway are State Roads controlled by TfNSW. The function of State Roads is (inter alia) to accommodate the movement of goods and services and generally higher traffic volumes. The proposal is expected to result in an increase on current traffic (i.e. not considering former quarry use) of four vehicles per hour (eight movements per hour) on average, and up to six vehicles per hour (12 movements per hour) during peak activity. This increase is minor and could not be expected to impact the safety and/or function of the surrounding road network.

Contention 11 (Points 7-11)

The notification of the Designated Development application attracted submissions from relevant Government agencies, local government, special interest groups and individuals. A total of 470 submissions of objection, excluding duplicates, were received by Council including 321 individual submissions and 149 form letters, expressing concerns in relation to:-

- *Traffic impacts on Bells Line of Road and Great Western Highway, in particular in Mt Victoria from additional heavy truck movements;*

As stated above, Bells Line of Road and the Great Western Highway are State Roads controlled by TfNSW. The function of State Roads is (inter alia) to accommodate the movement of goods and services and generally higher traffic volumes. The use of the state road network by the project is appropriate in this regard and residents are unlikely to notice any such minor traffic impacts.

Further to this, it is anticipated that 45 per cent of traffic will approach from/ depart to the south via Mt Victoria. As such, the increase in Mt Victoria is expected to be up to 2-3 vehicles per hour (4-6 movements per hour) which is considered within existing daily fluctuations limits along these roads through Mt Victoria.

It is also understood that facilities on Clarence Colliery Road to the west of the site also use the Darling Causeway and Great Western Highway route through Mount Victoria without issue.

- *Existing condition and width of Sandham Road unable to safely accommodate heavy truck movements, particularly in respect to the school bus, pedestrians, cyclists and local resident movements and needs to be upgraded if the proposal is approved;*

As stated above, it is proposed to provide a contribution to facilitate various locations along the currently sealed section of Sandham Road near Old Bells Line of Road to be widened by around 2 metres to allow for an effective sealed road width of 7 metres which is suitable to allow for two heavy vehicles (or school buses, cyclists and residents in cars) to pass.

- *Intersection of Sandham Road and Bells Line of Road has poor sight lines and needs to be improved;*

Tube counts were completed on Bells Line of Road, which indicates an 85th percentile speed of 74km/h for westbound vehicles and 72km/h for eastbound vehicles, despite there being a posted speed limit of 60km/h. In assessing the minimum sight distance requirements of the intersection, reference has been made to the Austroads Guide to Road Design (AGRD) Part 3: Geometric Design and Part 4A: Unsignalised and Signalised Intersections, as well as the TfNSW Supplement to Austroads Guide to Road Design Part 3.

The Bell Quarry TIA references stopping sight distance (SSD) requirements for trucks, which are generally less than the requirements for cars. It is noted that SSD requirements are not considered to be overly relevant in this case, with Safe Intersection Sight Distance (SISD) considered more appropriate as it relates to the available sight distance available for drivers on the major road to see and respond to a potential conflict at an intersection with a minor road.

The TfNSW Supplement states that industry practice in NSW is to use a driver reaction time of 1.5 seconds for calculating sight distance requirements for roads with design speeds less than or equal to 90km/h. Based on an 85th percentile speed of 72km/h, this results in a SISD requirement of 147 metres. Application of this SISD requirement to eastbound vehicles is shown in Figure 1.

Figure 1: SISD requirements

Base image source: Nearmap

Site observations indicate that required SISD can generally be achieved subject to minor pruning of trees along the northern side of Bells Line of Road as shown in Figure 2 and Figure 3. It is noted that there is a TfNSW road sign related to the heavy vehicle safety station located immediately after Sandham Road within the SISD. However, site observations indicate drivers are generally able to see around this sign, while also noting that vehicles are able to move forward from the hold line to the edge of the travel lane to further improve the available sight distance. This is typical driver behaviour at intersections where left turn deceleration lanes are provided (noting in this instance, the area forms the start of the exit lane for the heavy vehicle safety station. Alternatively, this TfNSW road sign could potentially be relocated outside of the SISD (possibly to the western side of the bridge) to further improve the available sight lines at Sandham Road.

Site observations indicate that there is adequate sight distance available to the east of Sandham Road, as shown in Figure 4.

Figure 2: Available sight lines from Sandham Road to the west

Figure 3: Driver's point of view from the SISD (147m) to the west of Sandham Road

Figure 4: Available sight lines from Sandham Road to the east

There is currently a truck crossing/ entering warning sign (Sign No. W2-22 shown in Figure 5) to the west of the bridge near the SISD to the west of Sandham Road. This could be supported with a new side road intersection warning sign for additional driver awareness (Sign No. W2-4_L shown in Figure 6), however not essential. The Applicant would liaise with TfNSW to agree any signage improvements that are considered beneficial for the existing intersection.

Figure 5: Truck crossing/ entering warning sign (Sign No. W2-22)

Figure 6: Side road intersection warning sign (Sign No. W2-4_L)

- *Potential for queuing of trucks in Sandham Road and Bells Line of Road prior to 7.00am opening of facility; and*

This is an operational matter and can be addressed through management measures such that vehicles are not queued on surrounding roads prior to the site opening. These are typical requirements/ expectations for construction sites around Sydney, and have been successfully addressed at various rehabilitation projects and waste management centres via consent condition and management plan(s). Accordingly, this would be addressed in an operational Plan of Management. Notwithstanding, any queuing at the entry to the quarry is unlikely to impact the surrounding area as there is approximately two kilometres of Sandham Road between the site and the nearest property access. Further, there would be no reason for vehicles to queue on Bells Line of Road.

- *Amenity impacts on Sandham Road residences with dust, noise and public safety.*

With respect to public safety, it is now proposed that various locations along the currently sealed section of Sandham Road near Old Bells Line of Road funded to facilitate widening by around 2 metres to allow for an effective sealed road width of 7 metres which is suitable to allow for two heavy vehicles to pass. The anticipated vehicle volumes generated by the project are low and equate to one heavy vehicle every 17 minutes on average or a maximum frequency of one heavy vehicle movement every eight minutes for peak haulage.

Contention 12:

The key matters to be addressed by conditions would include the following:

c) *Traffic and Transport: The development involves significant heavy vehicle movements over an extended period of time. This will impact on the required maintenance of the road and the safety of other road users. If the development were to be approved, significant measures would be required to mitigate these impacts. The recommendations of Council's Engineer for the widening and sealing of Sandham Road would address local concerns as to dust and public safety in the event of the approval of the development embodying the Council Engineer recommendations.*

As outlined in response to Contention 10, the proposal does not involve significant heavy vehicle movements. The proposal vehicle volumes are considered low, are consistent with the former quarry operations and equate to a maximum frequency of one heavy vehicle every eight minutes. The widening of various locations along the currently sealed section of Sandham Road near Old Bells Line of Road, by around 2 metres to allow for an effective sealed road width of 7 metres, is suitable to allow for two heavy vehicles to pass. The works required for safety and amenity are not significant as contentioned, rather the identified road widening on the sealed section is an acceptable response to the proposed frequency of heavy vehicle movements, without undue impact on the existing local road environment.

Given the low traffic volumes anticipated from the development, the proposal does not warrant full road widening upgrades to Sandham Road and is it not considered appropriate to put the onus solely on the Applicant. Maintenance of the road is the responsibility of Lithgow City Council and Blue Mountains City Council in the respective local government areas, noting it is reasonable for the proponent to be expected to contribute towards accelerated maintenance requirements resulting from haulage operations. The Applicant has offered a suitable developer contribution via planning agreement for Sandham Road works as described in this letter.

Given the limited property accesses and existing condition of Sandham Road within the Lithgow LGA, the majority of future traffic movements in this section would be associated with the former quarry. As such, the unsealed road could be more appropriately maintained as an unsealed haul road, with regular maintenance carried out by the proponent in order to maintain appropriate conditions, in conjunction with periodic Council maintenance works.

I trust the above provides the necessary information. Should you have any questions or require any further information, please do not hesitate to contact me on (02) 8448 1800.

Yours sincerely

GTA, NOW STANTEC

B.T. Maynard.

Brett Maynard
Director

ATTACHMENT 1

Sandham Road Upgrade – Indicative Scope of Works


957.58 m
1
2
754.79 m
← 335.1°
3
4
5
← 351°
6
7

Location ID1

GTAconsultants

Location ID2

Location ID3

GTAconsultants

Location ID4

Location ID5

GTAconsultants

Location ID6

GTAconsultants

Location ID7

Note: 2 options, widen one side only

SUMMARY OF WIDENING

ID1 = 20m

ID2 = 20m

ID3 = 25m

ID5 = 50m

ID6 = 50m

ID6 = 15m

ID7 = 30m

Total length = 210m

Total area = 210m length x 2m widening = 420m^2

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